An investigation into cognitive assessment tools for use in primary care

by

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of *PhD*, is entirely my own work, and that I have exercised reasonable care to ensure that the work is original and does not to the best of my knowledge breach any law of copyright and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abstract

Thesis Title: An investigation into cognitive assessment tools for use in primary care

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Background: More sensitive indicators of cognitive decline are needed in Primary Care. Self-report measures offer some potential but, to date, are not yet reliable indicators of objective performance or progression to dementia. Relationships between self-reported and objective performance remains unclear. Recent research suggests that prospective memory (PM) failures might reflect current and future cognitive decline more accurately than retrospective memory (RM) failures, yet PM is rarely assessed in clinical practice.

Methods: In order to determine the nature, extent and possible underlying causes of self-reported cognitive difficulties in older Irish adults, Study 1 obtained PRMQ data as well as sociodemographic, mood state and health-related information from 518 community-dwelling adults >50+ years using an anonymous survey. Study 2 obtained PRMQ data and data on objective tests recommended for Primary Care from a separate sample (n = 97) of community dwelling adults without history of dementia. Participants were then classified as high reporters/low reporters of memory difficulty and the effectiveness of objective tests for determining group membership was assessed. Study 3 employed advanced statistical methods in an attempt to identify an improved self-assessment tool (short-form PRMQ) that might prove useful in primary care whilst Study 4 generated normative data specific to older Irish adults (both for the long-form and the proposed short-form PRMQ) and examined the potential utility of the proposed short-form PRMQ for case-ascertainment.

Results: Study 1 data revealed that self-reported PM and RM failures are common in the older Irish population and are related, at least to some extent, to sociodemographic, mood state and health-status. Results from analysis of relationships between objective and subjective memory performance (Study 2) revealed complex relationships dependent upon factors such as mood state and multimorbidity. Study 3 resulted in a short-form PRMQ that does not compromise the psychometric properties of the long-form, whilst Study 4 resulted in normative data conversion tables and a proposed algorithm to aid GPs in their decision-making.

Conclusions: The relationships between self-reported memory failures and objective memory performance are complex but can be better understood when account is taken of co-morbidities such as mood state, sleep disturbance and multimorbidity. Based on these findings, care should be taken to understand the complexity and clinical relevance of self-reported difficulties in older adults but recognising atypical reports of everyday memory failures in older adults is worthy of greater consideration in primary care practice.

Chapter 1: Thesis Introduction

1.1 Background

Dementia refers to the symptomatic outcome of several serious neurodegenerative diseases that adversely affect cognitive function. Most people with dementia display cognitive and behavioural symptoms such as memory loss and difficulty organising and planning, as well as psychological changes, such as personality change, aggression, agitation, anxiety, depression, social withdrawal and hallucinations (MacFarlane & O'Connor, 2016). Cognitive decline, which is a main symptom of dementia, is characterised by impairments in memory and decision-making abilities including planning, organisation and mental flexibility. As well as day-to-day difficulties, important decisions about retirement, health, housing and finances may also be compromised in cognitively impaired older adults. Cognitive decline can, therefore, have far reaching consequences beyond daily forgetfulness, for both the individual and society. Identification and assessment of such decline constitutes an important personal and public healthcare need.

Since dementia, as an umbrella term, is the symptomatic outcome of a number of different neurodegenerative processes, the anatomical areas in the brain expected to show early signs of degeneration in dementia will depend on the nature of these underlying neurodegenerative processes. Over 200 subtypes of dementia have been defined, but the main subtypes include Alzheimer's disease (AD), Vascular Dementia (VaD), Fronto-temporal Dementia (FTD), Dementia with Lewy Bodies (DLB) and alcohol-related dementias. Other subtypes include Huntington's Disease, HIV-dementia, Motor Neuron Disease and Prion disease including Creutzfeldt-Jakob disease (Foley & Swanwick, 2014).

Although an overview of all subtypes of dementia is beyond the scope of this thesis, an account of the anatomical brain changes that occur in the main dementia subtypes is presented below. It should be noted that the areas affected in the different types of dementia show a degree of overlap but also some variation, depending on the underlying neuropathology. Changes or damage to different brain regions give rise to different profiles of cognitive deterioration and help explain the range of cognitive and behavioural symptoms and cognitive complaints that older adults with neuropathological burden may present with.

Alzheimer's disease (AD) is believed to be the most common type of dementia (Goedert & Spillantini, 2006). Although a rarer type of early-onset, familial AD (autosomal dominant) comprises about 5% of AD cases (Schott, Fox & Rosser, 2003), AD generally begins in late-life and results in a progressive dementia. Pathologically, AD is characterised by atrophy of neurons in the brain, loss of neural synapses

and the abnormal accumulation of amyloid-B protein as senile plaques and hyperphosphorylated tau protein as neurofibrillary tangles (Serrano-Pozo, Frosch, Masliah & Hyman, 2011). Post-mortem studies have enabled the staging of the progression of both amyloid and tangle pathologies and the development of AD diagnostic criteria based on these. Furthermore, clinicopathological correlation studies – now validated by longitudinal in-vivo studies using imaging biomarkers - have established that there is a continuum between normal aging and AD, and the amyloid plaque build-up occurs primarily before the onset of cognitive deficits, while neurofibrillary tangles, neuron loss and particularly synaptic loss parallel the progression of cognitive decline (Serrano-Pozo et al., 2011).

Although the spatiotemporal pattern of progression of amyloid plaques is far less predictable than that of neurofibrillary tangles, in general, the allocortex (including the entorhinal cortex and hippocampal formation), the basal ganglia, relevant nuclei of the brainstem and the cerebellum are involved to a lesser extent and later than the associative isocortex. Braak and Braak (1991) distinguished three stages. Stage A involves amyloid deposits mainly found in the basal portions of frontal, temporal and occipital lobes. Stage B finds all isocortical association areas affected, while the hippocampal formation is only mildly involved, and the primary sensory, motor and visual cortices are devoid of amyloid. Stage C is characterised by the deposition of amyloid in the primary isocortical areas and, in some cases, the appearance of amyloid deposits in the molecular layer of the cerebellum and subcortical nuclei such as the striatum, thalamus, hypothalamus, subthalamic nucleus and red nucleus. Similarly, according to Thal, Rub, Orantes and Braak (2002), the spatiotemporal pattern of amyloid plaque deposition can be summarised as follows; amyloid deposits accumulate initially in isocortical areas, followed by limbic and allocortical structures and, in a later stage, by subcortical structures including basal ganglia, selected nuclei in diencephalic and brainstem and in the cerebellar cortex. However, the amyloid burden does not correlate with the severity or the duration of dementia (Arriagada, Marzloff & Hyman, 1992; Hyman, Marzloff & Arriagada, 1993; Ingelsson et al., 2004).

Regarding the development of neurofibrillary tangles in aging and AD, research has shown that this proceeds in correspondence with ten brain cortical regions that are successively affected as follows: transentorhinal cortex (stage 1); entorhinal cortex (stage 2); hippocampus (stage 3); anterior temporal cortex (stage 4); inferior temporal cortex (stage 5); medial temporal cortex (stage 6); polymodal association areas (prefrontal, parietal inferior, temporal superior) (stage 7); unimodal areas (stage 8); primary motor (stage 9) or sensory areas (stage 9b, stage 9c) and finally all brain areas. Crucially, research by Serrano-Pozo et al. (2011) showed that the presence of neurofibrillary tangles in what are termed the polymodal association areas was always correlated with cognitive impairment; specifically, Brodmann Area 10 in the frontal cortex and Brodmann Area 39 in the parietal cortex exhibited dementia of the Alzheimer's type. Generally, the severity of pathological changes seen in AD is always

maximal in the hippocampal formation and in the adjoining cortex of the entorhinal area and uncus and is least in the sensorimotor and primary visual areas (Pearson, Esiri, Hiorns, Wilcock & Powell, 1985).

Symptomatically, the progressive increase of amyloid plaques and neurofibrillary tangles in the aforementioned brain areas manifest as impairments in a wide range of cognitive functions as well as behaviours. The temporal lobe structures of the hippocampus and entorhinal cortex, which are so crucial for memory function, are among the areas in which neurofibrillary tangles first develop. Consequently, memory is most often the predominantly affected cognitive process in the early stages of AD. It has been noted, however, that initial subtle damage to the area responsible for visuospatial function can also manifest in the early stages of AD as difficulties with reading, problems in discriminating form and colour, an ability to perceive contrast, difficulties in visual spatial orientation and motion detection, agnosia (inability to interpret sensations) and difficulty in developing visual strategies (Cronin-Golomb & Hof, 2004). Subtle problems in executive processes such as complex planning and organisation may also be observed in the early stages of AD due to the spread of neurofibrillary pathology to temporal, parietal and frontal lobe association areas, as Amyloid-B deposition commences in parallel in parietal, temporal and frontal association areas (Karantzoulis & Galvin, 2011). As cognitive impairment in AD is closely associated with the progressive degeneration and loss of synapses of the limbic system involved in the regulation of emotion (Arnold, Hyman, Flory, Damasio, & Hoesen, 1991; Klucken, McLean, Gomez-Tortosa, Ingelsson & Hyman, 2003), apathy and changes in mood are observed in many cases (Furstl & Kurz, 1999). Also still in the early stages of AD, synaptic loss and degeneration of the basal forebrain (Teipel et al., 2005), responsible for fine motor tasks such as writing, drawing or dressing, may manifest in difficulties with coordination of movement and planning difficulties (apraxia) that often goes unnoticed (Forstl & Kurz, 1999). Primary sensory and motor cortices and most subcortical structures are relatively spared until late in the disease process (Forstl & Kurz, 1999).

With further progression of disease into the moderate stage, impairments emerge in areas of the cerebral cortex responsible for other functions like language, leading to speech difficulties such as paraphasia, semantic knowledge, reading and writing skills (Forstl & Kurz, 1999), abstract thinking, attention, visuospatial behaviours including more pronounced impairment in the ability to coordinate complex motor sequences (Forstl & Kurz, 1999). Due to the continued deterioration of the amygdala and remaining limbic regions, behavioural and neuropsychiatric symptoms such as wandering, irritability, crying, aggression and sundowning increase. Hallucinations and delusional symptoms can appear (Holroyd, Shepherd & Downs, 2000) and limited insight (anosognosia) into one's condition is common (Michon, Deweer, Pillon, Agid & Dubois, 1994). As the integrity of respective associated brain

areas breaks down, the advanced stage of AD involves an eventual loss of speech (Forstl & Kurz, 1999), extreme apathy and exhaustion, the inability to perform activities of daily living independently and the loss of muscle mass and mobility.

In contrast to AD, vascular dementia is caused by a range of different diseases of the blood supply to the brain. It, therefore, has a wider and more variable range of symptoms than other types of dementia (Erkinjuntti et al., 2000) and brain regions affected depend on the cause of the vascular problem. For example, dementia with vascular origins may develop following a major stroke, in which a large area of tissue on one side of the brain dies because the blood supply is suddenly cut off. It can also develop following several mini-strokes across time, with each creating a small infarct. Thus, the commonly used term of multi-infarct dementia. Early symptoms of multi-infarct dementia can be very specific to where the infarct occurs. Another type of vascular dementia, subcortical vascular dementia, follows diseases of the small blood vessels deep in the brain, causing widespread damage to white matter beneath the cortex. Since nerve fibres in the white matter carry signals between different parts of the brain cortex, including the frontal lobes, a person with subcortical vascular dementia will often have slowed thinking and problems with executive functioning (e.g. Ramon, Erkinjuntti, Wallin. Pantoni & Chui, 2002).

In addition to a wider and more variable range of symptoms observed in vascular dementia compared with AD, cognitive impairment of vascular origin are often more sudden in onset. Executive dysfunction is also a more consistent finding in vascular cognitive impairment and dementia than in AD, while the extent of memory impairment is more variable (Hachinski et al., 2006; Moorhouse & Rockwood, 2008).

A pattern of milder atrophy (relative to AD) in the frontal lobes and hippocampal formation with sparing of the medial temporal lobes might be distinctive of frontotemporal dementia (FTD: Frisoni et al, 1996), an umbrella term for a number of different conditions. While executive function processes are known to be impaired in FTD, there is a relative sparing of daily function and learning ability in FTD as compared to AD (Neary, Snowden & Mann, 1993; Miller et al., 1991; Frisoni et al., 1995). Visuospatial abilities are also believed to be more preserved in patients with FTD than are verbal abilities (Neary et al., 1993; Miller et al., 1991; Frisoni et al., 1995). The different subtypes of FTD do, however, reflect different patterns of damage to the brain, thereby resulting in different presentations. However, in all forms of FTD, the areas of the brain associated with personality, behaviour and language, the frontal and/or temporal lobes (otherwise called frontomedial cortex) shrink (Schroeter, Raczka, Neumann, & von Cramon, 2008).

Behavioural variant FTD (BvFTD) is characterised by changes in social behaviour and conduct, loss of social awareness and poor impulse control (Sleegers, Cruts & Van Broeckhoven, 2010) and neuropsychological testing reveals impairments in executive functioning (Possin et al., 2013).

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Collectively, these symptoms arise due to dysfunction of the ventromedial prefrontal cortex (Rahman, Sahakian, Hodges, Rogers & Robbins, 1999). Specifically, in this type of FTD, degeneration is believed to begin in the orbitofrontal cortex, eventually extending to the dorsolateral cortex and the temporal lobe (Krueger et al., 2009).

The second major type of FTD, primary progressive aphasia (PPA) - of which there are subtypes - can be regionally dissociated in the brain from BvFTD. PPA is characterised by an increasing difficulty in using and understanding written and spoken language and is reflective of damage to the brain areas responsible for these functions. In semantic dementia (SD), one type of PPA, there is a difficulty with naming and often a loss of knowledge of the meaning of words, although speech remains fluent and grammatically faultless (Sleegers et al., 2010). Temporal-lobe damage affecting the lateral and medial cortexes has been related to semantic impairments (Burianova & Grady, 2007), although all individuals with SD are not identical (Snowden et al., 2018). For example, naming deficits are more severe in patients with predominant left-temporal atrophy and familiarity with faces is more impaired in predominant right-temporal cases (Binney et al., 2016).

Progressive nonfluent aphasia (PNFA), another type of PPA, is characterised by a progressive difficulty in speech production (Sleegers et al., 2010). In comparison to bvFTD, perception, memory, spatial skills and praxis are relatively preserved (and hence, the integrity of corresponding brain areas) in this type of FTD (Snowden, Neary & Mann, 2002). The classical pattern of brain atrophy in PNFA is bilateral frontal and temporal atrophy, which is more severe in the dominant hemisphere (Knibb, Woollams, Hodges & Patterson, 2009). However, this classic pattern has not been observed in other cases (e.g. Sonty et al., 2003; Josephs et al., 2006; Nestor et al., 2003). Meta-analyses of MRI and FDG-PET studies identified alterations in the whole left frontotemporal network for phonological and syntactical processing as the most consistent finding (Schroeter, Raczka, Neumann & von Cramon, 2007). Based on these imaging methods, PNFA can be regionally dissociated from both BvFTD and SD.

Brain neuropathology in FTD involves the accumulation in the brain of a protein called tau, and one involving the protein TDP-43. In other cases, the affected parts of the brain contain microscopic abnormal tau protein-filled structures that develop within brain cells, commonly called Pick's bodies. In later stages, the clinical phenotypes of FTD may overlap (Sleegers et al., 2010). Overall, individuals with FTD show marked deficiencies in executive functioning and working memory (Neary, Snowden & Mann, 2005).

Dementia with Lewy bodies (DLB) is the second most common cause of neurodegenerative dementia in older people, accounting for 10% to 15% of all cases (McKeith, 2004), and it occupies part of a spectrum that includes Parkinson's disease and primary autonomic failure (McKeith & Burn, 2000). All

these diseases share a neuritic pathology based upon abnormal aggregation of the synaptic protein α-synuciein. Neuropathological hallmarks of DLB consist of α-synuclein–positive Lewy Bodies, tiny deposits of protein, and Lewy neurites (LNs), which are abnormal neurites in diseased neurons, containing granular material and abnormal α-synuclein filaments similar to those found in Lewy Bodies. Amyloid plaques, a main pathological hallmark of AD, are often also present in cases of DLB (McKeith, 2004). The brain of a person with DLB often shows less overall shrinkage than the brain of someone with AD or FTD (Burton et al., 2000).

Simard, Reekum & Cohen (2000) present an overview of the distribution of neuropathology in DLB. Cortical Lewy Bodies are found in the cerebral cortex, limbic system and brain stem. Specifically, they are present in small and middle neurons in the deep cortical layers of every lobe, in particular, the anterior frontal and temporal area, the cingulate area and the insula. In the subcortical structures, Lewy Bodies are found in the substantia nigra and the nucleus basalis of Meynert, in the locus coeruleus and in the nucleus raphe dorsalis, and the amygdaloid complex. Degeneration of the neurons in the CA 2/3 region of the hippocampus, not seen in AD or normal aging, is correlated with Lewy Bodies. Individuals with DLB show more extensive neuronal loss in the substantia nigra, the nucleus basalis of Meynert and the frontal lobe than do people with AD. More severe glucose hypometabolism in DLB compared with AD has also been found in the cerebellar hemispheres and the temporal-parietal-occipital association cortices (Imamura et al., 1997) and in the medial and lateral occipital lobes (Ishii et al., 1998).

In DLB, early damage is seen in the visual pathways and, in some studies, also in the frontal lobes. Hence, visual-perceptual and attentional-executive impairments, translating as problems with vision and attention, as well as difficulties with problem solving, are core characteristics of DLB and these difficulties reflect the most frequent locations of Lewy Bodies in frontal, cingulate and inferior temporal cortex. This distribution of pathology is likely related to the characteristic visual hallucinations and clinical fluctuations of the disease (Collerton, Burn, McKeith & O'Brien, 2003). Similarly, Lewy Bodies in the brainstem may be linked to problems with movement also seen in Parkinson's Disease. These spontaneous features of parkinsonism are central to diagnosis of DLB. Fluctuating cognition and attention are also core features of DLB (McKeith et al., 1996; 2005). Symptoms of prominent or persistent memory impairment are sometimes, but not always, present early in the course of DLB but are likely to develop in most individuals with progression of the DLB (McKeith et al., 1996; 2005).

McKeith (2004) draws attention to the fact that it is important to identify DLB patients accurately because they have specific symptoms, impairments and functional disabilities that differ from other common dementia syndromes such as AD, vascular cognitive impairment and FTD. For example, Simard

et al. (2000) report that neuropsychological testing shows that individuals with mild and moderate DLB perform more poorly than patients with AD on visuospatial praxis tests. By contrast, episodic and semantic memory are equally impaired in subjects with mild, moderate and even severe DLB and AD. Those with mild DLB have performed badly on tasks of mental flexibility and visual set-shifting. Notably, as Lambon Ralph and et al. (2001) point out, overlapping distributions of pathology with those with AD can result in very similar clinical presentations, especially in the early stages, with memory impairment often being the earliest and most prominent feature of both types of dementia. DLB and AD are most likely to be correctly differentiated on neuropsychological grounds by marked attentional and visuospatial deficits and perhaps the relatively good orientation and delayed recall seen in DLB. In the later stages of DLB, differentiation from AD becomes more difficult when the deficits in memory, language and other cognitive skills frequently overlap with those seen in AD.

Closely linked to DLB is Parkisnon's disease (PD), a degenerative progressive motor disorder that affects nerve cells in the basal ganglia and the substantia nigra (NINDS, 2019). For reasons not fully understood (e.g. Kalia & Lang, 2015), the dopamine-producing nerve cells of the substantia-nigra begin to die off in affected individuals, resulting in PD symptoms such as tremor, slowness of movement, stiffness and balance problems. As the brain changes caused by PD gradually spread, they often begin to affect cognitive functions like memory, planning ability, attention, and judgement (Parker, Lamichhane, Caetano, & Narayanan, 2013). Around 30-40% of individuals with PD will develop PD dementia (PD-D) some years after their initial diagnosis of PD (Cummings, 1998; Emre et al. 2004).

Like DLB, PD-D may lead to motor symptoms. This is because PD and PD-D may be linked to the same underlying abnormalities in the brain processing of alpha-synuclein and LB-type degeneration in cerebral cortex and limbic structures and both conditions probably represent two clinical entities on a spectrum of LB disease (McKeith & Burn, 2000). Similar to those with DLB, many people with PD-D also have plaques and tangles, the hallmark neuropathology linked to AD (Braak et al., 2003). However, there are also differences in the pathology of DLB and PD-D, such as different patterns of LB distribution (Emre et al., 2007). However, even if people with PD have LB in their brains, prevalence studies show that not all of these individuals will develop dementia (e.g. Reid et al., 1996). PD-D is also different to DLB in the initial presentation of symptoms. Individuals with PD-D will first show PD symptoms, followed by symptoms of dementia, which appear one year or more after the diagnosis of PD, while individuals with DLB will either develop dementia symptoms first, develop symptoms of dementia in association with symptoms related to movement, or develop symptoms of dementia within one year of movement symptoms (McKeith et al., 2005). The defining feature of PD-D, therefore, is that dementia develops in in the context of established PD. Crucially, diagnosis of PD-D must be based on the presence of deficits in at least two of the four cognitive domains of attention, memory, executive

and visuospatial functions, as shown in clinical and cognitive examination, and deficits must be severe enough to affect normal functioning (McKeith et al., 2005).

PD-D has an insidious onset and is, as noted above, characterised by impairments in attention, memory, executive and visuospatial functions (Emre, 2003) reflecting the LB degeneration to the brain areas responsible for these functions. The cognitive profiles of individuals with PD-D and DLB are very similar, with evidence of some differences in the extent and profile of deficits in individual cognitive domains compared to patients with AD. More prominent memory impairment, reflective of a "cortical" profile, has been observed in AD whilst more prominent executive dysfunction, reflective of a "subcortical" profile has been observed in PD-D (Emre et al., 2007). Regarding the assessment of executive function and visuospatial abilities, Cahn-Weiner et al. (2003) reported that people with PD-D showed more "planning" errors in clock drawing performance, which taps both visuo-perceptual/visuospatial abilities and executive processes, than did people with AD. However, as noted by Emre and et al. (2007) such construction tasks involve significant motor control and a range of cognitive functions, and that the contribution of motor dysfunction to such deficits needs further investigation.

The study of language deficits has traditionally received much less attention in PD-D than other dementias. Aphasia is, however, rare and individuals with PD-D have, reportedly, less impairment in core language functions as compared with AD (Emre et al., 2007). In contrast, behavioural symptoms such as affective changes, hallucinations and apathy are also found in PD-D (Chiu et al., 2016).

Imaging studies reveal atrophy and hypometabolism, more prominent in the temporal and posterior areas in PD-D. Cross-sectional evidence shows greater atrophy of the frontal lobes in individuals with PD-D compared to controls (Beyer, Janvin, Larsen & Aarsland, 2007; Burton, McKeith, Burn, Willaims & O'Brien, 2004; Nagano-Smith, 2005), with some studies reporting greater regionally-specific atrophy of the anterior cingulate gyrus (Nagano-Saito, 2005; Summerfield et al., 2005). Atrophy of the temporal lobes (Beyer et al., 20007; Tam, Burton, McKeith, Burn & O'Brien, 2004), and less commonly in the occipital lobes (Burton et al., 2004). Due to the overlap of the pattern of regional atrophy in PD-D, PD and DLB, compared to AD and controls, Emre et al. (2007) concluded that no consistent pattern of structural changes clearly separates PD-D from PD without dementia or from other comparison groups.

Nevertheless, studies have shown that, compared to healthy controls, individuals with PD-D show brain hypoperfusion or reduced cerebral blood flow in several areas of association cortex, especially in the temporal, lateral parietal, precuneus, posterior cingulate and occipital regions (Antonini, de Notaris, Benti, de Gaspari, & Pezzoli, 2001; Firbank, Colloby, Burn, McKeith & O'Brien, 2003; Kawabata, Tachibana & Sugita, 1991). This contrasts with findings of no changes in patients without dementia (Sawada et al., 1992; Spaminato et al., 1991) or decreased cerebral blood flow limited to the frontal

lobes (Antonini et al., 2001). Nevertheless, extensive hypoperfusion found in individuals with PD but no dementia including in the parietal and temporal cortices (Liu, Qiao, & Dafny, 1992; Osaki et al., 2005) suggest that while temporal-parietal-occipital hypoperfusion is usually associated with PD-D, it may not always be useful for distinguishing PD-D from those without dementia. The topographical pattern of brain perfusion in PD-D and DLB have been shown to be comparable (Firbank et al., 2003; Kasama, Tachibana, Kawabata & Yoshikawa, 2005) and similar to that of AD, although hypoperfusion was found to be more pronounced in AD in a study by Spampinato et al., (1991).

A greater reduction in glucose metabolism has also been found in the inferior parietal (Peppard et al., 1990; Piert, Koeppe, Giordani, Minoshima & Kuhl, 1996) and occipital (Piert et al., 1996) cortices in PD-D as compared to PD, and in the cerebellar and occipital cortices relative to controls (Abe et al., 2003; Peppard et al., 1992). A similar global pattern of decreased cerebral glucose metabolism, affecting the frontal, parietal and parietal association cortices, and posterior cingulate area was observed in PD-D compared to AD (Peppard et al., 1990; Vander Borght et al., 1997). In sum, metabolic and structural changes to the parietal, occipital and frontal areas of the brain account for the observed core deficits in PD-D of visuospatial, constructional, and executive type cognitive abilities.

Alcohol-related dementia, another relatively common dementia, is widely acknowledged but not often used as a diagnostic term. Indeed, according to Gupta and Warner (2008), the condition needs further validation through research. Available evidence indicates that alcohol-related dementia is less progressive than AD and other dementias and is even potentially reversible (Gupta & Warner, 2008). The cognitive deficits most frequently observed in alcohol-related dementia occur in the domains of visuospatial functions, memory and executive tasks, with potential of partial recovery if abstinence is maintained (Sachdeva, Chandra, Choudhary, Dayal & Anand, 2016).

Evidence regarding anatomical areas damaged in alcohol-related dementia comes from neuroimaging, neuropathological reports and autopsy evaluations (Goldstein & Shelly, 1980). Volume shrinkage, glucose metabolism and perfusion along with evidence of markedly decreased neuron density have been observed and the frontal lobes are particularly affected (Sullivan, 2003; Moselhy, Georgiou & Kahn, 2001). Significant loss of white matter is most prominent in the prefrontal cortex, cerebellum and corpus callosum, and neuronal loss is observed in the superior frontal association cortex, cerebellum and hypothalamus (Harper, 2009; Harper & Matsumoto, 2005). As detailed by Bates, Bowden & Barry (2002), such brain changes arise from the direct neurotoxic effect of alcohol, oxidative stress, excitotoxicity, apoptosis, disruption of neurogenesis and mitochondrial damage.

Wernicke's encephalopathy, an acute neurological disorder precipitated by thiamine deficiency, is characterised by the clinical triad of opthalmoplegia, ataxia and confusion. It is defined pathologically

by neuronal loss and haemorrhagic lesions in the paraventricular and periaqueductal grey matter and it is reported to be most likely the main underlying pathology in both Korsakoff's syndrome and alcohol-related dementia (Sachdeva et al., 2016). Korsakoff's syndrome is a long-term outcome of Wernicke's encephalopathy and includes a syndrome of profound memory impairment related to disruptions in neural circuits in the hippocampus and diencephalon. Due to the similar pathological substrates involved, Wernicke's encephalopathy and Korsakoff's syndrome are often referred to as the Wernicke – Korsakoff syndrome (Harper, 2009). Individuals with this disorder show similar, yet more severe, deficits in regional brain volumes (mamillary bodies, thalamus, cerebellar hemispheres, and vermis) than alcoholic patients without Wernicke-Korsakoff syndrome (Sullivan & Pfefferbaum, 2009).

As can be seen from the brief account of the anatomical brain areas affected in varying forms of dementia presented above, cognitive decline due to dementia is understood to be a progressive process ranging from subtle or mild cognitive dysfunction involving one, or a small number of, brain areas to more severe dysfunction involving multiple areas of the brain. It follows, then, that the particular brain areas affected at a given time-point accounts for the particular type and range of cognitive difficulties experienced and reported by older adults.

In order to illustrate more fully how the brain changes due to dementia, of various etiology, might interfere with the proper functioning of memory, the focus of this thesis, an account of the main cognitive and neurocognitive models of memory is provided in Chapter 2. Moreover, since memory is not one process, but many, a review of the types of memory encompassed by what is referred to as retrospective memory and that might be expected to deteriorate as a result of pathological changes to anatomical brain areas impacted by dementia, is also provided in that chapter.

From a practical perspective, it is increasingly recognised that even subtle cognitive decline can impact in negative ways on an individual's quality of life (Fortin, Godbout & Braun, 2002), safety (Woods et al., 2008) and ability to live independently (Cockburn & Smith, 1988). There is general consensus, therefore, that the detection and diagnosis of cognitive decline need to occur at a much earlier stage in the disease process than is currently the case so that, at a minimum, affected individuals can be supported to live well with their cognitive difficulties, and potentially, supports and interventions believed to help delay or prevent further deterioration can be provided to affected individuals and families.

The phase of the progression from normal aging to dementia is referred to as Mild Cognitive Impairment (MCI). At present, there are a number of different definitions of this transitional phase (Panza et al., 2005) and the various definitions and operational criteria for MCI itself have developed over time (Petersen et al., 1999; Winblad et al., 2004; Albert et al., 2011; Bondi et al., 2008; Jak et al.,

2009). In general, however, the various definitions are in agreement that MCI involves the onset and evolution of cognitive impairments that go beyond those expected based on an individual's age and education. The cognitive impairments are not, however, significant enough to interfere with daily activities.

The etiology and prognosis of MCI remains unclear; there can be many different underlying causes for MCI (and self-reported cognitive impairments more generally), and some people who meet diagnostic criteria for MCI revert to a normal level of cognitive functioning while others progress to dementia. Given its nature, there has been increased interest in gaining a better understanding of this complex clinical condition.

There is also increasing interest in a clinical condition describing the simultaneous presence of physical frailty (i.e. increased vulnerability for developing increased dependency and/or mortality when exposed to a stressor) and MCI. Termed "cognitive frailty", this was defined in 2013 by an international consensus group organised by the International Academy on Nutrition and Aging (IANA) and the International Association of Gerontology and Geriatrics (IAGG). Physical frailty may increase the risk of future cognitive decline and cognitive impairment may increase the risk of physical frailty, suggesting that cognition and physical frailty may interact in advanced aging (Robertson, Savva & Kenny, 2013). Frailty has been shown, in a meta-analysis, to be a significant predictor of all dementias among community-dwelling older people (Kojima, Taniguchi, Iliffe & Walters, 2016). Cognitive frailty has since been suggested to divide into reversible and potentially reversible subtypes (Ruan, Yu, Chen, Bao, Li & He, 2015; Panza et al., 2015), and the concept may be helpful for identifying individuals with cognitive impairment due to the physical domain and not related to neurological disease.

In terms of the assessment and timely detection of cognitive impairment, major dementia care guidelines and national dementia strategies worldwide (including the Irish National Dementia Strategy) emphasise that Primary Care is the setting in which cognitive impairment and dementia should be detected. Typically, these strategies state the important role of general practitioners (GPs) in recognising the signs of cognitive impairment. However, it is currently estimated that as many as 50% of dementia cases go undiagnosed (Frankish & Horton 2017) and a study by Olafsdottir, Foldevi and Marcusson (2001) showed that 39% of GPs questioned thought that the early detection of dementia was the most difficult aspect of the condition. This evidence points to the need for more sensitive indicators of cognitive decline for use in Primary Care – so that correct diagnosis can be made, or so that individuals who require further evaluation might be referred appropriately to specialist services.

Many cognitive screening instruments are considered to be too long and too cumbersome to be administered in primary care, and only a minority have been validated in primary care samples and

settings for which they purport to be designed or suitable for. It must, of course, be acknowledged that this limitation combines with a number of other complex psychosocial factors impeding the successful detection of early cognitive decline, including, but not limited to, poor insight into cognitive problems (Vogel et al., 2004), human endeavour to cover up cognitive difficulties as a form of coping strategy, difficulties experienced by older adults, their families and GPs in opening the conversation, as well as stigmatic beliefs (Werner, Goldstein, Karpas, Chan & Lai, 2014). There is also evidence that cognitive symptoms are more readily identified as dementia (or possible dementia) and non-cognitive symptoms are more commonly attributed to stress or depression, and that individuals are less likely to seek help for such non-cognitive symptoms (Hamilton-West, Milne, Chenery & Tilbrook, 2010). For these and other reasons, detection of dementia in primary care often relies exclusively on clinical suspicion about patient symptoms and/or on the basis of caregiver concerns, without reference to cognitive test performance. Consequently, dementia diagnosis is prone to being missed or delayed (Bradford, Kunik, Schulz, Williams & Singh, 2009).

Self-report measures of memory impairment offer at least some potential to aid professionals to identify early symptoms of cognitive decline and/or those at risk of dementia, as longitudinal population studies have shown self-reported memory problems to predict future cognitive impairment and dementia (e.g. Schmand et al., 1997) even when objective test scores are in the normal ranges (Dufouil, Fuhrer & Alperovitch, 2005; Wang et al., 2004).

Of note also is the fact that some recent research suggests that prospective memory (PM) failures might reflect current and future cognitive decline better than does retrospective memory (RM) failures (Blanco-Campal, Coen, Lawlor, Wlash & Burke, 2009), but, as yet, assessment of PM function is not included in the typical assessment of cognitive health in primary care settings. Importantly, PM failures are common in the general population (Dobbs & Rule, 1987) and it might reasonably be argued that inclusion of an assessment of this type of memory within the primary care setting, given its potentially serious personal consequences, is, therefore, important.

Self-report assessments of cognitive difficulties are arguably less invasive to an individual, and potentially less damaging to the therapeutic relationship. Encouraging research also exists on the prognostic value of self-report measures of cognition. Despite this, however, self-reports are not generally considered, by professionals, to be reliable indicators of objective test performance or future progression to dementia. This is reflected in the absence of any self-report measures of cognition in the recommendations issued relatively recently by the Irish College of General Practitioners (ICGP) (Foley & Swanwick, 2014), and by the Alzheimer's Society for the assessment and diagnosis of cognitive impairment and dementia.

Part of the reason for this relative neglect in the assessment process may be the fact that the relationships between self-reported memory problems and objective test performance remains unclear. Indeed, self-reported memory problems have been reported to be strongly associated with mood state and other demographic variables (e.g. education, gender) than with performance on objective cognitive tests. Must of this research, however, might be questioned because of the nature of both the subjective measures used and the nature of the objective tests against which the subjective measures are benchmarked.

There is, therefore, an important ongoing need to clarify the relationship between self-reported memory problems and objective test performance. Specifically, there is a need to improve the quality of methods of capturing self-reports of memory difficulties and, it is contended here, a need to ensure that important aspects of memory, such as PM, are not neglected when seeking to identify MCI and dementia.

There is, also, an important need to clarify the relationship between self-reported memory problems and objective test performance when taking account of comorbidities such as mood state, general health and factors such as sleeping difficulties. Literature continues to emerge to demonstrate associations between subjective cognitive complaints and mood state (Bolla, Lindgren, Bonaccorsi, & Bleecker, 1991; Derouesne, Lacomblez, Thibault, & Leponcin, 1999; Montejo, Montenegro, Fernandez & Maestu, 2011), physical health (Carraciolo et al., 2013) and sleep disturbance/disfunction.

By examining these relationships, healthcare professionals might better understand the possible underlying causes and seriousness of self-reported memory and cognitive difficulties, thereby enhancing their ability to identify those with or at risk of developing dementia.

1.2 The Current Thesis

This thesis aims to address the main gaps as outlined briefly in the background by adopting a multi-staged approach to an examination of the relationships between self-reported prospective and retrospective memory failures and performance on objective cognitive tests in an Irish Primary Care context.

Study 1 aimed to determine the nature, extent and possible correlates of self-reported cognitive difficulties in older Irish adults. To achieve this objective, a large cohort (n=518) of community-dwelling older adults (aged 50+ years), with no known history of dementia, completed the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith, Maylor, Della Sala & Logie, 2000), which was administered as part of a larger anonymous survey. Each participant also provided a range of

sociodemographic information, completed a measure of mood state and answered a number of questions related to health-status and sleep quantity and quality.

In **Study 2,** a separate sample (*N*=97) of community-dwelling older adults without dementia completed the same Study 1 questionnaire, but the participants also completed a number of objective tests of cognition function. Three of these tests were selected on the basis that they have been recommended for use in Primary Care. A fourth test was selected as it provides an opportunity to assess prospective memory objectively. The goal of this study was to determine the relationships between subjective and objective test performance.

In an attempt to identify an improved self-assessment tool that might be attractive to GPs who are often pressed for time, **Study 3** employed item level analysis of the PRMQ data obtained in Study 1 in an attempt to develop and propose a brief and reliable version of the tool.

Study 4 aimed to help GPs interpret the potential significance of an older individual's self-reported memory difficulties by providing normative data for older Irish adults, for both this short-form PRMQ and for the original full-form of the PMRQ, as well as cut-offs for judging subjective impairment It also involved the development of an algorithm based on case profiling of participants' short-form PRMQ and objective test performance to assist primary care practitioners with ascertaining cases of cognitive impairment.

1.3 Thesis Layout

Chapter 2 provides an overview of the key aspects of the literature on cognitive impairment, with a particular emphasis on the literature pertinent to assessment and timely detection. The assessment approaches currently used by General Practitioners (GPs) are summarised, with a view to highlighting current limitations of these approaches and how assessment of cognitive impairment might be improved. Chapter 2 also provides a rationale for the current thesis and its aims and objectives.

Chapter 3 contains a general overview of the methodology and methods used for each of the three studies in this thesis; Study 1, Study 2 and Study 3. It describes the procedures used throughout the study phases as regards ethical considerations, participant recruitment, collection of data, and date analysis.

Chapter 4 describes those methods and procedures specific to Study 1. It also outlines in detail the specific goals of the study as well as the results of this investigation of the nature, extent and correlates of self-reported memory lapses. The chapter concludes with an interim summary and discussion.

Chapter 5 presents the procedures particular to Study 2, alongside the sample characteristics. The specific goals of this study are identified and the findings of this study examining the relationships between subject and objective test performance are presented. Like chapter 4, an interim summary and discussion of the data is presented.

Chapter 6 describes the specific procedures used to analyse individual items of the PRMQ and select items for the construction of a briefer, yet reliable, self-report measure for use in Primary Care.

Chapter 7 presents normative data, for older Irish adults, for both this short-form PRMQ and for the original full-form of the PMRQ. This chapter also presents a proposed algorithm to assist practitioners in primary care based on case profiling of participants' short-form PRMQ and objective test performance.

Chapter 8 presents a synthesis of the findings of each of the four studies. The chapter then proceeds to a discussion of the thesis findings in relation to the current literature and it summarises the implications of findings for the assessment of memory and cognitive difficulty in Primary Care. The strengths and limitations of each of the studies and of the overall thesis are identified, and suggestions are outlined for future research.

Chapter 2: Setting the Scene - Identifying Cognitive Problems in Primary Care Settings

2.1 Overview

This chapter is designed to provide a brief overview of what we hope to gain by assessing memory in Primary Care, followed by an overview of the complexity of memory, and a broad description of some of the main models and theories that have attempted to account for this fundamental and dynamic cognitive function. It goes on to give an overview of the different types of memory encompassed by retrospective memory and to give a brief account of an often-neglected aspect of memory (i.e. prospective memory). Unlike retrospective memory (RM), PM is concerned with remembering to carry out goals and intentions at the correct time in the future. The significance of PM is increasingly recognised in clinical and research contexts for its validity in the prediction of cognitive and memory impairment. Nevertheless, the incorporation of the PM construct into formal clinical assessment and brief cognitive screening instruments has been extremely slow or neglected entirely. The clinical significance of PM and the extent to which it is included in formal clinical assessments of memory and brief cognitive screening tools is outlined. Finally, the value of assessing other variables shown to be associated with subjective memory complaints is presented. This is done to help clarify the relationship between self-reported memory problems and objective cognitive performance. It is also done as an understanding of these relationships might assist healthcare professionals to identify potential cases

of subtle cognitive dysfunction in older adults. By so doing, appropriate interventions and, if necessary, treatments, to help maintain cognitive health may be implemented.

2.2 Why assess cognition in Primary Care?

It is well acknowledged in the literature that memory complaints are common among older adults living in the community (Jonker, Geerlings & Schmand, 2000), and attending Primary Care (Waldorff, Siersma, Vogel, & Waldemar, 2012), and that they can cause considerable distress to those experiencing them (Mol et al., 2007; Commissaris, Ponds & Joles, 1998). Nevertheless, older adults are often reluctant to seek help (Stewart, 2012; Commisaris et al., 1993; Waldorff, Rishoj & Waldemar, 2008), whether due to stigma (Werner et al., 2014), because of normalising beliefs about the effects of aging on memory (Werner., 2003) or other reasons. When an individual does present in Primary Care with subjective memory concerns, it is often unclear how significant such verbal reports are for the determination of the individual's underlying cognitive function. For example, a survey of 600 randomly selected GPs in Ireland found that that 31% of GPs reported that they experienced difficulty differentiating normal aging from symptoms of dementia (Cahill, Clark, Walsh, O'Connor & Lawlor, 2006). Subjective concerns with one's memory are often strongly related to mood (e.g. Hanninen et al., 2004) and a range of other variables such as poor physical health or multimorbidity (Aarts et al., 2010) and education (Montejo et al., 2011) and are not, in and of themselves, indicative of MCI or dementia.

Notwithstanding the challenges involved, there is consensus that there is a need for timely, reliable assessment and detection of cognitive decline in Primary Care (Vernooiji-Dassen et al., 2005). Timely detection has been described as when the patient and caregiver and the primary care physician recognise that there may be a developing disease or disease process (Vernooiji-Dassen et al., 2005). Ideally, early and accurate identification of subtle cognitive decline could allow Primary Care professionals to put in place interventions of a secondary prevention type (Solomon, 2014) to promote and maintain cognitive resilience (Steinberg et al., 2013) and to prevent further cognitive deterioration.

While no disease altering treatments for dementia yet exist, evidence continues to emerge for the benefits of non-pharmacological and lifestyle interventions for those with subtle cognitive dysfunction. There is consistent evidence that cognitive stimulation interventions benefit cognitive function and aspects of well-being (Asguirre, Woods, Spector & Orrell, 2013). Other potentially beneficial non-pharmacological interventions are cognitive training (Ball et al., 2002) and cognitive rehabilitation (Vernooiji-Dassen et al., 2005), cognitive behavioural therapy (CBT) to help with emotional adjustment to cognitive changes (Teri, Logsdon, Uomoto & McCurry, 1997), and exercise programmes (Baker et al., 2010) to help prevent further deterioration or even to improve memory.

Many studies show that even subtle cognitive deficits, whatever their reason, can impact negatively on a person's quality of life, independence and safety and individuals who are aware that something is amiss with their cognitive functioning may experience distress and isolation due to their uncertainty (Clare, 2003; Vernooiji-Dassen et al., 2005). Without assessment and detection of this subtle cognitive dysfunction, interventions to mitigate further decline cannot be implemented and support cannot be offered to lessen the burden when an actual disease process is present. It is worth noting that assessment of the older individual with memory complaints and/or subtle or mild cognitive impairment should not simply comprise a means to an end – the end being diagnosis. There is a need for more holistic assessment that better points to how we might support these individuals. Related to this point, social prescription in Primary Care is increasingly relevant as means of providing alternative support, involving as it does the referral of suitable individuals to voluntary services and community groups. Although social prescribing is valued by GPs (Stickley & Hui, 2012), GPs may be slow to identify patients for a social prescribing service (Fox, 2003). This is despite the advantages of this holistic approach to support; social prescribing can help individuals self-manage their psychological, social and emotional difficulties (Polley et al., 2017), and benefit mental health, improve community well-being and reduce social inclusion (Friedli & Watson, 2004). All these potential benefits are especially pertinent to individuals experiencing subjective and objective cognitive difficulty.

At present, cases of dementia may be underdiagnosed by as much as 50% (Frankish & Horton, 2017), and the underdiagnosis of MCI and mild dementia is even higher. The literature cites numerous reasons for the failure to identify earlier stages of cognitive impairment (e.g. Cahill et al., 2006; Vernooji-Dassen et al., 2005) and these reasons include, but is by no means limited to, the approach taken to measurement of cognitive and memory functioning and the type of assessment tools used (e.g., Lonie, Tierney & Ebmeier, 2009).

Whilst it is recommended that cognitive assessment screens for MCI and dementia should cover more than just memory – to avoid what Cullen et al (2007), Royall (2003) and Knopman (2001) refer to as the *"Alzheimerisation of dementia"* - assessment of memory must remain a hallmark of cognitive screening tools given the prevalence of memory problems across the dementia spectrum.

Memory may be assessed using either a subjective or objective approach and each approach may be used alone or in combination. The various methods and measures of memory assessment within the objective and subjective domains are briefly described below, alongside their main demonstrated strengths and limitations.

As outlined in Chapter 1, in keeping with the needs and demands of primary care, the assessment of memory – whether subjective or objective - needs to be brief and easy for GPs to use, to score and to

interpret while still reliable and acceptable to both patients and GPs. It is also preferable that more than one domain (e.g. memory) is assessed by a measure, given the range of cognitive domains typically affected in MCI and dementia. It might also be argued that more than just one aspect of memory should be assessed and the fact that even earlier, subtle signs of impairment may be experienced in a type of memory other than retrospective episodic memory.

Crucially, the appropriate assessment method needs to be sensitive enough to detect subtle dysfunction in memory to permit the primary care physician to identify potential problems, to seek to determine likely cause and to be able to seek out specialist referral or to provide other interventions oriented towards prevention of further cognitive decline. Findings as to the sensitivity and specificity of existing objective screening instruments for the detection of MCI and mild dementia in clinical contexts, including primary care, as evidenced by key reviews in the literature, are briefly summarised below.

Relevant issues and evidence from the literature are also outlined regarding the utility and validity of self-report measures of memory in the reliable assessment of subtle memory impairment.

Finally, a sensitive and reliable assessment of memory and the likely underlying causes of difficulty must take into account the range of other variables that have been demonstrated to impact on, or to be associated with, experienced memory problems. These include sociodemographic variables such as age, gender, education, and occupation, mood state, such as levels of anxiety and depression, sleep quantity and quality, alcohol use, and physical health. An account of the implications of each of these key variables in the assessment of memory (and other cognitive domains) is also given below.

2.3 Memory – one process or many

Memory, a fundamental cognitive process, can be defined as the acquisition and retention of information (Loring, 1999). It involves a range of capacities (Roediger, Marsh & Lee, 2002) and at a general level, there are several terms describing different *forms* or *kinds* of memory, and a distinction is often made between short-term and long-term memory.

Paller (2000) explains that memory research traditionally has been segregated into (a) research on the cognitive organisation of memory and (b) research on the brain basis of memory. Those theories of memory that are generally concerned with the way in which memory is organised can be broadly divided into systems theories, concerned with the *architecture* or *structure* of memory and process theories, concerned with the *activities* or *processes* involved (e.g., Eysenck & Keane, 2013). In more recent memory research, however, there is a trend towards using neural information to inform theories

of memory, giving rise to neurocognitive models of memory which go some way towards reconciling the traditional cognitive and brain-based strands of memory research.

An early model of memory was the multistore model of memory, also known as the modal model (Atkinson & Shiffrin, 1968), a structural model in which memory is proposed to consist of three stores; a sensory register, a short-term memory (STM), and long-term memory (LTM). Information was proposed to pass through these in a linear way. Thus, it is a type of information processing model. In this model, if maintenance of the memory through rehearsal does not occur, information will be lost from STM through a process of displacement or decay. Support for the model was provided by experimental psychology studies demonstrating primacy (wherein, relative to mid-list words, words at the beginning of a list are more easily recalled) and recency effects (wherein, compared to mid-list words, words near the end of a list have a higher probability of being recalled; Healy & McNamara, 1996). Support also comes from findings of oft-cited neuropsychological case-studies in the literature such as patient HM (Milner & Corkin, 1968) and patient KF (Shallice & Warrington, 1975), both of whom showed dissociation between STM and LTM. Anterograde amnesia was observed in patient HM following resection of HM's medial temporal lobe structures for the relief of medically intractable epilepsy, affecting his declarative and episodic memory but leaving his short-term memory intact. Prior to this, memory functions were believed to be distributed in the cortex (Eichenbaum, 2013). Performance of patient KF in a series of experiments showed that KF had a greatly reduced short term memory capacity which could not be attributed to a retrieval failure, however his performance on long-term memory tasks was normal.

Evidence has since emerged, however, that STM and LTM do not operate in a single uniform fashion (Davelaar, Goshen-Gottstein, Ashkenzai, Kaarmann, & Usher, 2005). Furthermore, STM comprises different components such as a central executive component and visuospatial component (Baddeley & Hitch, 1974) and LTM also consists of different types of memory (e.g. episodic: memory of events; procedural: knowledge of how to do things and semantic: general knowledge). It has also been shown that simple rehearsal is too simplistic an account for the transfer of memory from STM to LTM and that the modal model ignores other factors and processes of memory such as motivation and elaboration. These limitations were subsequently addressed by more sophisticated models of memory that better took account of the interaction of various processes involved in memory. Two main or influential models in this regard are the Levels of Processing (LOP) Model (Craik & Lockhart, 1972) and Baddeley's Working Memory (WM) model (Baddeley & Hitch, 1974).

The LOP model of memory is based on the theory that the way that information is encoded affects how well it is remembered. It proposes that processing of memories can take place at a shallow level

(maintenance rehearsal leading to short-term retention) or a deep level (involving semantic processing and elaboration rehearsal, e.g. images and associations), leading to better retention and recall. Although the concepts of depth of procession and elaboration have been criticised as ill-defined (Nelson, 1977; Baddeley, 1978) and difficult to demonstrate empirically due to circular reasoning (the tendency to define depth in terms of the memory outcome) (Proust, 1993), the LOP model improves on the modal model of memory by accounting more comprehensively for processes involved in the transfer of memory from STM to LTM and it paved the way for the development of an influential model of working memory (Baddeley & Hitch, 1974).

Working memory is a system that temporarily stores and maintains information in the form of internal representations and manipulates these representations (Nilsson, 2003). According to Schacter and Tulving (1994), it is one of five major memory systems; the other four being semantic memory, episodic memory, procedural memory, and the perceptual representation system.

Connectionist models, also known as Parallel Distributed Processing (PDP) models, are a class of computational models often used to explain memory storage and retrieval, using an information processing approach (McClelland & Rummelhart, 1988). As a class of model, it represents a paradigm shift from previously outlined models of memory that describe a serial and linear account of how memory works. In this model, cognitive processes are described as networks in which the elements have multiple links. According to these models, 'memory' is the activation of these connections in different areas (the "distribution") at the same time ("parallel"). The patterns of the activations that occur at and between a multitude of nodes in the brain give rise to cognitive representations such as memory and knowledge. The strength of such memory traces and knowledge is aided by the strength of the connections activated between the relevant parts of the brain.

More recent neurocognitive models of memory build upon these earlier cognitive models and attempt to incorporate knowledge of the neural basis of memory into the framework for understanding the organisation of memory. A brief overview of some of these models is presented below.

The classical consolidation model proposed by Larry Squire and colleagues (Squire, 1987; Zola-Morgan & Squire, 1990; Squire & Alvarez, 1995; Squire & Zola, 1996; Squire, 1992) is one such influential neurocognitive model. The term "consolidation" was coined around the turn of the century by Muller & Pilzecker (1900) to describe a time-dependent process needed to assimilate an experience and store it permanently as a memory that would not be easily disrupted. According to the model, consolidation is distinguished into two specific processes; synaptic consolidation, which is synonymous with late-phase long-term potentiation and occurs within the first few hours after learning and systems consolidation, where hippocampus-dependent memories are purported to become independent of the

hippocampus over a period of weeks to years and are moved to the neocortex in a more permanent form of storage (Roediger, Dudai & Fitzpatrick, 2007). A third process, reconsolidation, refers to previously-consolidated memories becoming labile again through reactivation of the memory trace (Nader, Scafe & Le Douz, 2000; Sara, 2000). Support for the memory consolidation model is forthcoming from a variety of sources, including lesion studies of human patients (e.g. Squire, Haist & Shimamura, 1989; Kapur, 1999), experimental animal studies (Anagnostaras, Maren & Fanselow, 1999) and computational-based neural modelling (McClelland, McNaughton & O'Reilly, 1995).

The standard consolidation model was substantially informed by lesion studies of individuals with damage to their medial temporal lobe or diencephalic nuclei, most notably following Scoville and Milner's 1957 publication on the effects of excision of the anterior and medial temporal lobes bilaterally to control intractable epilepsy in patient HM. These individuals displayed normal short-term memory. Similarly, it was observed that older (remote) memories, both autobiographical and semantic, were stored and could be retrieved readily without the medial temporal lobe (Corkin, 1984). These observations were interpreted as showing that the function of the medial temporal lobes and related diencephalic structures was not to process short-term memories or to store long-term memories but, rather, was to help consolidate memories in other brain regions and to encode, store and retrieve them until consolidation was complete (Squire, 1992). The standard consolidation model, therefore, argues that the hippocampus is a time-limited memory structure for all forms of memory.

This standard account characterises "recent memories" as those that depend on both cortical and hippocampal networks. It draws distinctions between declarative and non-declarative (procedural) memory systems. Declarative memory pertains to the conscious recollection of complex facts and personally-experienced events. Non-declarative or procedural memory, on the other hand, refers to non-conscious recollection of a diverse set of phenomena including skill learning, habit learning, simple forms of conditioning, various types of priming that can be measured in implicit memory tests and non-associative forms of learning like habituation and sensitisation (e.g. Squire & Zola, 1996). This distinction based on research on amnesic patients that showed retained ability to be trained on tasks and to exhibit learning without the patient having been aware that the training had ever taken place (Squire, 1986). As noted below, a declarative memory does not reside in a single location, but rather depends on a dynamic network of neurons. The standard consolidation model proposes that procedural knowledge is consolidated in some cases by the extrapyramidal motor system (Squire, 1986).

According to the standard account, when new information is encoded and registered, memory of these new stimuli are retained in both the hippocampus and neocortical regions for allegedly up to one week,

representing the hippocampus-dependent stage (Frankland & Bontempi, 2005). During this time, a process whereby declarative memories outgrow their dependence on cortico-hippocampal networks to become cortically self-reliant occurs. This process is believed to involve the hippocampus "teaching" the cortex more and more about the information. Recall of the information further strengthens the connection between the hippocampus and surrounding cortex, thus enabling the memory to become hippocampal-independent. Since it may involve increased connectivity among the components of the memory in the cortex, the process is sometimes referred to as cross-cortical consolidation (e.g. Paller, 2002; 2009). Medial temporal-lobe structures are also believed to play a role in the consolidation of memories within the neocortex by providing a binding area for multiple cortical regions involved in the initial encoding of the memory (Squire & Alvarez, 1995). This "training" of the neocortex by the hippocampus allows new information to be assimilated into neocortical networks with a minimum of interference. A recent revision of this account from a neurocomputational perspective (McClelland, 2013), a factor believed to influence the rate of consolidation more than a fast or slow rate of learning, is the amount of prior knowledge that is available about the material to be learned (Tse et al., 2007; van Kesteren, Ruiter, Fernandez & Henson, 2012). In other words, if the information to be learned is consistent with prior knowledge, neocortical learning can become more rapid.

The standard model also proposes the formation of new cortical representations that function to represent the gist or higher-order meaning of the memory while simultaneously enhancing the coherence of the set of neocortical storage sites. How exactly this occurs is somewhat in debate, although Wiltgen et al. (2010) favour the view that consolidation entails an active process of extracting the gist or pattern from what was learned, although forgetting individual instances (including the most recent instance). However, Squire, Genzel, Wixted, and Morris (2015) recognise that it is unclear whether a qualitative process/mechanism of gist extraction is in practice, required, and that the possibility that there are qualitative changes in the character of memory during consolidation is currently an active area of research.

This standard model acknowledges that memory is reconstructive and vulnerable to errors, or false remembering (Schacter & Dodson, 2001). As previously mentioned, it also recognises that under some conditions, long-term memory can transiently return to a labile state (and then gradually stabilise), a process known as reconsolidation (Nader et al., 2000; Sara, 2000).

The consolidation process for relatively new memories is interrupted by retrograde amnesia so that enough consolidation to produce a stabilised cortical memory is not achieved. It follows that these memories cannot, therefore, be accessed in the absence of retrieval mechanisms that depend on the

hippocampus and related structures. However, if enough consolidation has otherwise been achieved, an old or long-term memory can be retrieved via cortical mechanisms.

The standard model makes no distinction with respect to consolidation among different types of explicit memory, be they spatial or non-spatial, episodic or semantic, recollective or familiar (Squire & Zola, 1998; Squire, 2004). All are dependent on the hippocampal complex/medial temporal lobe (HC/MTL) for the duration of the consolidation period, after which time they can be retained and retrieved independently of it. Thus, damage to the HC/MTL and diencephalon leads to a graded, temporally limited, retrograde amnesia for both episodic and semantic memory, whether autobiographical or spatial. Memories acquired most recently are most severely affected, with remote memories, having already been fully consolidated before the brain insult or onset of amnesia, being retained normally (Squire, 1992; Squire & Alvarez, 1995).

The standard account of consolidation has also been investigated in healthy volunteers using neuroimaging methods like PET or fMRI. Squire and colleagues (2015) explain that neuroimaging studies can establish whether a particular structure (e.g. the hippocampus, medial prefrontal cortex, or a network of structures) is active when recent and remote memories are retrieved, but this method does not conclude whether a structure is *necessary* for retrieval. Specifically, a temporal gradient of hippocampal activation (e.g. greater activation for recent than remote memories) might reflect a decreasing dependence on the hippocampus as memories age, but this might also reflect differences in the extent to which memories of different ages are relearned or re-encoded as they are recollected. Imaging studies used to explore how and under what conditions consolidation occurs, led to the proposed phenomenon of "neural replay." This refers to the spontaneous recurrence of hippocampal activity that occurred originally during learning, a phenomenon supported by animal and human studies (e.g. Takehara-Nishiuchi & McNaughton, 2008; Peigneux et al., 2004).

To this end, Squire and colleagues (2015) cite the results of neuroimaging studies (Takashima et al., 2006; 2009; Yamashita et al., 2009; Furman et al., 2012; Harand et al., 2012) employing a prospective design that affords experimental control over the memories from different time periods. In such designs, participants learn similar materials at multiple different time points before scanning. The results of these prospective studies are also mixed in their support of the standard account of consolidation. For example, in the study by Takashima et al., (2006), participants memorised two sets of face-location associations; one was studied 24 hours before testing (remote memories) and others studied 15 minutes before testing (recent memories). Activity in the hippocampus decreased (and activity in the neocortex increased) as a function of time after learning. At the same time, functional connectivity between the hippocampus and cortical areas decreased over time, whereas connectivity

within the cortical areas increased. This temporal gradient is shorter than what is typically observed in lesion studies, but Squire and colleagues state that these findings are nevertheless in agreement with the idea that the hippocampus becomes less important for memory with the passage of time.

In another prospective study, by Furman et al. (2012), participants were tested on their memory of documentary clips. When memory was tested by recognition, a sign of memory consolidation, activity in the hippocampus was observed to decline as time passed over a period of months. By contrast, hippocampal activity remained stable across time when memory was tested by recall. Cortical activity also decreased as time passed. The findings of this study suggest a continuing role for the hippocampus in long-term memory, in contrast to the fundamental tennet of the standard model of consolidation.

There remains, however, a concern regarding the use of prospective designs for the investigation of memory that, by the time memory is tested in the scanner, many older memories will have been forgotten. Thus, the possibility exists that surviving remote memories may be relatively durable and are being compared with a mixture of durable and less durable recent memories. One study (Yamashita et al., 2009) addressed this potential issue, by monitoring activity in the hippocampus and temporal neocortex as participants recalled two sets of paired-associate figures that they had memorised at two different times – 8 weeks before testing (remote memories) and just before testing (recent memories). Imaging results showed that an area in the right hippocampus was more active during retrieval of new memories than old memories, whereas in the left temporal neocortex, the opposite pattern occurred. These results were considered consistent with the standard account of memory consolidation, i.e. a decreasing role of the hippocampus and an increasing role of the neocortex as memories age across a period of 50 days. Recent evidence, however, has not always been consistent with the standard model of consolidation. Neuroanatomical and functional considerations are at the core of the discrepancy concerning consolidation and the representation of remote memories in the brain (Moscovitch et al., 2005).

The main issue in relation to the standard consolidation model is the fact that retrograde amnesia for episodic (including spatial) memory is prolonged yet memory is relatively preserved for semantic (including spatial) memory (Nadel & Moscovitch, 1997, 1998; Moscovitch & Nadel, 1998; Fujii, Moscovitch & Nadel, 2000). Indeed, Kinsbourne and Wood (1975) argued that retrograde amnesia is a deficit only of episodic (autobiographical) memory that affects recent and remote memory equally. Retrograde amnesia for autobiographical episodic memory can extend for decades, or even a lifetime – longer than biologically plausible for a consolidation process to last. In contrast, retrograde amnesia for semantic memory is less extensive and is often temporally graded (Fujii et al., 2000). Thus,

contrasting to the argument of the standard consolidation model, non-spatial semantic and episodic memories are affected differentially by lesions producing retrograde amnesia (Warrington, 1996).

Semantic memories themselves, depending on their characteristics, may also be differentially affected by lesions. Evidence reviewed by Moscovitch and colleagues (2005) suggests that it is useful to distinguish between those spatial memories that consist of detailed perceptual-spatial representations of experienced environments (corresponding to episodic autobiographical memory) and those that consist of schematic representations of the topography of the environment (corresponding to semantic memory). The authors conclude that schematic (semantic) spatial memories can survive damage to the HC)/MTL), but perceptually detailed (episodic) spatial memories cannot.

To account for the evidence at odds with the standard model, Nadel and Moscovitch (1997) proposed a multiple trace theory (MTT) of memory. According to the MTT and in line with standard consolidation model, the HC and possibly the diencephalon rapidly encodes all information that is consciously apprehended (Moscovitch & Umilta, 1990; Moscovitch, 1992) and binds the neocortical (and other neurons) that represent that experience into a memory trace. In line with reasoning in the standard consolidation model, formation and consolidation of these memory traces is relatively rapid, lasting for the order of seconds or, at most, days. However, in the MTT model, in contrast to the standard consolidation model, there is no prolonged consolidation process that is proposed to slowly strengthen the neocortical component of the memory trace, so that with time, the trace becomes independent of the HC/MTL. Instead, MTL has a static role; each time an old memory is retrieved, a new hippocampally-mediated synaptic connection between the MTL and neocortex is created. Since older memories are represented by stronger, or a greater number of, HC/MTL neocortical traces than are new memories, they are less susceptible to disruption from restricted lesions of the MTL. This produces the temporally graded memory loss that is observed.

Whereas each autobiographical memory trace is unique, the creation of multiple, related traces facilitates the extraction of the neocortically-mediated information common to them and that is shared with other episodes. This information is then integrated with pre-existing knowledge to form semantic memories that can exist independently of the HC/MTL. Thus, knowledge about the world, about people and about events acquired in the context of a specific episode is separated from the episode and ultimately stored independently of it. This process of increased semanticisation with experience and retrieval over time may give the impression of prolonged consolidation of the original trace. Without a well-functioning hippocampal system, acquisition of a semantic memory is slow and effortful, at least in adulthood.

According to MTT, only detailed episodic information, directly linked to the re-experiencing of an event, is mediated by the hippocampus. Generic, allocentric spatial information necessary for navigation, which Moscovitch and colleagues (2005) term schematic (semantic) spatial memory, is mediated initially by the hippocampus, but like other forms of semantic memory, can exist independently of it once the memory has been assimilated.

Challenges to the MTT model are also noted. A study investigating MTT against the standard consolidation model, by looking at the temporal nature of consolidation, concluded that the hippocampus did not substantially contribute to the recollection of remote memories after a period of a few years. In that study, Haist, Gore and Mao (2001) claimed that advances in functional magnetic resonance imaging have allowed them to improve the distinction between the hippocampus and entorhinal cortex. They concluded, based on their study using a famous faces recognition test, that the participation of the MTL in long-term declarative memory functions is time-limited and the entorhinal cortex may be centrally involved in memory consolidation lasting many years. They suggested that support for the MTT model derived in some previous studies was not reliable. For example, the accuracy of memories elicited during testing could not be or were not confirmed, and they point to obscuring of recent and remote memories in another key study that included an initial interview in a scanner.

In summary, MTT, as proposed by Moscovitch and colleagues, posits that important distinctions exist between different types of memories and the structures that mediate them and, importantly, that the retention and retrieval of autobiographical memories depend on the hippocampal system no matter how long ago they were acquired. By contrast, they claim that semantic memories are dependent on the hippocampus for consolidation for a limited time, before they are transferred to adjoining cortical regions and can be retrieved independently of the hippocampus. It is acknowledged, however, that some semantic memories may have an autobiographical content that continues to require the hippocampus. Similar distinctions are drawn regarding spatial memories that are experientially detailed (and hence, akin to episodic memory) and spatial memories that are more schematic in nature (akin to semantic memory) that are sufficient for navigating one's environment, and these are stored in the extra-hippocampal structures. In other words, the function of the hippocampus (and possibly that of related limbic structures) is to help encode, retain and retrieve experiences, no matter how long ago they occurred and no matter whether the memories are episodic or spatial.

These cognitive and neurocognitive approaches to understanding the varied components of memory have dominated the literature in clinical and cognitive psychology and have formed the bedrock of methods of assessing memory function. Even a cursory review of the extensive literature on memory

and memory assessment reveals that clinicians and researchers understand that no single test of memory can evaluate all relevant components. It is obvious, however, that traditional objective tests of memory have, for the most part, focused on the evaluation of retrospective memory (i.e. memory for past events) – and typically retrospective episodic memory.

As the preceding neurocognitive models of memory highlight, however, memory can be considered a broad system that encompasses many different categories of memory processes. Traditionally, these different types of memory processes have been delineated according to whether they are, for example, autobiographical, semantic, source, or context-associative in nature. These types of memory processes can be subsumed under an overarching framework of declarative (involving conscious processes) versus non-declarative (involving unconscious or reflexive-associative processes) memory.

Episodic memory refers to the ability to consciously remember our own experiences in a determined temporal and spatial context (Cansino, 2008). It is, therefore, a type of declarative, or explicit, memory. The term was coined by Endel Tulving in 1972 when he was referring to the distinction between knowing and remembering. As noted by Clayton, Salwiczek & Dickinson (2007), knowing is considered to be a factual (semantic) phenomenon, whereas remembering is considered a feeling that is located in the past (episodic). Episodic information can be retrieved either with or without the context information that took place when the episodic event was encoded (Cansino, 2008). Recollection is the main component process of episodic memory. Tulving defined three key properties of episodic memory recollection. These involve a subjective sense of time (involving the ability to mentally travel back in time to a previous experience), a connection to a sense of self and a phenomenon titled autonoetic consciousness. Autonoetic consciousness refers to a special kind of consciousness that accompanies the act of remembering that enables an individual to be aware of the self in a subjective time (Clayton, Salwiczek & Dickinson, 2007). Additional to these three seminal properties of episodic memory as defined by Tulving, other researchers have identified visual imagery (Rubin, Schrauf & Greenberg, 2003), retrieval of semantic information (Wheeler, Stuss & Tulving, 1997) and feelings of familiarity (Wagner, Shannon, Kahn & Buckner, 2005) as other important elements of episodic recollection.

Consistent with Tulving's view (Tulving, 2002) that all cognitive tasks are multiply determined, Hassabis and Maguire (2007) point out that different cognitive functions call on combinations of different component processes depending on the precise nature of the content and the goal to be achieved, with episodic memory at the apex of this group. Episodic memory recall, therefore, is a very complex cognitive function that can be divided conceptually into several distinct component processes (Conway & Pleydell-Pearce, 2000; Wheeler et al., 1997; Greenberg & Rubin, 2003). As a result, episodic memory appears to be more vulnerable than other memory systems (Tulving, 2002) to the effects of age and

damage due to lesions, since it relies on a wide range of underlying component processes across an extensive network of brain regions (Maguire, 2001; Svoboda, McKinnon, & Levine, 2006).

Central, however, to the formation of new episodic memories are the MTL, which includes the hippocampus, and the prefrontal cortex – in particular the right prefrontal cortex (Tulving, Kapur, Craik, Moscovitch & Houle, 1994). It is generally believed that the prefrontal cortex may draw on its role in executive function to help strategic processing of memories (Moscovitch, 1992), the temporal ordering of episodic memory (Petrides, 1989; Milner & Petrides, 1984), and the organisation of search strategies (Shallice, 1988). As previously mentioned, there is continued debate about how long episodic memories are stored in the hippocampus. The traditional view espoused by the standard consolidation model is that episodic memories are only dependent on the hippocampus for limited amount of time (e.g. Squire, 1987) after which the memories are consolidated to the neocortex, while the more recent MTT (e.g. Moscovitch et al., 2005) claims that episodic memories with an autobiographical aspect always rely on the hippocampus.

In any case, fMRI studies show an extensive overlap in the brain areas and networks activated during episodic recall and that engaged during other activities such as thinking about the future (e.g. Szpunar, Watson & McDermott, 2007), navigation (Burgess, Maguire & O'Keefe, 2002), theory of mind (perspectives taking) (Frith & Frith, 2003) and the "default network" (a network of interacting brain regions that is active when a person is not focused on the outside world) (Raiche et al., 2001). Hassabis and Maguire (2007), based on fMRI studies, have proposed that scene construction predominantly accounts for a good deal of the brain network consistently activated by episodic memory. Specifically, several temporal and parietal regions, as well as ventromedial prefrontal cortex, support the construction, maintenance and visualisation of a scene, including important roles for the hippocampus and the retrosplenial cortex and this is also a large part of the network consistently activated in episodic memory recall tasks (Maguire, 2001; Svoboda et al., 2006).

Semantic memory is the second type of declarative (explicit) memory proposed by Tulving (1972) to be distinct from episodic memory. While episodic memory is our memory of experiences and specific events that occur during our lives, semantic memory refers to general knowledge that we have gathered throughout our lives (McRae & Jones, 2013). Semantic memory is, reportedly, derived from accumulated episodic memory. It stores the "gist" of an experience. As such, both episodic and semantic memory each represent different parts of context to form a complete picture.

Although Tulving originally proposed that episodic and semantic memory were separate systems that competed in retrieval, contradictory evidence was offered by Howard and Kahana (2002) from their experiments on latent semantic analysis. These experiments showed that instead of an increase in

semantic similarity when there was a decrease in the strength of temporal associations, the two worked in tandem so that semantic cues on retrieval were strongest when episodic cues were strong as well (Howard & Kahana, 2002). Indeed, some argue that neural imaging makes it appear that episodic and semantic brain systems are distinct because of the activation of different mental processes during retrieval (Rajah & McIntosh, 2005).

Regarding the location of semantic memories, views differ on whether semantic memories are stored by the same brain systems involved in episodic memory. There is evidence to suggest that the hippocampus is involved in episodic memory and spatial cognition but not semantic memory. For example, studies of amnesiacs with damage to the hippocampus but some spared hippocampal cortex (entorhinal and perirhinal cortex) were cited in Vargha-Khadem et al. (1997) in which the amnesiacs were able to demonstrate some degree of intact semantic memory despite a total loss of episodic memory. This suggests that encoding of information leading to semantic memory does not have its physiological basis in the hippocampus (Vargha-Khadem et al., 1997).

Historically, semantic memory was believed to be widely distributed across all brain areas, but more recent evidence from neuropsychological and brain activity research suggests that semantic memory is localised mainly in the posterior region of the left temporal lobe, and that categories of knowledge may be represented in different but overlapping regions within this area (Saumier & Chertkow, 2002). This being the case, while findings from studies of various patient groups and functional neuroimaging in normal participants have consistently demonstrated a critical role of left prefrontal and temporoparietal regions in semantic cognition (Berthier, 2001; Devlin, Matthew & Rushworth, 2003; Thompson-Schill, D'Esposito, Aguirre & Farah, 1997), results from a study by Pobric and Hamilton (2006) supports the involvement of the bilateral anterior-temporal regions and the hypothesis that semantic cognition is actually supported by a three-region neural network consisting of the left prefrontal, temporoparietal and bilateral anterior-temporal regions. In that study, Pobric and Hamilton induced a temporary virtual lesion in healthy volunteers by low frequency repetitive transcranial magnetic stimulation (TMS) over left anterior temporal lobe. TMS is a non-invasive technique that generates magnetic pulses over the scalp, inducing electrical activation in a highly specific area of underlying cortex. A long train of low-frequency repetitive TMS temporarily suppresses neural processing and disrupts behavioural tasks that rely on this cortical region. Results from the study showed that repetitive TMS over the left anterior-temporal lobe significantly increased naming latencies for a specific-level naming task but not for number naming. Stimulating this region also significantly slowed synonym judgement times but not number quantity decisions, thereby illustrating a combination of impaired comprehension and naming that is selective in nature, as is similarly

observed in people with semantic dementia (Nestor, Freyer & Hodges, 2006; Lambon-Ralph et al., 2001).

It is recognised that there is a division of labour across the three afore-mentioned areas, such that core semantic representations are reliant on the anterior-temporal lobes, whereas semantic control, like other forms of executive control, is reliant on prefrontal–temporoparietal circuitry (Garavan, Ross, Li & Stern, 2000; Hermann et al., 1999; Peers et al., 2005). These two key interconnected processes support semantic cognition. Therefore, damage to the prefrontal-temporoparietal system, which controls the aspects of meaning that are relevant for the task at hand, can also result in multimodal comprehension deficits. Not surprisingly, individuals with semantic dementia show poor comprehension of items presented in every modality, including spoken and written words, pictures and environmental sounds, smells and touch (Bozeat, Lambon Ralph, Patterson, Garrard & Hodges, 2000; Coccia, Bartolini, Luzzi, Provinciali & Lambon Ralph, 2004; Luzzi et al., 2007) and poor performance in production tasks such as picture naming (Lambon-Ralph et al., 2001), verbal definitions (Lambon-Ralph, Patterson & Hodges, 1999), object drawing (Bozeat et al., 2003) and object use (Bozeat, Ralph, Patterson & Hodges, 2002).

Autobiographical memory is also a type of retrospective, declarative (explicit) memory system comprising episodes recalled from an individual's life, based on a combination of episodic (personal experiences and specific objects, people and events experienced at a particular time and place) and semantic (general knowledge and facts about the world) memory (Williams, Conway & Cohen, 2008). It has been proposed that autobiographical memory is constructed within a self-memory system (SMS) – a conceptual model composed of an autobiographical knowledge base and the working self. According to Conway (2005), the autobiographical knowledge base contains knowledge of the self, used to provide information on what the self is, what the self was, and what the self can be (Conway, 2005). Moreover, this information is categorised into three broad areas: lifetime periods (a distinguishable and themed time in an individual's life), general events (single representations of repeated events or a sequence of related events), and event-specific knowledge (vividly detailed information about individual events, often in the form of visual images and sensory-perceptual features) (Conway & Pleydell-Pearse, 2000).

Regarding event-specific knowledge, it has been noted that the high level of detail involved fades very quickly, though certain memories for specific events tend to endure longer (Pillemer, 2001). However, "originating events" (events that mark the beginning of a path towards long-term goals), "turning points" (events that re-direct plans from original goals) and "analogous events" (past events that direct behaviour in the present) are all event specific memories that are believed to resist memory decay (Pillemer, 2001). Incidentally, it is the sensory-perceptual details held in event-specific knowledge, that

are a key component in distinguishing memory of experienced events from imagined events (Johnson, Foley, Suengas & Raye, 1988).

According to Conway (2005), these three areas – lifetime events, general events, and event-specific knowledge – are organised in a hierarchy within the autobiographical knowledge base and together make up the overall life story of the individual. It is theorised that knowledge stored in lifetime periods contain cues for general events, and knowledge at the level of general events calls upon event-specific knowledge. Then, when a cue activates the autobiographical knowledge base hierarchy, all levels of knowledge become available and an autobiographical memory is formed (Conway & Pleydell-Pearce, 2000).

According to Conway (2005), autonoetic consciousness reflects the integration of parts of the autobiographical knowledge base and the working self. The working self is proposed to act as a central control mechanism, controlling access to the autobiographical knowledge base (Conway, 2005). It is believed to be a process akin to working memory, where it manipulates the cues used to activate the knowledge structure of the autobiographical knowledge base and, in this way, can control both the encoding and recalling of specific autobiographical memories (Conway, 2005). However, the relationship between the working self and the autobiographical knowledge base is a bidirectional one in that the autobiographical knowledge base is believed to contain the goals and self-images of the working self.

According to several authors, autobiographical recall involves a distributed network of brain regions that support a wide range of cognitive processes, such as memory storage, memory consolidation, memory search, autobiographical episodic counterfactual thinking, self-reference and goal-related processes (Cabeza & St.Jacques, 2007; Rubin, 2005; Svoboda et al., 2006). This highly interconnected core set of brain structures, known as the "default mode network" (DMN) involves, in most accounts, the nodes at the medial and lateral prefrontal cortex, the postero-medial parietal lobe (precuneus and retrosplenial cortices) and the cingular gyrus as well as medial temporal lobes (Cabeza & St.Jacques, 2007; Spreng & Grady, 2010).

Autobiographical memory may decline to an extent because of normal age-related changes as it depends on an interaction between retrieval of contextual details mediated by the hippocampus and cognitive control processes mediated by frontal regions - both regions and processes sensitive to age (Jacques, Rubin & Cabeza, 2012). An age-related decrease in contextual richness of autobiographical memory has also been observed, potentially due to impairment in strategic retrieval processes and poor recruitment of the hippocampus and ventrolateral prefrontal cortex (Jacques et al., 2012).

In AD, decreased performance on episodic autobiographical memory performance has been associated with anterior lateral temporal cortex and medial temporal lobe atrophy (Gilboa et al., 2005). This finding can be explained by the fact that the medial temporal lobes, especially the hippocampus, are preferentially targeted by the neuropathological processes underlying AD (e.g. Ball et al., 1985). There is also an increasing loss of episodic information in AD that leads to the de-contextualisation, semanticisation, or overgenerality of autobiographical memories, affecting both newly acquired and remote memories. This over generality of autobiographical memories in AD may be attributed to impairments in the DMN and hippocampus, as well as compensatory over-activation of the left prefrontal cortex during episodic retrieval (El Haj, Antoine, Nandrino & Kapogiannis, 2015). Tulving et al., (1994) had previously concluded from a review of PET studies that the left prefrontal cortex is differentially more involved in retrieval from semantic memory, thus increased activation of this area helps explain the increasing semanticisation of autobiographical memory in AD.

Source memory has been referred to as the recollection of the episodic source from which a specific item or fact was acquired (e.g. from a person, a book, or television, etc.) (Schacter, Kaszniak, Kihlstrom & Valdiserri, 1991). However, it can also also be viewed more broadly to include any aspect of context, whether perceptual, spatiotemporal, affective or social, that are present when an event occurred (Johnson, Hashtroudi & Lindsay, 1993). Source memory is contrasted with item or fact memory or with memory for the content of an experience and studies of hypnotic and organic amnesia indicates that source memory can be dissociated from item/fact memory (Schacter et al., 1991). Failures of source memory involves the retrieval of fragments of a memory without remembering how or when the fragment was acquired. In other words, the individual retains the semantic knowledge (facts) but cannot retrieve the episodic knowledge to indicate the context in which the knowledge was gained.

Since the way a memory is encoded depends on the way in which the memory was acquired (for example through reading, listening, etc) as well as on events coinciding with the memory (e.g. having a conversation, watching the television), the mental representations produced differ from one another in the brain. This makes it harder for retrieval where information was first learned when it is presented again in a different context (Mitchell & Johnson, 2000). Source amnesia occurs when we only encode content and do not integrate the context-specific information into memory (Glisky, Rubin & Davidson, 2001). It is not unusual for cognitively healthy individuals to experience this type of source amnesia daily, since it is usually more important, practically, for us to remember information rather than its source (Shimamura & Squire, 1987).

One can engage in source monitoring to help improve source memory. This refers to a systematic process of slow and deliberate thought of where information was originally learned and can include

conscious noting of relations between items or events and extended reasoning (Mitchell & Johnson, 2000). Theories on flashbulb memory suggest that context-specific information is better recalled in situations that involve emotionally-laden stimuli or words (Doerkson & Shimamura, 2001). The related phenomenon of misattributed familiarity is the failure to recall the correct source of where the information came from and instead attributing the information to a different, incorrect, source (Johnson, Hashtroudi & Lindsay, 1993).

Source amnesia appears to be more prevalent in elderly compared to younger individuals, with older individuals often misattributing the source of their knowledge, after both long- and short time delays (Schacter, Harbluk & McLachlen, 1984; McIntyre & Craik, 1987). This age-related decline in source memory is most likely a result of neuronal loss in the frontal lobes that accompanies normal aging (Haug et al., 1983). Accordingly, source memory impairments are disproportionately represented in patients with frontal-lobe lesions. Studies of source memory in amnesic patients have demonstrated that those patients who show deficits on tests of frontal-lobe function are more likely to exhibit impaired source memory performance (Schacter, Harbluk & McLachlan, 1984; Shimamura & Squire, 1987), whereas those without frontal impairment perform normally on source tasks, even when they show severe impairment on tests of fact memory. In general, individuals with frontal-lobe damage have difficulties with recency and other temporal judgements, such as placing events in the order in which they occurred (Shimamura, Janowsky & Squire, 1988) and this is believed to contribute to their inability to attribute memories or knowledge to the appropriate sources.

Brain activity underlying encoding and retrieval of source memory was explored using event-related fMRI by Cansino, Maquet, Dolan and Rugg (2002). They aimed to determine whether it was possible to identify neural activity at the time of the study that is associated with the encoding of contextual information using event-related fMRI to search for so-called "subsequent memory effects" in a source memory task. Results showed that the most prominent region manifesting a subsequent memory effect was the right lateral occipital cortex, a region overlapping an area that has been termed the "lateral occipital complex" (Malach et al., 1995; Grill-Spector, Kalanit, Kourtzi & Kanwisher, 2001). This area, in both hemispheres, is believed to play a role in the relatively early stages of object recognition. Thus, findings from Cansino and colleagues support the notion that objects (and their contexts) that engage perceptual processes to a relatively greater extent are more likely to be effectively encoded into episodic memory. Their findings were in alignment with previous work by other authors that found that the loci of subsequent memory effects for words varied according to the type of encoding tasks undertaken (semantic versus phonological) and, in each case, the effects were found primarily in a subset of the regions selectively engaged by the respective task (Otten & Rugg, 2001).

In contrast to some previous studies (Brewer, Zhao, Desmond, Glover & Gabrieli, 1998; Wagner et al., 1998; Kirchoff, Wagner, Maril & Stern, 2000; Otten, Henson & Rugg, 2001), there was, however, no evidence in Cansino et al's study for subsequent memory effects, either in the hippocampal formation or in the medial temporal cortex more generally. In the study, a number of brain regions were identified as having greater activity for accurate judgements of source. Several of these regions, especially the lateral parietal cortex and the left anterior prefrontal cortex, have been described in previous event-related studies of recognition memory (Rugg & Henson, 2002). The right hippocampal formation also demonstrated increased activity in association with successful source memory, like findings in a small number of other studies (Cabeza, Rao, Wagner, Mayer & Schacter, 2001; Donaldson, Petersen & Buckner, 2001; Eldridge, Knowlton, Furmanski, Bookheimer & Engel, 2000; Maratos, Dolan, Morris, Henson & Rugg, 2001). Another region demonstrating greater activity in association with correct source judgements in the study by Cansino and colleagues was the anterior medial frontal cortex (BA10/32).

Not surprisingly, frontal-lobe degeneration in AD typically leads to impaired source memory. For example, one laboratory-based study found that participants with AD were correctly performing source memory attributions at approximately chance levels (Dalla Barba, Needjam & Dubois, 1999). It has also been proposed by Johnson & Raye (1981) that the lack of ability to attribute correct source to memory by individuals with AD is due to deterioration in reality monitoring ability that occurs with AD. Reality monitoring refers to the process of distinguishing whether information came from an external or internal source and it involves judgement as to whether information is real or imagined (Johnson & Raye, 1981). Difficulty with reality monitoring is also believed to underlie the mild confabulation seen in some individuals with AD.

As noted by Smith (1994), memory is said to be context-associative or context-dependent when remembering is affected by contextual cues. Context-dependent memory implies that when events are represented in memory, contextual information is stored along with the memory and that the context can, therefore, cue memories containing that contextual information. Context, thus, refers to that which surrounds a target memory, whether spatial, temporal or meaningful in nature (Smith, 1994). Smith (1994) also makes a distinction between incidental context and meaningful context. Incidental context refers to spatial and temporal contexts that are not obviously related to a target memory. Unlike the relatively sparse literature on incidental context, a vast literature exists on meaningful contexts, encompassing the contribution of principles such as encoding specificity (e.g. Tulving & Thomson, 1973), depth and spread of processing (e.g. Craik & Tulving, 1975) and representational structures such as scripts (e.g. Shank & Abelson, 1977), schemata (e.g. Thorndyke, 1977) or mental models (e.g. Glenberg, Meyer & Lindem, 1987).

Research demonstrates improved recall for information that is both encoded and retrieved in the same cognitive state (Baddeley, Eyesenck & Anderson, 2009). Context-dependent forgetting refers to the phenomenon wherein individuals have more difficulty accessing memories when the environment differs from encoding to retrieval than if the two environments were the same (Chu, Handley & Cooper, 2003). This context-dependent forgetting is demonstrated and overcome in several ways.

In experimental research studies, incidental context-dependent memory is typically assessed via reinstatement context (Smith & Vela, 2001). Specifically, memory testing is organised to occur either in the context in which target events were experienced, or in another context. If events are remembered better when the original context is reinstated, this provides evidence of contextual cueing. Of note, however, is that the incidental environmental contexts do not always need to be physically reinstated; a few studies show that participants who have been tested in a different context to the learning context, but who are instructed to imagine the learning context, recall as much as those who are physically returned to the original learning context (Smith, 1979). The effectiveness of this context recall technique has led to its use as a recall aid in situations requiring eyewitness memory (e.g. Malpass & Devine, 1981).

Another phenomenon influencing the success of context-dependent memory is referred to as cue overload theory. This states that the effectiveness of an environmental cue will decline when there is an increase in the number of items associated with the cue (Watkins & Watkins, 1976). It follows then that increasing the number of environmental cues will increase an individual's recall performance (Smith, 1984). Attention and conscious effort at the encoding phase have also been shown to be crucial for overcoming context-dependent forgetting (Chu et al., 2003). Other research indicates that changes in motivational state between encoding and retrieval may also affect recall. For example, Woike, Benders and Besner (2009) tested the effect of motivational contextual cues on recall of specific word pairs and found that associating word pairs with achievement cues produced a motivational context that increased memory for these word pairs compared to neutral cues that were used as a control. A related type of context-dependent memory is mood-dependent or mood-congruent memory. It is suggested that this phenomenon occurs because a person's mood at any given time has a strong influence on which aspects of their environment seems most salient, affecting what they remember about the past as well as what they encode about the present (Lewis & Critchley, 2003).

A few neuroanatomical structures are thought to play a role in context-dependent memory, including the hippocampus and prefrontal cortex (Maren, Phan & Liberzon, 2013). Evidence for a meditational role of the hippocampus in context-dependent memory processes is provided by imaging studies (Davachi, 2006; Diana, Yonelias & Raganath, 2007). It has also been demonstrated that activation of

the right prefrontal cortex depends on contextual information (Wagner, Desmond, Glover & Gabrieli, 1998). These researchers also reported that, depending on the retrieval context, participants use different strategies to recall information, based on imaging evidence illustrating differential activation of the prefrontal cortex in response to different contexts.

These classical or traditional delineations of memory are well accounted for in the literature. In the past two decades or so, however, the distinction between retrospective and prospective memory (RM and PM) has received growing attention, both in cognitive and in clinical psychology (e.g. Maylor, 1993; Burgess & Shallice, 1997, Carlesimo & Costa, 2011). RM refers to the ability to remember information from the past. For this, it relies on different memory systems and processes, for example implicit or explicit, semantic or episodic, depending on the information to be recalled (Squire, 2004). RM can be understood through any of the models outlined above (Atkinson & Shiffrin, 1968; Craik & Lockhart, 1972; Baddeley & Hitch, 1974; McClelland & Rummelhart, 1988; Rummelhart, McClelland & PDP Research Group, 1986; Rummelhart & McClelland, 1986). In terms of underlying brain structure, the processes involved in RM rely largely on the medial temporal lobe and its connection to the frontal lobe (Squire & Zola-Morgan, 1991; Dove, Brett, Cusack & Owen, 2006; De Haan, Mishkin, Baldeweg, & Vargha-Khadem, 2006).

In contrast, PM refers to remembering to carry out previously formed intentions at the correct time in the future (Brandimonte, Einstein and McDaniel, 2014). It is considered a multifactorial, complex construct of memory, since remembering to do something in the future has been shown to place greater demands on frontal/executive functions than does thinking about the past (Weiler, Suchan, Koch, Schwarz, & Daum, 2011). Increased effort is believed to be required at both the encoding and retrieval stages of PM in comparison to RM (Einstein, Smith, McDaniel & Shaw, 1997).

PM also contains a RM component, since it is not only important to remember you had something to do, but it is also necessary to remember the content of the intention or task (see, for example, Burke et al, 2010; Clune-Ryberg et al, 2011). Accordingly, PM and RM appear to involve similar neural structures, relying on both medial temporal-lobe and frontal/central-executive functions (Ferbinteau & Shapiro, 2003; West & Krompinger, 2005). There is, however, also evidence from laboratory and brain injury research to support the distinctiveness and dissociation of the two types of memory. For example, Kvavilashvili (1987) demonstrated that people's ability to perform a PM task was unrelated to their ability to do an associated RM task. Using patients with damage to the temporal-lobe (largely involved in supporting RM) and patients with damage to the frontal-lobe (widely implicated in PM), Burgess and Shallice (1997) demonstrated a double-dissociation. Moreover, electrophysiological evidence supports the hypothesis of PM and RM as related, but dissociable, neuropsychological

components of memory (West et al., 2000). Given this evidence, it can be argued that both RM and PM should be investigated when seeking to establish the integrity of memory systems.

As with RM, there are numerous taxonomies of PM. Einstein and McDaniel (1996) suggested that PM tasks could be conceived of as time-based or event-based tasks depending upon whether the cue for task completion is a particular time or is in association with an event. However, Meacham and Leiman (1975) divided PM tasks into habitual and episodic tasks. Habitual tasks are routine tasks such as remembering to dress in the morning before leaving the house, or to lock the front door at night, while episodic tasks are less frequent tasks, such as remembering to pass on a message to a colleague at work. PM has also been viewed through the lens of simple tasks and compound tasks, wherein the cue for simple tasks occurs in the context of an ongoing activity and the cues for compound tasks must be monitored for in the environment, outside the ongoing activity (Harris, 1984). Similar to a short-term vs. long-term memory perspective, Ellis (1988) divided PM tasks into pulses and steps. Pulses refer to PM activities that must be completed at a particular time, whereas steps are those that must be completed within a much broader time frame.

Craik's hierarchy of memory tasks (Craik, 1986) was intended to be of use when seeking to understand the different effects of normal aging across studies. PM tasks were placed at the top of the hierarchy since they are low in environmental support and require a high degree of self-initiated activity. Below the PM tasks in the hierarchy come RM tasks of free recall, cued recall, recognition, and priming, in descending order of age-related deficits. However, while the complexity of PM in relation to RM is acknowledged, it should be noted that not all PM tasks are necessarily low in environmental support and high in self-initiated activity, and, like RM tasks, PM tasks may vary in the salience of contextual cues available and the extent to which associative or automatic processes are involved in successful remembering (Lee & McDaniel 2103; Scullin, McDaniel & Shelton, 2013).

PM deficits are not only potential markers of insipient memory disorder due to a dementia, but are also a relatively frequent feature in various neurological populations, such as individuals who have suffered traumatic brain injury (Carlesimo, Casadio & Caltagirone, 2004; Groot, Wilson, Evans & Watson, 2002; Henry, Rendell, Kliegel & Altgassen, 2007), individuals with Parkinson's disease without dementia (Katai, Maruyama, Hashimoto, & Ikeda, 2003; Kliegel, Phillips, Lemke & Kopp, 2005), epilepsy (Adda, Castro, de Silva, de Manreza, & Kashiara, 2008), thalamic stroke (Carlesimo, Lombardi & Caltagirone , 2011), and focal lesions involving the prefrontal cortex (Burgess, 2000). The unknown etiology of subjective cognitive complaints and subtle objective cognitive problems that may present in a primary care context speaks to the importance of taking into account the possibility of a wide range of underlying causes of impaired PM ability.

In terms of broader assessment, it is valuable and important, for a number of reasons, to include an assessment of PM. Firstly, PM can be considered a complex cognitive construct that draws on a wide range of cognitive functions and implicates a number of brain areas. Specifically, since PM involves remembering the content of an intention and its successful implementation, it requires retrospective episodic and declarative memory, as well as supervisory executive functions (Martin et al., 2007). Structures of the limbic system, namely the hippocampus, parahippocampal region, thalamus, and anterior and posterior cingulate, are involved in PM. The hippocampus is activated in both time-based and event -based tasks and is said to be responsible for searching for the prospective intention among other memories (Martin et al., 2007). As noted by Adda et al. (2008), the left hippocampus in particular appears to be crucial in PM performance. The parahippocampal gyrus, which surrounds the hippocampus, facilitates the passing of sensory information from the cortical areas to the hippocampus (Dickerson & Eichenbaum, 2010) and potentially plays a role in recognising cues that trigger the performance of intended actions (Kondo et al., 2010). The thalamus, which relays sensory information among cortical areas of the brain, is also activated when PM cues are presented and acted upon (Burgess, Scott & Frith, 2003). It is believed to help maintain intentions and execute intentions only at the appropriate time (Burgess, Quayle & Frith, 2001). The cingulate, which relays information between the hippocampus and cortical areas (Andreasen et al., 1995), is also involved in PM. Specifically, the anterior and posterior cingulate are involved in planning and creating intentions and lesions in the left cingulate lead to failing to recall intentions, especially after a delay (Burgess, Veitch, de la Costello, & Shallice, 2000).

The parietal lobe is also engaged in PM through the process of recognising cues that trigger an intended action, especially cues that are visual or spatial (Martin et al., 2007; Burgess, Quayle & Frith, 2001). The parietal lobe also maintains attention on the intended tasks and inhibits other potentially interfering activities (Kondo et al., 2010). Furthermore, neural areas ranging from the inferior parietal cortex to the frontal gyri are involved in the monitoring of time during time-based PM tasks (Harrington, Haaland & Knight, 1998). Moreover, it is generally believed that PM is more effortful and requires a greater degree of self-initiated retrieval operations compared with RM tasks, since successful PM requires executive processes such as inhibition of an ongoing task and switching to an ongoing action (Einstein & McDaniel, 1996). At the same time, it is acknowledged that the involvement of the executive function system is not always necessary for the successful performance of PM tasks. Indeed, depending on the conditions, retrieval of the prospective intention in an event-based PM task may be underpinned by different cognitive processes that may be either reflexive-associative or cue-focused. Either or both the prospective component and the retrospective component of PM can be impaired in MCI. Declarative memory dysfunction may account for the RM impairment, while either reduced executive abilities or a

deficit of reflexive mechanisms could explain the prospective component impairment (Costa, Caltagirone & Carlesimo, 2011).

Because of the generally greater cognitive effort required and the wide range of cognitive processes implicated in successful performance of PM tasks, it is particularly vulnerable to disruption in the case of impairment in any one of the cognitive processes it encompasses and is, therefore, a sensitive marker of cognitive decline. Support for this comes from a number of studies documenting that PM is impaired in dementia of the Alzheimer's type (Huppert, Johnson & Nickson, 2000; Maylor, Smith, Della Sala & Logie, 2002), as well as amnestic MCI (Kazui et al., 2005; Troyer & Murphy, 2007; Karantzoulis, Troyer & Rich, 2009; Costa et al., 2010; Thompson, Henry, Rendell, Withall & Brodaty, 2010) and non-amnestic MCI (Costa, Caltigirone & Carlesimo, 2011b; Schmitter-Edgecombe, Woo & Grealey, 2009; Thompson et al., 2010). Indeed, there is evidence to suggest that PM tasks, owing to a greater demand on self-initiated retrieval operations relative to RM tasks (Einstein & McDaniel, 1996) and requiring the monitoring of the environment to identify the cue that signals the initiation of the action, may provide discriminatory efficacy for detecting MCI above and beyond that provided by traditional RM tasks (Blanco-Campal, Coen, Lawlor, Walsh & Burke, 2009). Of note is longitudinal evidence from the Betula cohort study in Sweden that showed that self-reported PM failures, as measured with the Prospective and retrospective Memory Questionnaire (PRMQ: Smith, Maylor, Della Sala & Logie, 2000) were significantly associated with later cognitive impairment and dementia (Ronnlund, Sundstrom, Adolfsson & Nilsson, 2015).

PM failures deserve special attention for other reasons also. PM failures are shown to be common or frequent in occurrence, even among healthy community-dwelling older adults (e.g. Dobbs & Rule, 1987). Indeed, PM deficits have been found to be associated with self-rated memory problems even more frequently than RM disorders (Kinsella et al., 1996). It can be argued that the salience of PM failures to older individuals is increased not only because of their experienced frequency, but also by the potentially important consequences such failures may have for the personal safety and independence of older individuals. Indeed, even when PM failures in everyday life occur in the context of unimpaired intellect and seemingly intact RM and problem-solving skills, they usually do so in the context of a specific problem with behavioural organisation of which PM problems are one symptom.

Related to this, PM is particularly crucial to the process of multi-tasking, since multi-tasking often requires delayed intentions: the times for returns to task are not signalled directly by the situation (Burgess, 2000a,b). Indeed, Burgess and colleagues (2007) argue that the most common example of a PM in action in everyday life is the dovetailing of one's activities and that, without this ability, one's behaviour would be very inefficient. With impaired PM, one would always need to finish one task

before starting another and activities that involve the integration of many sub goals, such as visiting a number of different shops during one shopping trip, would be performed very inefficiently. Accordingly, individuals displaying what is described as a "strategy application disorder" exhibit a pattern of problems that manifest themselves most in real-life complex situations that require the organisation and structuring of goal-related behaviour in situations with few external constraints, such as shopping and other situations requiring multitasking (Shallice & Burgess, 1991).

Burgess (2000) points out that for some of these cases of strategy application disorder studied, the most obvious feature is a failure of PM that shows itself as an "*inability to follow time constraints, to meet deadlines or keep appointments*." Crucially, these individuals displaying problems with behavioural organisation may show their deficits in the context of unimpaired intellect, and intact RM, language, visuospatial abilities, as well as in the context of normal performance on a wide range of objective executive tests known to be sensitive to frontal-lobe damage (Shallice & Burgess, 1991; Goldstein, Bernard, Fenwick, Burgess & McNeil, 1993; Duncan, Burgess & Emslie, 1995; Eslinger & Damasio, 1985).

An explanation offered to account for this discrepancy is that popular executive function tests implicate regions of the brain not directly implicated in some of the core components of multitasking. Specifically, Burgess (2000a;b) concluded from neuroimaging evidence that the frontal-lobe regions most often implicated in performance of the Wisconsin Card Sorting Task (WCST) are either more posterior or inferior than those identified as functional in multitasking. Similarly, the frontal regions implicated in verbal fluency performance include Broadman areas 6, 11, 44 and 46 of the left hemisphere (e.g. Warburton et al., 1998; Phelps, Hyder, Blamire & Shulman, 1997) but not area 10, known to be implicated in PM (Yamadori et al., 1997; Burgess, Quayle & Frith, 2001). These findings would suggest that not only is it important to assess for PM impairments, but it is necessary to do so with a test purposively designed for the evaluation of PM ability.

Of course, while impaired episodic memory is the main symptom of amnestic-type MCI and may represent a potential prodromal phase of Alzheimer's disease (Grundman et al., 2004), non-amnestic MCI involves impairment(s) in one or more other cognitive domains (Petersen, 2004) and such deficits may predict the future development of other non-AD dementias. Deficits in cognitive domains other than RM or PM, such as language, visuo-spatial ability and executive functions, are present to varying degrees in all dementias. For example, language deficits are frequent in dementia subtypes and manifestations include word-finding problems (anomia), sentence completion deficits and lack of cohesion in discourse (Kempler & Goral, 2008). Problems with sentence level processing are also observed across different types of dementia – AD, VaD, DLB and FTD and are believed to be a result of

impairments in executive functions and memory. While speech itself may appear fluent and grammatically correct in SD (Rochon, Kave, Cupit, Jokel & Winocur, 2004), the speech errors of those with PNFA are more likely to be phonological (relating to sound) than semantic paraphasias (George & Mathuranath, 2005) and impairment is typically seen in tasks that involve word production (Rogers et al., 2006). Hence, conversation is impaired in PNFA and there is often omission of information (Ash et al., 2006). In the early stages of PD-D, receptive type aphasia may be present and in advanced PD-D, core language functions are largely preserved, although word finding difficulties and impaired comprehension of complex sentences may be present (Emre et al., 2007).

Visuospatial abilities are also affected in the dementia subtypes (including the early stages of AD) and can be manifested by individuals getting lost in familiar environments and forgetting where they placed personal items (Karantzoulis & Galvin, 2001). Visuospatial difficulties are also a common impairment in DLB (Morris & Galvin, 2005) and these tend to be present early in the disease course and are apparent on visuospatial tasks with or without motor speed components (Gorno-Tempini et al., 2008). Notably, in contrast to individuals with AD and DLB, those with bvFTD, owing to spared occipito-parietal-cortical regions, tend to perform rather well on tests of visuospatial skills, although amotivational performance and perseverative drawing in bvFTD have been observed (Looi & Sachdev, 1999). Although the symptoms of VaD vary depending on the nature and location of the underlying pathology, visuospatial deficits are also observed in VaD such as subcortical vascular dementia (Graham, Emery & Hodges, 2004).

Regarding executive functions, including attention, the degree of early impairments may differ according to underlying dementia subtype. Some studies have found that executive functions are relatively preserved in the early stages of AD (Razani, Boone, Miller, Lee & Sherman, 2001), whereas others suggest this domain is impaired to the same extent or more than are other cognitive domains (Baudic et al., 2006; Crowell, Luis, Vanderploeg, Schinka & Mullan, 2002). Howver, as AD progresses, impairments in executive functions become more obvious, with changes in abstract reasoning, concentration, calculation and sustained visual attention, the most commonly observed deficits, progressing to deficits in judgement, planning and difficulty completing tasks. Individuals with bvFTD develop impairments in executive function abilities that, over time, come to resemble those seen in AD (Von Gunten, Giannakopoulos & Duc, 2005). Attentional and executive function impairments are core deficits in DLB and attentional disturbance is believed to likely underlie the fluctuating cognition that is a hallmark of DLB, and which leads to difficulties with sustained engagement in a task and switching between tasks (Karantzoulis & Galvin, 2011). Varying degrees of executive dysfunction are also present in VaD. For example, subcortical VaD is characterised by primary deficits in executive functions and

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speed of information processing, with secondary deficits in episodic memory (Villardita, 1993; Kertesz & Clydesdale, 1994; Looi & Sachdev, 1999).

The brief overview of cognitive deficits in dementia presented above highlights the importance of assessing these other non-memory domains. While time and resource restraints in the Primary Care setting do not permit full comprehensive neuropsychological assessment, these cognitive functions are currently already assessed to various extents in brief cognitive assessments recommended for, or popular in, Primary Care. For example, of the brief cognitive measures recommended for use by the Irish College of General Practitioners (ICGP) (Foley & Swanwick, 2014), most of these tests include an assessment of domains other than memory. For example, the Mini Mental State Exam (MMSE: Folstein, Folstein, & McHugh, 1975) measures orientation, attention and calculation, various aspects of language and visuospatial skills as well as immediate memory and recall. The GPCOG (Brodaty, Pond, Kemp, Luscombe, Harding, Berman *et al.*, 2002) assesses, alongside RM, time orientation and construction/visuospatial skills and executive functions via the Clock Drawing Test. Similar to the GPCOG, the Mini-Cog (Borson, Scanlan, Brush, Vitaliano & Dokmak, 2000; Borson, Scanlan, Watanabe, Tu & Lessig, 2006) includes a clock drawing test as well as a test of short-term memory. The Abbreviated Mental Test Score (AMTS: Hodkinson, 1972) uses verbal items to assess orientation, alongside recognition and short-term and long-term memory. The Six-item Cognitive Impairment Tool (6CIT: Brooke & Bullock, 1999; Katzman, Brown, Fuld, Peck, Schechter & Schimmel, 1983) assesses orientation, attention/concentration as well as short-term memory. The Quick Mild Cognitive Impairment Screen (Q-mci) places most emphasis on verbal fluency and episodic memory.

Similar to the ICGP, the Medicare expert group that derived the Annual Wellness Visit Algorithm for Assessment of Cognition (Cordell et al., 2013) also recommends use of the GPCOG, Mini-Cog and/or Memory Impairment Screen (MIS: Buschke, et al., 1999; Kuslansky, et al., 2002) as key brief cognitive assessment tools and it also indicates the use of the MMSE, Montreal Cognitive Assessment (MoCA: Nasreddine, Phillips, Bédirian, Charbonneau, Whitehead, Collin et al. 2005) and St. Louis University Mental Status Exam (SLUMS: Tariq, Tumosa, Chibnall, Perry 3rd & Morley, 2006) as potential alternatives. The MoCA authors state that the measure assesses attention and concentration, executive functions, language, visuo-constructional skills, conceptual thinking, calculation and orientation, in addition to memory. The SLUMS assesses not only memory, but also executive functions, orientation and memory.

Although the assessment of non-memory cognitive processes in these tests are admittedly brief, the inclusion of items pertaining to those cognitive functions speaks to the existing recognition amongst professionals of their importance for the cognitive health and everyday functioning of older adults.

Significantly, however, none of the recommendations for comprehensive assessment of mild forms of cognitive impairment in primary care or other clinical settings acknowledge the need to assess subjective or objective PM ability. Moreover, none of the currently available or recommended brief cognitive assessment tools contain items testing PM. Therefore, while it is important for primary care professionals to remain cognisant of the need to asses for a wide range of cognitive functions, apart from memory more generally, the glaring absence of attention across clinical settings to the assessment of PM function relative to these other cognitive processes in older adults is concerning. Like deficits in other cognitive functions, problems with PM may reflect a range of underlying issues or conditions, but PM deficits may also be sensitive indicators of subtle or mild cognitive impairment as well as future dementia. Moreover, even if PM problems have an underlying reversable cause, their detection and treatment, where applicable, is paramount, given the accumulated evidence of their impact of older adults' independent functioning in daily life.

2.4 Assessment of Memory and Other Cognitive Functions:

Typically, memory can be assessed using either objective or subjective memory assessment tools and the nature and extent of the memory assessment will reflect the purpose for which the assessment is being undertaken. An overview of measures typically used for brief objective assessment of memory is now provided, followed by an overview of subjective methods of memory assessment.

2.4.1 Brief Screening Tools: Assessment of Objective Performance

Objective assessment of cognitive and memory impairment in Primary Care generally involves the administration of a cognitive screening tool. These screening tools need to be brief enough for use within a typical 10-15-minute consultation. They must also be acceptable to both GPs and to patients, and they must display good psychometric properties. They should also be easy to administer, to score and to interpret and they should be relatively unaffected by sociodemographic factors (Iatraki et al., 2017).

At this point, the literature in relation to the best cognitive screening tool(s) to use in primary care is controversial and although a number of recommendations exist for test selection (e.g. those issued by the Alzheimer's Association (USA) (Cordell et al., 2013) to help healthcare professionals to meet the requirements of the Annual Wellness Visit (AWV), a new Medicare benefit introduced in the US in 2011, under the Patient Protection and Affordable Care Act (PPACA) and the Irish College of General Practitioners (Foley & Swanwick, 2014), no widely accepted set of recommendations have been adopted.

The AWV requires primary care physicians to undertake an annual assessment to detect cognitive impairment in older adults. More specifically, as noted by Cordell et al (2013), the AWV requires physicians to detect cognitive impairment by:

> assessment of an individual's cognitive function by direct observation, with due consideration of information obtained by way of patient report, concerns raised by family members, friends, caretakers, or others [PPACA, 2010] .

In order to offer guidance to these physicians in relation to the cognitive assessment component of the AWV (in the absence of guidance from the Centers for Medicare and Medicaid Services (CMS), and to help advise physicians on the issue of when onward referral, or further testing, is required, the Alzheimer's Association (USA) convened an expert group (the Medicare Detection of Cognitive Impairment Workgroup) to develop recommendations.

As reported by the expert group, the Alzheimer's Association was motivated by the fact that the CMS choose not to make recommendations to healthcare providers as they recognised that there was, at that time, no nationally recognised best-practice screening tool for the detection of cognitive impairments (Cordell et al., 2013). The Alzheimer's Association was, however, concerned that, without guidance, healthcare providers would, individually, have to determine how they should *"detect cognitive impairment"*.

This group reached early agreement on the general principles guiding the development of recommendations regarding cognitive assessment and the principles specific to the AWV. Because of their relevance to this thesis, these principles are identified below in Table 2.1.

To help identify candidate screening tools to recommend for use in primary care, the workgroup set out to determine whether there was, within the literature, a consensus regarding brief cognitive assessment during time-limited primary care visits (evidence of consensus; Cordell et al., 2013; pg. 142). To this end, the workgroup focused initially on systematic evidence review (SER) studies published since 2000, identifying four such reviews (Lorentz, Scanlan & Borson, 2002; Brodaty, Low, Gibson & Burns, 2006; Holsinger, Deveau, Boustani & Williams, 2007; and Milne, Woolford, Mason & Hatzidimitriadou, 2008). As noted by Cordell et al. (2013), each of these review studies had a similar objective - to determine which tools were best for use during primary care visit - but they differed in terms of the criteria employed to select the assessment tools.

Table 2.1: Medicare Detection of Cognitive Impairment Workgroup: Guiding Principles for Recommendations (Cordell et al., 2013)

General Principles
- Detection of cognitive impairment is a stepwise, iterative process.
- Informal observation alone by a physician is not sufficient (i.e., observation without a specific cognitive evaluation).
- Detection of cognitive impairment can be enhanced by specifically asking about changes in memory, language, and the ability to complete routine tasks.
- Although no single tool is recognized as the "gold standard" for detection of cognitive impairment, an initial structured assessment should provide either a baseline for cognitive surveillance or a trigger for further evaluation.
- Clinical staff can offer valuable observations of cognitive and functional changes in patients who are seen over time.
- Counseling before and after cognitive assessment is an essential component of any cognitive evaluation.
- Informants (family member, caregiver, etc.) can provide valuable information about the presence of a change in cognition.

Principles Specific to the Annual Wellness Visit (AWV)
- The AWV requires the completion of a Health Risk Assessment (HRA) by the patient either before or during the visit. The HRA should be reviewed for any reported signs and symptoms indicative of possible dementia.
- The AWV will likely occur in a primary care setting. Tools for initial cognitive assessments should be brief (<5 min) appropriately validated, easily administered by non-physician clinical staff, and available free of charge for use in a clinical setting.
- If further evaluation is indicated based on the results of the AWV, a more detailed evaluation of cognition should be scheduled for a follow-up visit in primary care or through referral to a specialist.

The workgroup also identified two other literature review studies that provided evidence related to primary care use and performance characteristics (psychometric properties) of brief assessments of cognition – that of Ismail, Rajji, and Shulman (2010) and that of Kansagara and Freeman (2010). The Kansagara and Freeman (2010) review was, however, designed not to identify the best measures to use for detection of cognitive impairment but, rather, to identify alternatives to the MMSE now that it was a copyrighted instrument (copyright held by Psychological Assessment Resources, Inc.) with an associated fee for use. Of the five reviews that focused on identifying the most suitable (or most often used) brief cognitive assessment tools for use in primary care settings, a wide range of assessment tools were evaluated. These brief assessment tools, together with identified advantages and limitations are identified in Table 2.2 below.

Table 2.2 Test: Brief cognitive assessment tools evaluated in multiple reviews - Key advantages and limitations (adapted from Cordell et al., 2013).

Test	Reference	Time (mins)	Advantages	Disadvantages
7-Minute Screener	Solomon & Pendlebury (1998)	7–12	• Little or no education bias • Validated in primary care	• Difficult to administer • Complex logarithmic scoring
AMT – Abbreviated Mental Test	Hodkinson, (1972)	5–7	• Easy to administer • Verbal memory test (no writing/drawing)	• Education/language/culture bias • Limited use in US (mostly used in Europe) • Does not test executive function or visuospatial skills
CAMCOG - Cambridge Cognitive Examination	Roth, Huppert, Tym & Mountjoy (1988)	20	• Tests many separate domains (7)	• Difficult to administer • Long administration time
CDT – Clock Drawing Test	Shulman (2000)	≤1	• Very brief administration time • Minimal education bias	• Lacks standards for administration and scoring
GPCOG - General Practitioner Assessment of Cognition Patient Informant	Brodaty et al. (2002)	2-5 1-3	• Developed for and validated in primary care • Informant component useful when initial complaint is informant-based • Developed for and validated in primary care • Informant component useful when initial complaint is informant-based • Little or no education bias • Available in multiple languages	• Patient component scoring has an indeterminate range that requires an informant score to assess as pass or fail • Informant component alone has low specificity • Lacks data on any language/culture biases
Mini-Cog – Mini Cognitive Assessment Tool	Borson, Scanlan, Brush, Vitaliano & Dokmak (2000); Borson, Scanlan, Watanabe, Tu & Lessig (2006)	2-4	• Developed for and validated in primary care and multiple languages/cultures • Little or no education/language/race bias • Short administration time	• Use of different word lists may affect failure rates • Some study results based on longer tests with the Mini-Cog elements reviewed independently
MIS – Memory Impairment Screen	Buschke, *et al. (1999)*; Kuslansky, et al., (2002)	4	• Verbal memory test (no writing/drawing) / little or no education bias	• Does not test executive function or visuospatial skills
MMSE - Mini-Mental State Examination	Folstein, Folstein, & McHugh (1975)	7-10	• Most widely used and studied worldwide • Often used as reference for comparative evaluations of other assessments • Required for some drug insurance reimbursements	• Education/age/language/culture bias • Ceiling effect (highly educated impaired subjects pass) • Proprietary—unless used from memory, test needs to be purchased at www.parinc.com • Best performance for at least moderate cognitive impairment
MoCA – Montreal Cognitive Assessment	Nasreddine *et al. (2005)*	10–15	• Designed to test for mild cognitive impairment	• Lacks studies in general practice settings • Education bias (≤12 years)

Test	Reference	Time (mins)	Advantages	Disadvantages
			• Multiple languages accessible at www.mocatest.org • Tests many separate domains (7)	• Limited use and evidence due to published data relatively new (2005) • Admin time ≥10 min
RUDAS - Rowland Universal Dementia Assessment;	Storey, Rowland, Basic, Conforti & Dickson (2004)	10	• Designed for multicultural populations • Little or no education/language bias	• Validated in Australian community • Limited use and evidence due to published data relatively new (2004)
SAS-SI - Short and Sweet Screening Instrument;	Belle, Mendelsohn, Seaberg & Ratcliff (2000)	10	• Detected dementia better than neuropsychologic testing in a community population	• Does not test memory • Lacks data on any education/language/culture biases
SBT - Short Blessed Test (**BOMC** - 6-item Blessed Orientation-Memory-Concentration Test; and **6-CIT** - 6-Item Cognitive Impairment Test)	Katzman et al. (1983); Brooke & Bullock (1999)	4-6	• Verbal test (no writing/drawing)	• Education/language/cultural/race bias • Scoring can be cumbersome • Does not test executive function
SLUMS - St Louis University Mental Status	Tariq, Tumosa, Chibnall, Perry 3rd & Morley (2006)	7	• No education bias • Tests many separate domains (7) • Available at: http://aging.slu.edu/pdfsurveys/mentalstatus.pdf	• Limited use and evidence due to published data relatively new (2006) • Studied in VA geriatric clinic (predominantly white males)
SPMSQ - Short Portable Mental Status Questionnaire;	Pfeiffer (1975)	3-4	• Verbal test (no writing/drawing)	• Scoring can be cumbersome • Does not test short-term memory
STMS - Short Test of Mental Status	Kokmen, Naessens & Offord (1987)	5	• Validated in primary care • Tests many separate domains (7)	• Education/language/race bias • Studied in relatively educated subjects, may not be applicable to general population
T&C - Time and Change Test.	Inouye, Robison, Froehlich & Richardson (1998)	≤1	• Very brief administration time • Little or no education bias	• Strong language/cultural bias

Despite review of many tests, there was clear evidence of a consensus in terms of the best measures for use in primary care. All selected the Memory Impairment Screen (MIS) as most suited or suited, and four selected the GPCOG and Mini-Cog as most suited (Lorentz et al., 2002; Brodaty et al., 2006; Milne et al., 2008; Ismail et al., 2010).

Among the reasons identified by the review study authors, and by the Medicare Detection of Cognitive Impairment Workgroup, for selection of these specific tests for use in primary care were the fact that:

- The test requires 5 minutes or less to administer.
- The test is validated in a primary care or community setting.
- The test is easily administered by medical staff members who are not physicians.
- The test has good to excellent psychometric properties.
- The test is relatively free from educational, language, and/or culture bias.
- The test can be used by clinicians in a clinical setting without payment for copyrights.

Kansagara and Freeman's (2010) review identified GPCOG, Mini-Cog, MoCA, SBT - Short Blessed Test; (BOMC, 6-item Blessed Orientation-Memory-Concentration Test; 6-CIT, 6-Item Cognitive Impairment Test), STMS – Short Test of Mental Status; and SLUMS as possible alternatives for the MMSE, but they did not make recommendations regarding the best alternative(s) to use.

Holsinger et al, (2007) also considered the CAMCOG - Cambridge Cognitive Examination; the CDT - Clock Drawing Test, the MMSE and the MoCA as suited but other review authors did not agree [CAMCOG: Brodaty et al., 2006; CDT: Lorentz et al., 2002, Brodaty et al., 2006, Milne et al., 2008, Ismail et al., 2010; MMSE: Lorentz et al., 2002, Brodaty et al., 2006, Milne et al., 2008, Ismail et al., 2010; MoCA: Ismail et al., 2010, Kansagara &Freeman, 2010].

Based on their review of these review studies, and in line with the guiding principles adopted by the Medicare Detection of Cognitive Impairment Workgroup, the workgroup concurred that the GPCOG, Mini-Cog, and MIS represented brief structured assessment tools suitable for use during the AWV. In making this recommendation, the workgroup highlighted that each of these brief tools has unique benefits. As they noted, the GPCOG has both a patient and an informant component (that can be used alone or together), the Mini-Cog has been validated in population-based studies and in community-dwelling older adults heterogeneous with respect to language, culture, and education, and the MIS is a verbal word-recall task that tests encoding as well as retrieval (Buschke et al., 1999) and is an option for patients who have motor impairments that prevent use of paper and pencil.

The Irish College of General Practitioners (ICGP), in their Quality in Practice Committee report, on Dementia: Diagnosis and Management in General Practice (Foley & Swanwick, 2014), recognised that testing of cognitive function adds evidence to the clinical assessment and investigations of older adults

with suspected MCI or dementia. They also recommend the same three tests as recommended by the Medicare Detection of Cognitive Impairment Workgroup (Cordell et al., 2013), namely: GPCOG (Brodaty, et al., 2002); Mini-Cog (Borson et al., 2000) and MIS (Bushke et al., 1999). In their report, Foley & Swanwick (2014) identified a small number of what they described as validated cognitive screening tools used in general practice and they noted that performance on these tests may be affected by, amongst other things, an individual's educational ability, language, or hearing. A brief overview of each of these measures (adapted from the ICGP report) presented in Table 2.3 below.

As identified by Foley and Swanwick (2014), three well-conducted systematic reviews of cognitive screening tests used in primary care have compared the properties of screening tools in common use (Lorentz et al., 2002; Brodaty et al., 2006; Milne et al., 2008). Each of these reviews concurred that the best three tools for use in primary care were the GPCOG (Brodaty et al., 2002), the Mini-Cog (Borson, Scanlan, Brush, Vitaliano & Dokmak, 2000) and the MIS (Bushke et al., 2009). All three measures were found to be practical, feasible, have wide applicability and were psychometrically robust.

An even more recent review of screening instruments recommended the GPCOG as one of the instruments most reliable and suitable for the detection of dementia in primary care (Yokomizo, Simon & de Campos Bottino, 2014) and the Mini-Cog was also recommended as one of the instruments most reliable and suitable for the detection of dementia in primary care (Yokomizo et al., 2014).

As noted by Cordell et al., (2013), the expert group, as a result of its deliberations, derived the Alzheimer's Association Medicare Annual Wellness Visit Algorithm for Assessment of Cognition. Whilst this algorithm provided guidance on the objective cognitive tests that might be used with the patient as part of the decision-making process (GPCOG, Mini-Cog and MIS as frontline tools), key components of the algorithm are a review of the patient Health Risk Assessment (HRA) information, patient observation, unstructured questioning during the AWV, and, where deemed necessary, informant information about cognitive function.

Table 2.3: Cognitive Screening Tools in Primary Care as identified by Foley & Swanwick (2014)

Test	Test Characteristics*
Mini-Mental State Examination (MMSE) Folstein, Folstein & McHugh (1975)	The MMSE is the most commonly used tool in Geberal Practice (>50% GPs use it; e.g. Milne et al., 2008). It measures orientation, immediate memory, attention and calculation, delayed recall, various aspects of language and visuospatial skills. It is scored on a scale from 0 to 30. Typically, a score of <24 is taken to be suggestive of dementia. Scores may, however, be difficult to interpret, and it shows age, cultural and educational bias (Cullen et al., 2007), and the fact that it has low sensitivity measn that it is best used in community and primary care settings to rule out dementia (Lin, O'Connor, Rossom, Perdue & Eckstrom, 2013). The MMSE may take up to 20 minutes to complete and so it may be less practical for primary care. There are copyright restrictions on the MMSE.
General Practitioner Assessment of Cognition (GPCOG) (Brodaty et al., 2002).	The GPCOG is a 6-item cognitive screening tool developed by Brodaty et al., (2002) as a brief, reliable screening tool suitable for administration in the busy primary care setting. It typically takes approximately 5 minutes to complete. There are two components: a cognitive assessment conducted with the patient, and an informant questionnaire, which is considered necessary only if the results of the cognitive section are equivocal, i.e. score of 5-8 inclusive). The test consists of an evaluation of time orientation (Max 1 point), a clock drawing task to evaluate visuospatial functioning and executive function processes (max 2 points), information retrieval (report of a recent news event) (max 1 point) and a delayed recall task (recall of a previously presented name and address) (max score 5 points). Thus, scores can range from 0-9. For individuals requiring an informant questionnaire, a score of 3 or less out of 6 in the informant section indicates cognitive impairment (Brodaty, Kemp and Low, 2004). Areas covered in the informant interview include memory, word finding difficulties, trouble managing finances, difficulties managing medication independently and needing assistance with transportation. GPCOG is considered to perform well within the primary care setting and is psychometrically robust and free of educational bias. Results >8 on the GPCOG patient section are assumed to reflect those of an individual who is cognitively intact whilst scores <5 indicates impairment and standard investigations are recommended. It has a reported pooled sensitivity of 82-85%, a specificity of 83-86%, a positive predictive value (95% CI) of 0.71 and a negative predictive value of 0.92 and higher (Yokomizo, Sanz Simon and de Campos Bottino, 2014). While scores have been shown to be affected by depression and education in people with DSM-IV diagnosed dementia (Broadty. Kemp & Low, 2004), the GPCOG has been reported to be minimally affected by education, self-reported depression and gender (Brodaty, Kemp & Low, 2004, Yokomizo et al., 2014). A community-based study by Basic et al., (2009) found that GPCOG scores were influenced by depression as measured by the Geriatric Depression Scale (GDS). However, it is worth noting that in the sample of 151 participants, 58 (38.4%) had dementia, which may explain the significant predictive effect of depression on the GPCOG in that study. In total, the GPCOG takes about 6 minutes to administer. It has strong performance on sensitivity and specificity *versus* MMSE in detecting dementia in a typical primary care population (Ismael et al., 2009). It was noted nonetheless that the GPCOG showed variation in diagnostic ability with age, gender and education (Brodaty, Kemp & Low, 2004). Moreover, it has been found to have a misclassification rate the same or less than that of the MMSE (Milne et al., 2008). There is little information to date about the diagnostic accuracy of the GPCOG for MCI. Overall, however, it is regarded as brief, easily administered, well-accepted by clinicians, efficient and minimally affected by education, sex and race (Milne et al., 2008). There is, however, a need for further study of the GPCOG in populations representative of a primary care setting (Holsinger et al., 2007).

Test	Test Characteristics*
Mini-Cognitive Assessment Instrument (Mini-Cog) (Borson et al., 2000)	Mini-Cog (Borson et al., 2000) is a brief screening tool designed for, and validated in, a primary care setting (Borson et al., 2000). primary care use. The Mini-Cog incorporates a clock-drawing test and a three-item delayed word recall task. The words must be recalled after a maximum of 3 registration trials that occur immediately prior to the clock drawing task. and the intervention of a clock drawing task) and clock drawing. In total, Mini-Cog takes 3-5 minutes to complete and it performs comparably to the GPCOG. Like GPCOG, it too is free of educational bias. Scoring criteria are as follows: 3 recalled words: Negative for cognitive impairment; 1-2 recalled words + normal CDT: Negative for cognitive impairment; 1-2 recalled words + abnormal CDT: Positive for cognitive impairment; 0 recalled words: Positive for cognitive impairment (Borson, Scanlan, Brush, Vitaliano, & Dokmak, 2000; Borson, Scanlan, Chen, & Ganguli, 2003; McCarten, Anderson, Kuskowsi et al. (2012)
Memory Impairment Screen (MIS) (Bushke et al., 1999; Kulansky, et al.,2002)	The MIS is a 4-item assessment test that takes approximately 4 minutes to complete. Individuals are shown a sheet of paper with 4 words that they are required to read and to subsequently recall. They are asked to read the words aloud and are then presented a category cue and asked to indicate which of the 4 words came from that category; the other 3 category cues are presented in turn. In total, there are 4 category identification trials, with failure to identify category membership after 4 trials taken as an indication of language difficulty The MIS is considered appropriate for use with ethnic minorities, as it does not show educational or language bias. Scores less than or equal to 4 are deemed impaired.
Abbreviated Mental Test Score (AMTS)	The MTS is a well-established 10-item screen that samples various cognitive domains. There are only verbal items. Orientation, long-term memory, recognition and short-term memory are assessed.
Six Item Cognitive Impairment Tool (6CIT) *The Kingshill Version (2000)*	The 6-item Cognitive Impairment Test (6CIT) Kingshill Version 2000® was developed originally in 1983 and was validated for use in primary care by Brooke and Bullock (1999), by means of regression analysis of the Blessed Information Memory Concentration Scale (BIMC) (Blessed, Tomlinson & Roth, 1968). It assesses orientation, short-term memory and attention/concentration and approximately 5 minutes to complete. The 6CIT uses an inverse scoring system and questions are weighted to produce a total out of 28. Scores of 0-7 are considered normal and 8 or more significant. Accurate scoring, without the benefit of computer scoring algorithms, can be confusing. Among the listed advantages of the test is the fact that it has high sensitivity and specificity, even in mild dementia (at the 7/8 cut-off: Overall figures - sensitivity = 90%, specificity = 100%; in mild dementia, sensitivity = 78%, specificity = 100%) and it is easy to translate linguistically and culturally. As a result, it was used in a large European assessment tool (Easycare©).

*modified from Foley & Swanwick, 2014

Figure 2.1 provides a graphical representation of the Algorithm for Assessment of Cognition. As is clear from this algorithm, assessment of cognition depends, ultimately, on much more than administration of a brief cognitive screening tool. At the first phase of assessment, clinicians are required to review the HRA, especially reports of functional decline, to observe the patient, take account of self-reported concerns, and question the patient and, if available, an informant. Where signs/symptoms of cognitive impairment are present (either by clinician observation or self-report), or where an informant is not available to confirm the absence of signs/symptoms of cognitive impairment, the second phase of the algorithm requires a brief structures assessment (of the patient and, where necessary or possible, an informant report). Then, where the brief assessment(s) triggers concern, the clinician or the healthcare provider should conduct a full dementia evaluation or, typically more likely, the patient should be referred for a full dementia assessment to a service with the capacity and the experience to provide such an assessment.

Whilst GPCOG, Mini-Cog and the MIS are the tests of choice for the expert group, this algorithm advises clinicians that alternative tools such as MMSE, SLUMS or MoCA can be used in place of the GPCOG, Mini-Cog and the MIS – but no advice regarding limitations of these alternative tests is provided.

The **Mini-Mental State Examination (MMSE) (**Folstein, Folstein & McHugh, 1975) is the most commonly used tool in General Practice (>50% of GPs use it; see for example, Milne et al., 2008). The MMSE measures orientation, immediate memory, attention and calculation, delayed recall, various aspects of language and visuo-spatial skills. It is scored on a scale from 0 to 30, with a score of <24 taken to be suggestive of dementia. Scores may, however, be difficult to interpret and the test shows age, cultural and educational bias (Cullen et al., 2007). The low sensitivity of MMSE to mild cognitive deterioration means that it is best used in community and primary care settings for the purpose of **ruling out** (rather than detecting) **dementia** (Lin, O'Connor, Rossom, Perdue, & Eckstrom, 2013). The difficulty here, however, is that it performs poorly in terms of detecting cases of mild dementia and it performs even more poorly in terms of detecting MCI. As noted in several studies and reviews, a large proportion of individuals who meet the clinical criteria for mild AD are not detected by MMSE and a large proportion of individuals who meet the clinical criteria for MCI score well within the range for normal older adults (>23, with many, indeed, scoring above 26) (see for example, Tombaugh and McIntyre, 1992; Wind, Schellevis and Van Staveren, 1997; Cullen, O'Neill, Evans, Coen, & Lawlor 2007). Furthermore, the MMSE may take up to 20 minutes to complete and so, even if the limitations of the test are recognised, it may not be entirely practical for primary care. In addition, although the test used to be freely available, there are now copyright restrictions on the use of the MMSE.

Note: Whilst GPCOG, Mini-Cog and the MIS are the tests of choice, the algorithm advises clinicians that alternative tools such as MMSE, SLUMS or MoCA can be used – but no advice regarding limitations of these alternative tests is provided.
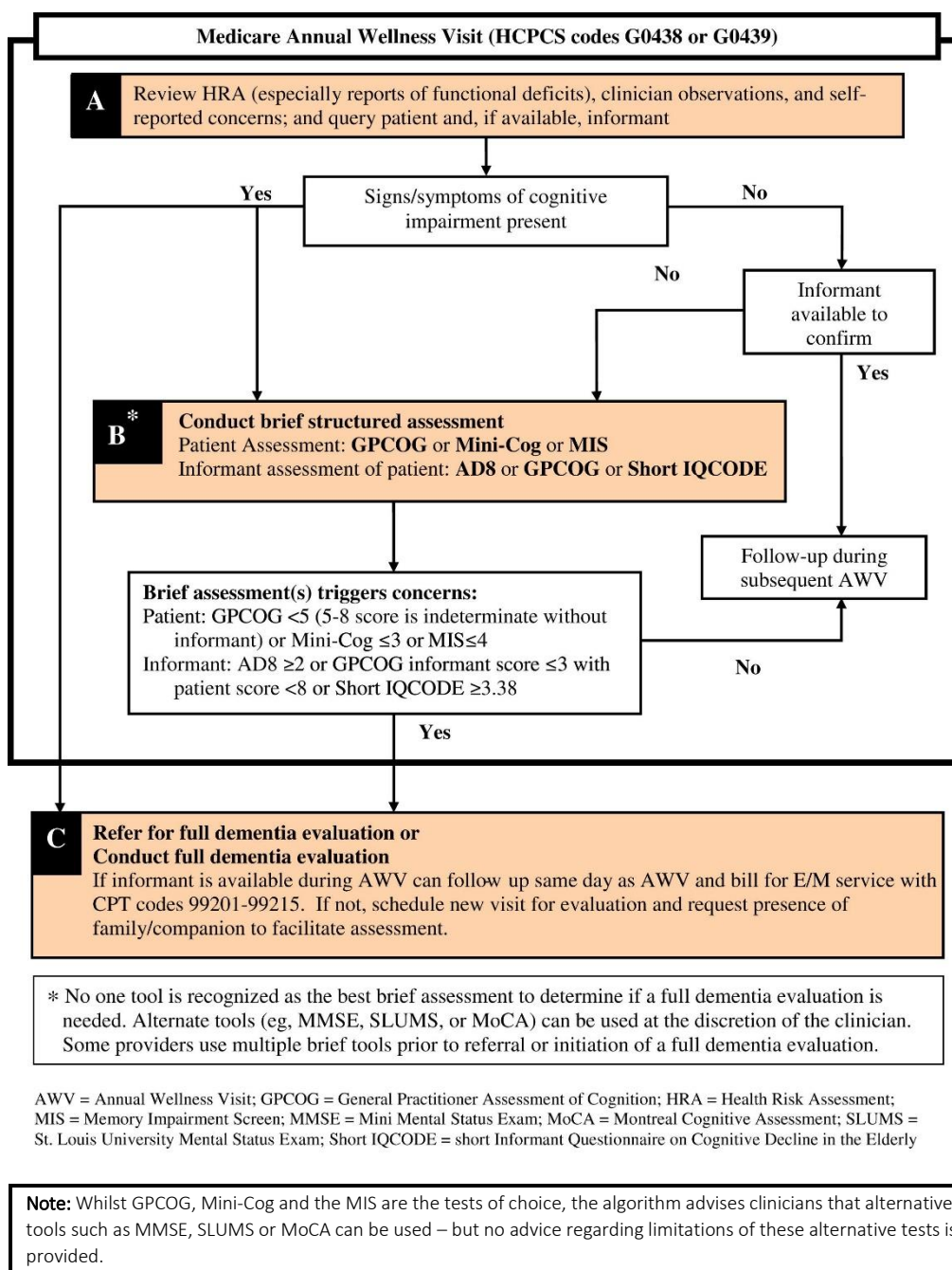
Figure 2.1: Alzheimer's Association Medicare Annual Wellness Visit Algorithm for Assessment of Cognition (adapted from Cordell et al., 2013)

The **SLUMS** - St Louis University Mental Status (Tariq, Tumosa, Chibnall, Perry 3rd & Morley, 2006) takes approximately 7 minutes to administer, tests a number of cognitive domains, and appears free of an education bias. It does, however, suffer from limited validation in primary care settings.

Increasingly, researchers and clinicians are using the Montreal Cognitive Assessment **(MoCA)** (Nasreddine et al., 2005) rather than, or in conjunction with, the MMSE. The MoCA was developed to screen individuals who present to their GP (or other healthcare professional) with reports of mild cognitive complaints but who, on examination, perform (or would likely perform, if tested) in the normal range on the MMSE.

According to the authors: *"The MoCA is a simple, stand-alone cognitive screening tool with superior sensitivity. It covers important cognitive domains, can be administered in 10 minutes, and fits on one page. Moreover, the data indicate that it has excellent test-retest reliability and positive and negative predictive values for MCI and AD. It is sensitive to the presence of MCI and is feasible to use in a clinical setting, where assessment time is often limited."* (Nasreddine et al., 2005; pg. 699).

They went on to say: *"The MoCA promises to fill an urgent unmet need for a brief screening tool capable of detecting patients with MCI and distinguishing them from cognitively intact older people".* (Nasreddine et al., 2005; pg. 699).

In their initial validation study, Nasreddine et al. compared three groups of participants (mild AD, n=93); MCI (n=94) and normal elderly controls (n=90).

As the criterion standard, clinical diagnoses were made previously in a memory clinic and were supported by neuropsychological assessment. For the purpose of the study, the definition of MCI corresponded to those established by Petersen and colleagues (Petersen et al., 1999; Petersen, 2000a; 2000b; Petersen et al., 2001).

Specifically, the criteria for MCI were:

- the presence of subjective complaints of gradual memory loss over at least 6 months (reported by the patient or by family members).
- objective evidence of memory loss, demonstrated on clinical memory tests
  - Rey Auditory Verbal Learning Test, Schmidt, 1996; Delayed Visual Reproduction and Logical Memory, from the Wechsler Memory Scale, Wechsler, 1997.
- general preservation of other cognitive domains - although subtle changes in other domains were present in 35% of cases.
- preserved functioning in terms of activities of daily living, with only mild if any impairment in instrumental activities (e.g., keeping memory lists).
- absence of other obvious medical, neurological, or psychiatric explanation for the memory loss (with the exception of mild depression)

- insufficient findings to warrant a clinical diagnosis of dementia

None of the group of 94 individuals judged to have MCI had fully preserved memory, as assessed by the Rey Auditory Verbal Learning Test, Schmidt (1996); Delayed Visual Reproduction and Logical Memory, Wechsler, (1997). In total, 90 had primarily a memory loss, scoring below normative values on age- and education-adjusted norms on at least one of these three tests (at least a 1.0-standard deviation (SD) decrease in all cases and a 1.5-SD decrease in 85/90 cases). The remaining 4 had mild memory loss, as well as impairment in multiple other cognitive domains.

All participants in the AD group had a diagnosis of probable AD, meeting the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) 1994 criteria and the National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association NINCDS-ADRDA criteria. According to the authors, all were considered to fall within the category of mild AD, with all but three obtaining MMSE scores of 17 or greater.

All participants completed both the MMSE and the MoCA so that the sensitivity and specificity of both tests for correct detection of MCI and mild-AD could be compared with clinical diagnosis.

The authors reported that, for both the MMSE and the MoCA, the difference between the three groups differed significantly and that the differences between the groups were much more pronounced using the MoCA than the MMSE.

For both patient groups, sensitivity and specificity (patient –v- controls) were determined using clinical diagnosis as the standard. Notably, the ability of the MoCA to distinguish between MCI and mild-AD was not examined. According to the authors, a cut-off score of 26 (scores ≤25 indicate impairment) yielded the best balance between sensitivity and specificity both for the MCI group and the group with AD groups. For comparison purposes, a cut-off score of 26 was also used for the MMSE.

Based on these cut-off scores, the authors report that the MoCA exhibited excellent sensitivity in identifying MCI (90% correctly classified) and AD (100% correctly classified), and these sensitivity rates were substantially better than those achieved with the MMSE (MCI: 18% correct classification; AD: 78%, respectively). They also reported what they referred to as very good to excellent specificity (87%) for the MOCA, where specificity referred to the percentage of normal controls who scored at or above the cut-off score of 26. Positive and negative predictive values were also reported as excellent, both for MCI (89% and 91%) and for AD (89% and 100%). These figures contrast with those of the MMSE which, although having excellent specificity, correctly identifying 100% of the healthy controls, performed relatively poorly in terms of sensitivity – thereby compromising negative predictive power.

Among the most important points raised by Nesreddine et al. (2012), but not always considered by others, is the fact that when within-subject comparisons were made, MoCA clearly outperforms MMSE in identifying those with MCI. Here, most healthy controls scored in the normal range on both MMSE and MoCA. Similarly, most of the AD patients scored in the abnormal range on both tests (as defined for study purposes). In contrast, a high proportion (75%) of the MCI participants scored in the abnormal range on MoCA (<26) but were considered normal on MMSE. As they noted, patients screened in clinical practice and found to have a MoCA score over (sic) 26 would be: *"extremely unlikely to meet clinical and neuropsychological criteria for MCI even after extensive evaluation"* (pg. 698). They went on to say that: *"In general practice therefore, using the MoCA as a screening tool should provide quick guidance for referral and further investigation of MCI"* (pg. 698). In other words, MoCA can be used with a high degree of confidence to rule out MCI, but it cannot be used to make a diagnosis of MCI (i.e. those at or below the cut-off should undergo further evaluation).

Burton and Tyson (2015) consider the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) to be the most valid and clinically feasible screening tool to identify post-stroke cognitive difficulties, but, according to the authors, the MoCA cannot distinguish properly between normality and MCI of vascular origin, or between MCI and dementia of vascular origin.

A further difficulty with the MoCA is the observed impact of education on test performance. Nasreddine et al, (2005) reported an impact of education level on MoCA performance – those with 12 years of education, or less, tended to perform more poorly. Thus, they recommended the addition of 1 point to the overall scores of those with 12 years of education or less (if their total score was less than 30). More recently, Kenney, Coen, Frewen, Donoghue, Cronin & Savva (2013) questioned the current recommended cut-off scores, based on an evaluation of data from the first wave of The Irish Longitudinal Study on Ageing (TILDA). Measurements included height and weight, walking speed, Timed Up-and-Go, handgrip strength, bone mineral density and measures of cognitive function - MMSE, MoCA, Color Trails Test. Performance on all tasks decreased with age and educational attainment was a strong determinant of performance on all cognitive tests.

Further evidence of the impact of demographic variables on MoCA is seen in the recent study by Borland et al (2017) who identified the need for revised normative data for a Swedish population, making the argument that Swedish normative data did not exist and international norms are often derived from populations where cognitive impairment has not been screened for and not been thoroughly assessed to exclude subjects with dementia or mild cognitive impairment. In presenting their normative data, they indicate that level of education, sex, and age should be taken in account

when evaluating MoCA scores. From a practical perspective, they made available an online regression-based calculator that provide percentile and z-score for a subject's MoCA score.

Given these observations, the utility of the MoCA, at least in its present form and with the currently recommended cut-off score is questionable.

Separately, Blanco-Campal, Coen, Diaz-Orueta, Irving & Burke (2016) argued that although each MoCA task is, according to the authors, subsumed under a single cognitive domain, giving the impression of measuring a single cognitive function, all the MoCA tasks are complex, multifactorial tasks that require a range of cognitive processes for successful completion. Indeed, a similar point was made by Coen, Robertson, Kenny and King-Kallimanis (2016) and was confirmed by exploratory factor analysis. In their study examining a large data set from the TILDA study, they showed that many MoCA items cross-load onto several factors and are not clearly a measure of any single domain (Coen et al., 2016)

Whilst this same argument might well be made in relation to several other screening tools, there is a clear need for caution if relying on domain scores to make inferences about the nature of underlying difficulties or for differential diagnosis.

Other researchers advocate use of the ACE and ACE-R (Mioshi, Dawson, Mitchell, Arnold & Hodges, 2006) but it cannot reliably distinguish between normality, MCI and dementia in the presence of poor health or mood disorders (Burton & Tyson, 2015).

Table 2.4 below presents some summary information on the tests identified for review by Cullen, O'Neill, Evans, Coen & Lawlor (2007) on the basis that they are potentially useful to use in the doctor's office: administration time and aspects of cognition covered (adapted from Cullen et al., 2007). On the basis of their review of cognitive screening tools that are useful in the context of primary care assessments, eliciting information about key cognitive abilities, with robust validity in non-selected samples, the authors suggested that the 3MS (Teng & Chui, 1987) and the CASI (Teng, Hasegawa, Homma et al. 1994) both perform well. They also suggested that the ACE-R (Mioshi et al., 2006) and DemTect (Kalbe et al., 2004) are potentially useful in community/primary care samples, but they acknowledged that these latter two tests had not yet been validated in this way.

Two points are worth noting here. MoCA was not included in the Cullen et al (2007) review. The MIS (Buschke, et al., 1999) was listed in the overall schedule of screening tests reviewed – but did not make it into the listing of tests for use in GP practice – presumably because it assesses only memory.

Table 2.4: Brief assessment tools for use in the doctor's office: administration time and aspects of cognition covered (adapted from Cullen et al., 2007)

Test	Test Author	Admin Time	Mental Tracking — Digit Span	Mental Tracking — Other	Executive Function — Verbal Fluency	Executive Function — Reasoning/ Judgement	Language — Expressive	Visuospatial — Construction	Memory* — Immediate free verbal recall	Memory* — Delayed free verbal recall	Memory* — Cued verbal recall	Validity — All Dementia	Validity — MCI
3MS	Teng & Chui (1987)	10-15		Y	y	y	y	y	y	y	y	Sen: 83-89 Sp: 85-90	Sen: 78 Sp: 76
CASI	Teng et al. (1994)	15–20	Y	Y	y	y	y	y	y	y	y	Sen: 91-95 Sp: 33-97	
MMSE	Folstein, Folstein & McHugh (1975)	8–13		Y			y	y	y	y		Sen: 69-91 Sp: 87-99	
SASSI	Belle et al. (2000)	10–15		Y	y		y	y	y	y		Sen: 94 Sp: 81-91	
STMS	Kokmen, Naessens & Offord (1987)	5	y (f)			y		y	y	y		Sen: 86-95 Sp: 88-94	AUC: 82
CAST	Drachman et al. (1996)	15					y	y				Sen: 88-95 Sp: 88-100	
GPCOG	Brodaty et al. (2002)	5					y			y		Sen: 85 Sp: 86	
7MS	Solomon et al. (1998)	7–15			y					y	y	Sen: 91 Sp: 94	
AMT	Hodkinson (1972)	5		Y					y	y		Sen: 73-100 Sp: 71-100	
Mini-Cog	Borson et al. (2000)	3-4						y**		y		Sen: 76-99 Sp: 89-93	Sen: 55 Sp: 74-84
T&C	Froehlich, Robison & Inouye (1998)	1										Sen: 63-95 Sp: 54-96	
ACE-R	Mioshi et al. (2006)	16		y	y		y	y	y	y		Sen: 84-94 Sp: 89-100	
DemTect	Kalbe et al. (2004)	8-10	Y		y					y		Sen (AD): 100 Sp (AD): 92	Sen: 80 Sp: 92

* all memory tests are for Retrospective Memory; Sen: sensitivity; Sp: specificity; AUC: Area under the curve; MCI: Mild cognitive impairment; 3MS: Modified Mini-Mental State Examination; CASI: Cognitive Abilities Screening Instrument; MMSE: Mini-Mental State Examination; SASSI: Short and Sweet Screening Instrument; STMS: Short Test of Mental Status; CAST: Cognitive Assessment Screening Test; GPCOG: General Practitioner Assessment of Cognition; 7MS: 7-Minute Screen; AMT: Abbreviated Mental Test; Mini-Cog: Mini-Cog; T&C: Time and Change; ACE-R: Addenbrooke's Cognitive Examination—Revised; DemTect: DemTect; y: cognitive domain covered; f: digit span forwards; **not indicated by Cullen et al.

As noted by Cullen et al, the 3MS and the CASI both perform well in the context of *"eliciting information about key cognitive abilities, with robust validity in non-selected samples"* (Cullen et al, 2007; pg. 794). They do, however, acknowledge that low specificity has been reported for CASI (Fujii et al., 2003), as has wide variation in scores on the 3MS, without any evidence of clinical change (Correa, Perrault & Wolfson, 2001).

They also note that age and education biases have been detected on some of these tests, identifying exemplars for both the MMSE (Boustani, Petersen, Hanson, Harris & Lohr, 2003) and GPCOG (Brodaty & Kemp, 2004) and they flag low positive predictive value of the AMT (Antonelli Incalzi, Cesari, Pedone, Carosella & Carbonin, 2003).

In a 2009 systematic review of 15 different cognitive screening instruments, most of which were designed to detect early and moderate stage dementia, Lonie, Tierney and Ebmeier concluded that whilst several of the measures reviewed afforded the clinician some ability to detect MCI, early AD, and in some cases non-AD dementia, none of them satisfied all of the criteria considered to be important in the detection of MCI. Furthermore, according to the authors, none of the measures reviewed could be used currently to make reliable inferences about the course and eventual outcome of MCI. In addition, they noted that, across the range of tests, there was an absence of data about (1) the sensitivity of the tests for detection of early atypical dementia presentations, (2) test specificity when compared with psychiatric and non-progressive neurological conditions, (3) cross-cultural usage of the tests and (4) reliability and predictive validity.

Taken together, it can be concluded that while a range of screening tools can be considered adequate and at least reasonably reliable (subject to appropriate norms) in the detection of dementia in primary care, the sensitivity of these instruments to detect MCI is generally lower (Lin, O'Connor, Rossom, Perdue & Eckstrom, 2013) and there are issues regarding the best methods of evaluation.

Although cognitive decline or impairment that "falls below the expected level" (DSM5) or is "beyond that expected for both age and education level" (Petersen et al., 1999) is an essential part of the operational criteria for MCI, there is, as yet no gold standard to operationalise this concept. Some tests use a simple cut-off score, without reference to demographic factors such as gender, age, education or pre-morbid levels of intellectual function.

In their very recent review of cognitive screening instruments in MCI, Diaz-Orueta, Blanco-Campal and Burke (2018) identified a number of potentially useful screening tools for screening of MCI and dementia in primary and secondary care. In their paper, they note that *"while an in-depth neuropsychological*

evaluation of a wide range of cognitive domains is considered to be optimal for the detection and clinical differentiation of MCI subtypes, access to tertiary services such as memory clinics with the full complement of neuropsychological evaluation is relatively rare and most clinical cognitive examinations are conducted using brief cognitive screening measures… (Díaz-Orueta et al. 2018, pg. 664).

Thus, the need for solid recommendations about brief screening tools. Based on the review presented above, there is reasonable agreement that the GPCOG, the Mini-Cog and MIS are useful brief objective cognitive tests for use in primary care. These recommended cognitive screening tools have demonstrated acceptable psychometric properties (Brodaty, Low, Gibson & Burns, 2005; Milne et al., 2008; Ismael et al., 2010) and go some way towards the inclusion of cognitive domains other than memory, in line with the identified need of screens that obtain information about the functioning of a wide range of cognitive domains (Cullen et al., 2007). However, the type of memory assessed in each of these instruments is memory for previously presented information and events (retrospective memory; RM), with none of these tests incorporating an assessment of PM.

2.4.2 Room for Improvement?

Despite the predictive value of PM for detecting MCI, above and beyond that of RM (Blanco-Campal, Coen, Lawlor, Walsh and Burke, 2009), none of the screening tools recommended by the Alzheimer's Association and ICGP contain a test for PM. Indeed, few recommendations for fuller objective assessment of memory include a validated assessment of this aspect of memory. This appears to be an important oversight given the evidence showing that PM failures make an independent contribution to the prediction of AD over and above that of RM failures (Jones, Livner & Backman, 2006).

As noted in Chapter 1, PM failures are common in the general population (Dobbs & Rule, 1987). Inclusion within the primary care setting of an assessment of this type of memory, given its potentially serious personal consequences, is, therefore, potentially important. Although such a test needs to be brief enough for use in a primary care setting, based on findings in numerous research studies, an interesting consideration for potential use in clinical practice (perhaps in an abbreviated format) is the Cambridge Prospective Memory Test (CAMPROMPT) described next.

The CAMPROMPT is one of just two commercially available standardised objective assessment of complex prospective memory (PM). This 25 minute test is comprised of three time-based and event-based (one focal and two non-focal) items embedded within a series of attention-demanding puzzles that serve as an ongoing task, e.g. "when there are seven minutes left, remind me not to forget my keys" and "when you come to a quiz question about (television show), give me this book." Participants are allowed to engage

in any external strategies they like to help them remember, including taking notes, and are provided with a pen and paper.

The CAMPROPMPT has a very high inter-rater reliability of 0.998 (Pearson) and moderate test-retest reliability of 0.64 (Kendell's Tau-b; Wilson et al., 2005). Delprado et al. (2012) found moderate inter-item reliability, with a Cronbach's alpha coefficient of 0.75, indicating good internal consistency.

Delprado et al. (2012), in their study assessing the clinical utility of PM measures, including the CAMPROMPT, in predicting amnestic MCI (aMCI) found that the CAMPROMPT had the ability to discriminate aMCI from healthy individuals. So too did two other simple, single-trial event-based tasks of PM, albeit to a lesser extent. They observed that both the time- and event-based scales of the CAMPROMPT were equal in their discriminative ability.

The CAMPROMPT, therefore, appears to be a sensitive test of mild memory and cognitive difficulty. However, proper administration of the entire CAMPROMPT battery in its present state is unfortunately not feasible in the time-constrained setting of primary care.

Another gap in terms of current practice is the lack of attention paid to the formal assessment of self-reports of memory problems. This, despite the phase 1 aspects of the AWV (Cordell et al., 2013).

The lack of attention granted to self-reports of memory problems in screening tool development, and hence clinical practice, is reflected by the absence of any measure of self-reported memory dysfunction in the ICGP guidelines for cognitive screening in primary care. This absence of a subjective assessment is regrettable, given the mounting literature supporting the validity and utility of self-reported memory failures for detecting cognitive impairment, which will be outlined next.

According to Cullen et al. (2007), the ideal screen is not only statistically robust but also qualitatively rich, allowing referring clinicians to better describe a patient's symptom profile, and lending itself to use in a wider range of settings. In this regard, it is surprising that the qualitative information conferred by self-reported accounts of memory problems has not been utilised fully to date in a cognitive screening tool for the primary care setting, and, in particular, for the detection of very early potential impairment, since older adults have shown to possess accurate insight into subtle cognitive changes experienced by them (Dufouil, Fuhrer & Alperovitch, 2005; Jessen et al., 2010).

2.4.3 Subjective Assessment: self-reported difficulties:

As outlined earlier , self-reported cognitive and memory failures are common in elderly people living in the community (Geerlings, Jonker, Boute, Ader & Schmand, 1999; Jonker, Geerlings & Schmand, 2000) as well as amongst those attending primary care (Waldorff et al., 2012). Recently, a longitudinal study by Reisberg, Shulman, Torossian, Leng & Zhu (2010) showed that those with subjective cognitive or memory decline were 4.5 times more likely to progress to MCI and dementia that were those without. Indeed, on the basis of findings from a number of longitudinal clinical and population-based studies, self-reported cognitive failures are now proposed to constitute an early symptom of cognitive impairment or dementia (e.g. Johansson, Allen-Burge & Zarit, 1997; Schamnd, Jonker, Geerlings & Lindebooom, 1997; Schofield et al., 1997; Geerlings, Jonker, Bouter, Ader & Schmand, 1999; Jorm, Christensen, Korton, Jacomb, & Henerson, 2001), even in the absence of objective cognitive decline (Dufouil et al., 2005; Wang et al., 2004), and after adjustment for depressive symptomatology (Jonker et al., 2000). Their importance is reflected in their inclusion in the Diagnositic and Statistical Manual (DSM) 5 criteria for Minor Neurocognitive Disorder.

Biomarker evidence, such as brain activation on functional imaging (Erk et al., 2011), cerebral hypometabolism (Scheef et al., 2012), grey matter volume loss (Saykin et al, 2006), amyloid accumulation (Perrotin, Momino, Madison, Hayenga & Jagust, 2012) and cerebrospinal fluid markers (Visser et al., 2009) lend putative objective support to older adults' self-perceived changes in cognition regardless of their performance on cognitive tests or intact daily functioning.

The significance of self-reported memory problems are signified by their inclusion in traditional MCI criteria, as well as clinical staging systems for dementia, and diagnostic systems such as DSM 5 (which now refers to dementia as Major Neurocognitive Disorder and MCI as Minor Neurocognitive Disorder) and the International Statistical Classification of Diseases and Related Health Problems (ICD-10; World Health Organisation, 1992). Arguably, it is also feasible to assume that self-report assessments may represent a less invasive or less stressful, and more acceptable means of assessment of cognition to older adults, and therefore present less risk of disruption to the therapeutic relationship between the GP and older person.

Despite all of this, the relevance of self-reported memory failures has been questioned, with an extensive literature suggesting that there is little relationship between subjective complaints and objective test performance (e.g. Jungwirth et al., 2004; Minette, Da Silva, Ortiz & Bertolucci, 2008).

According to some authors, heterogeneity in study methodology (the use of clinical versus non-clinical samples, differences in the assessment and measurement of subjective memory problems and the use of cross-sectional designs, as well as the differential treatment of associated variables) is the main reason for the lack of a significant relationship (Jonker et al., 2000; Montejo, Montenegro, Fernandez & Maestu, 2012).

Other reasons proposed for lack of an observed relationship between subjective and objective test performance are the low correspondence of the cognitive tests typically employed to assess objective function with real-world cognitive functioning i.e. lack of ecological validity (Shilling & Jenkins, 2007). Another, as detailed earlier in this chapter, is the lack of sensitivity of many of the tests used to examine the relationship between subjective and objective tests are, in essence cognitive screening tools with questionable sensitivity to mild dementia and MCI (Rabin, Smart & Amariglio, 2017).

Shortcomings in the instruments used to assess self-reported cognitive functioning might also explain the lack of observed relationships between subjective and objective performance (Lai et al., 2009).

These limitations include the observation that metamemory (beliefs about one's own memory) does not always correlate with actual memory performance as assessed by objective tests and clinical observations (Craik, Anderson, Kerr and Li, 1995; Morris, 1984). Respondents may also have limited insight into their memory problems (Herrman, 1984), or people with memory failures may forget about their errors (Cohen, 1996). Findings concerning the relationship between subjective and objective memory may also be influenced by the nature and number of self-reported memory problems. Previous research on the relationship between the type and number of self-reported memory failures and performance on objective cognitive tests has shown that some subjective failures, such as difficulty following a group conversation, or finding one's way around familiar streets, were more highly associated than other subjective failures with odds of cognitive impairment. For each additional subjective memory problem endorsed, the odds of cognitive impairment increased approximately 20% when each SMC was weighted equally (Amariglio, Townsend, Grodstein, Sperling & Rentz, 2011).

There are many possible approaches and measures for eliciting and assessing subjective cognitive or memory complaints, which, although correlated with each other, yield different results (Reid & MacLullich, 2006; Abdulrab & Heun, 2008).

These methods range from using a single or just a small number of general complaint questions (e.g. Do you have trouble with your memory?) accompanied by a yes/no response format, or questions with a scaled/graded response format (e.g. asking participants to rate their memory at the present time from

poor to excellent, or asking participants to rate their memory compared to others of the same age, etc.), to subsets of scored questions from diagnostic and screening instruments for the elderly with a cut-off score indicating subjective memory impairment. Other studies have employed structured questionnaires with multiple items designed to indicate the severity or frequency of memory failures (Abdulrab & Heun, 2008).

Many studies have limited the assessment of perceived or self-reported cognitive dysfunction to a single domain of memory (episodic or retrospective), often including only a single question about perceived forgetfulness. Typical of this approach is the question used for assessing memory complaints in the older Irish population aged 50 years and above in The Irish Longitudinal Study of Aging (TILDA; Barret, Burke, Cronin, Hickey & Kamiya, 2011). In that study, participants are asked to rate their memory as excellent, very good, good, fair, or poor. However, a structured, specific self-report questionnaire is preferable for providing a more detailed insight of the exact nature, type and frequency of self-reported forgetfulness in the general population.

A specific questionnaire on subjective memory complaints was also found to be preferable to an instrument that uses an aggregate of complaints questions on self-reported memory for detecting associations between self-reported memory problems and other variables in community-dwelling older adults (Montejo et al., 2014). Such associated variables, some of which are outlined further below in this chapter, may represent useful predictors of subjective cognitive and memory complaints.

It is also imperative that such a questionnaire assesses domain(s) other than episodic/retrospective memory alone (Cullen et al., 2007); the importance of this is underlined by the prevalence of deficits in cognitive domains other than episodic memory revealed in detailed neuropsychological testing of patients with MCI (Ribiero, de Mendonca & Guerreiro, 2006).

Prospective memory (PM) referring to memory for future plans and intentions (Einstein & McDaniel, 2000) is a complex, multifactorial type of memory, often involving processes beyond those involved in retrospective memory (RM), such as planning, monitoring, maintenance, initiation, and implementation of intentions (Kliegel, McDaniel & Einstein, 2000). Of direct relevance to this study is the fact that the content of memory complaints generally relate to PM tasks more than RM tasks (Mantyla, 2003). Prospective memory failures are common in the older general population; The Irish Longitudinal Study of Aging (TILDA) reported that of adults aged 80 and over, 42% forgot to carry out an action they had earlier been instructed to perform (Barrett, Burke, Cronin, Hickey & Kamiya (2011). PM is believed to be more vulnerable than RM to impairment in dementia (Huppert & Beardsall, 1993) and a more pronounced

deficit than RM failure in a study of people with MCI; therefore, PM deficits have been suggested to have predictive validity for the development of cognitive impairment above and beyond RM deficits (Blanco-Campal et al., 2009).

The content of memory complaints generally relate to PM tasks more than RM tasks (Mantyla, 2003) and from a more holistic social prescribing perspective such failures are important for primary care professionals to assess since they can have serious consequences for medication management (Woods et al., 2014) and completion of instrumental activities of daily living (Woods, Weinborn, Veinoweth, Rooney & Bucks, 2012).

The Prospective and Retrospective Memory Questionnaire (PRMQ; Smith, Maylor, Della Sala and Logie, 2000) is the only validated standardised questionnaire that assesses prospective and retrospective memory difficulties to an equal extent. Importantly, the PRMQ is also accompanied by normative data obtained from a UK population sample by Crawford, Smith, Maylor, Della Sala and Logie (2003). These normative data represent a highly useful benchmark against which practitioners and researchers in the UK can make a reliable comparison of an individual's self-rated memory difficulties to memory difficulties reported by those of a similar age and sociodemographic background. Distribution of the PRMQ (as opposed to a single global memory complaint question, or any number of single episodic/retrospective memory domain questions) therefore provides a more comprehensive account of what can be considered usual in the general population in terms of the type and frequency of forgetfulness. It also provides opportunity for the establishment of normative data specific to the older Irish population, the need for which is suspected from cross-national comparisons of memory and health data more generally.

For example, data from the TILDA study showed that Irish people self-reported better memory than their English counterparts (Savva, Maty, Setti & Feeney, 2011), indicating differences between the two national populations in self-perceived memory difficulties.

Although the TILDA study employed a single general item asking people to self-rate their memory at the present time as excellent, very good, good, fair, or poor, other findings in the literature reveal significant differences in mean scores on the PRMQ between countries, specifically Sweden and the UK (Ronnlund, Mantyla & Nilsson, 2008), further highlighting the potential need for country-specific normative data for self-reported memory failures.

2.5 Factors impacting on memory (self-reported and/or objective)

2.5.1 Impact of demographic factors:

2.5.1.1 Age: Since there is a general decline in cognitive functioning with age (Jonker et al., 2000), an association between age and self-reported memory failures may be expected. However, findings in this regard have differed (Montejo et al., 2014). While an association between memory complaints and increasing age has been demonstrated in many studies (e.g. Trouton, Stewart & Prince, 2006; Montejo et al., 2011), this relationship is not conclusive. For example, Jorm et al. (1997) found no relationship between increasing age and either a general question about memory complaints or an eight-point scale of specific questions about everyday memory problems, and Montejo et al (2014) did not find a significant correlation between self-reported memory failures, measured by a structured questionnaire or three complaint questions, and the age variable. Neither did age influence PRMQ scores in middle-aged and older people in UK samples in several investigations (Crawford et al., 2003;2006; Smith, Della Sala, Logie & Maylor, 2000). In contrast, Ronnlund et al (2008) found that higher age was associated with minor decrements in self-reported PM failures on the PRMQ in a Swedish sample. A lack of age effects in studies of subjective cognition may be attributable to the normalisation of perceived memory failures due to ageing expectations, social comparison, or attributing forgetfulness to other conditions (e.g. Hodgson & Cutler, 2004; Prohaska, Keller, Leventhal & Leventhal, 1987; Connell & Gallant, 1996; Werner, 2003; Oritz & Fitten, 2000; Wackerbath & Johnson, 2002).

2.5.1.2 Gender: Findings related to the effects of gender on self-reported memory failures are inconsistent. Crawford et al (2003) found that women reported fewer retrospective memory failures than men on the PRMQ. This is in contrast to a study using the PRMQ in Brazil, which found women reported more retrospective and prospective memory than men. Other clinical and population-based studies using the PRMQ show that female gender is generally associated with more subjective memory failures (Jonker et al., 2000; Crook, Feher & Larabee, 1992), and some authors have attributed this to the higher prevalence rates of depression in females compared to males (e.g. Jorm et al, 1997). However, Montejo et al (2011) found that females reported significantly more subjective memory problems than men even after controlling for depression and anxiety. In contrast, Mendes et al (2008), using the Subjective Memory Complaints (SMC) scale (Schmand et al., 1996) found no gender effect of self-reported memory failures. Similarly, TILDA reported no significant difference between men and women in response to a single item of self-rated memory (Barrett et al., 2011).

2.5.1.3 Education: Findings regarding the effect of education on self-reported memory are inconclusive, with methodological differences being cited as the reason for this. Some studies (e.g. Blazer et al., 1997; Savva et al., 2013) found associations between education and self-reported memory failures such that a low level of education is associated with more self-reported failures , and the TILDA study also found self-rated memory assessed by a single item was poorer in those with low education, and this association was most pronounced in the young-old, i.e. 50 – 64 year age group (Barrett, Burke, Cronin, Hickey and Kamiya (2011). Other studies have demonstrated more self-reported memory failures in subjects self-reporting a higher level of education (e.g. Comijs, Deeg, Dik, Twisk & Jonker, 2002). A review of clinical and population-based studies concluded that memory complaints in highly educated elderly subjects may be predictive of dementia even when there is no indication of cognitive impairment on short cognitive screen tests (Jonker et al., 2000).

2.5.1.4 Marital Status: Marital status is a significant social factor associated with health and cognition (Mousavi-Nasab, Komi-Nouri, Sundstrom & Nilsson, 2012). Despite the positive associations between marital status and various health factors (Mousavi-Nasab et al., 2012), there appear to be fewer studies that have specifically reported the relationship between marital status and either objective or subjective cognitive functioning. However, marital status was seen to exert effects on objective episodic and semantic memory on healthy milddle-aged and old adults in a longitudinal population-based study in Sweden (Mousavi-Nasabi et al.,2012), such that married people showed significantly better performance on recall and recognition subtests of episodic memory. The rate of decline was also significantly larger for singles and widowed than other groups over the 5-year period across all ages.

A few studies do confirm a relationship between marital status and Alzheimer's disease (AD) and show an excess risk for development of AD among never-married individuals (e.g. Helmer et al., 1999). In general, living without a partner appears to confer an increased risk for development of cognitive impairment and dementia (Hakansson et al., 2009).

Fewer studies report the direct relationship between self-reported memory ability and marital status. However, in Israel, a large sample of community dwelling older adults' participants with and without self-reported memory failures did not differ in marital status (Balash et al., 2013).

Marital status of people aged 50 and above in Ireland however exhibits a unique marital status pattern compared with many other European countries due to our unique historical inheritance pattern. Marital status here differs as a function of education and gender, with the proportion of men who never married

decreasing with increasing educational attainment but more highly educated women being less likely to have married, relative to those with second level schooling (Barrett et al., 2011).

The marital status response categories in the current study were mirrored from the most recent Irish Census and included a response option for Civil Partnership.

2.5.1.5 Occupation: Objective cognitive impairment has been found to be more prevalent in individuals with low-qualification occupations than in those with high qualification occupations (Juncos-Rabadan et al., 2012). Cognitively complex or demanding work was shown to confer a protective effect on cognitive ability in later life in both men and women (Shcooler, Mulatu & Oates, 1999; Smart, Gow & Deary, 2014). In a sample of US veterans, the effect was independent of education and intelligence (Potter, Helms & Plassman, 2008). Considerably less attention has been granted in the literature to the association of current or previous occupation with subjective memory.

Several variables are known to impact memory and are of interest in their own right as predictors of objective and self-reported and cognitive problems (Cutler & Grams, 1988). Each of these factors may impact on subjective and objective memory performance and may confound the relationship between subjective and objective cognitive performance (Montejo et al., 2014). A deeper understanding of these variables relating to sociodemographic characteristics, mood state, sleeping difficulties and physical health, that may be associated with self-reported memory failures could arguably help Primary Care professionals to better identify individuals at an early stage of cognitive decline or subtle cognitive impairment or increased risk for further cognitive deterioration. Information regarding significant associations of other variables to subjective memory complaints are also helpful in the context of identifying individuals who might benefit from social prescribing, i.e. non-clinical interventions usually involving referral to local voluntary services and community groups (Brown, Friedli & Watson, 2004).

Drawing on the findings of Hart, Burns, Brown and Barrowclough, (2012), Steinberg and colleagues (2013) argue that greater awareness is needed regarding the value of measuring self-reported memory problems among both practitioners and individuals in the community. Since many older adults do not complain about, or seek help for, their memory (Waldorff et al., 2008; Commissaris et al., 1993), even though these concerns can cause considerable distress to them (Commissaris et al., 1998; Mol et al., 2007), more extensive knowledge of the associations of self-reported memory failures with other variables may give practitioners a greater appreciation for the value of assessing or inquiring as to an older individual's cognitive functioning.

The decision to assess may be more easily informed by the presence of certain comorbid symptoms or person characteristics, and on the other hand, memory complaints themselves may be an indicator of the presence of these other symptoms or conditions that may warrant attention in and of themselves. Knowledge of other variables associated with subjective memory ability can therefore help GPs to be more adept at identifying individuals with subtle cognitive dysfunction so that they can implement interventions to help build and maintain cognitive resilience or assist older adults with implementing lifestyle changes to prevent further cognitive decline.

Depression, in particular, has shown consistent associations with self-reported memory failures and objective memory performance (Gagnon et al., 1994; Derouesne et al., 1999), and an increasing number of studies show an association with anxiety (e.g. Steinberg et al., 2013; Hanninen et al., 1994; Derouesne et al., 1999). Assessment of self-reported depression and anxiety were, therefore, included in the methodology of the current thesis, alongside other demographic variables associated with self-reported memory, albeit inconsistently – age, gender and education – as well as health-related variables and sleep variables.

The rationale for assessment of each of these variables when assessing memory is outlined below.

2.5.1.6 Impact of mood state (anxiety and depression)

Numerous studies, of both community volunteers (Montejo et al., 2011) and self-referred memory clinic attendees (Bolla et al., 1991; Derouesne et al., 1999) have shown that self-reported memory failures are strongly associated with self-reported symptoms of depression. Higher PRMQ scores, reflecting poorer self-reported memory, were associated with subclinical depression as measured by the Geriatric Depression Scale (GDS) in one study of healthy older community dwelling adults aged 65 years and above (Steinberg et al., 2013). Memory complaints are more common in those with self-reported depression than in those without (Montejo et al., 2011), and self-reported depression is often a stronger predictor of self-reported memory problems than objective cognitive status in cross-sectional studies (e.g. Jonker et al., 1996; Grut et al., 1993; Bolla et al., 1991). Depression also negatively affects cognitive ability as measured by objective tests (Montejo et al., 2014). In particular, memory problems reported by self-referrals to a memory clinic (Bolla et al., 1991; Barker, Prior & Jones, 1995; Derouesne, Guigot & Chatellier, 1995) were more often correlated with depressive symptoms than poor objective cognitive performance.

Depressive symptoms in and of themselves are claimed by some authors to predict the development of dementia (Gatz, Tyas, St. John & Montgomery, 2005), while other authors propose they are early manifestations, rather than predictors, of Alzheimer's disease (Chen, Ganguli, Mulsant & DeKosky, 1999).

In line with this latter theory, subjective memory failures in those self-reporting depression may be reflective of a genuine cognitive deficit, indicative of an early pathological dementia process presenting as depression. Alternatively, perceived failures of everyday memory may be a result of poor motivation or concentration resulting from depression (Jae-Min, Stewart, Il-Seon, Sung-Ku & Jin-Sang, 2003), as mood disorders themselves may present with a distinct pattern of cognitive impairment (Austin, Mitchell & Goodwin, 2001). Tobiansky, Blizard and Livingston (1995) studied a community sample of elderly residents with a 2-year follow-up period and found that subjects with self-reported memory problems were at a four-fold increased risk of developing dementia, and a two-fold increased risk of developing depression. Self-reported memory failures are therefore of interest as potential predictor or risk factor for depression even in people with no previous history of depression (Heun & Hein, 2005).

Depression and subthreshold depression is common in the general population in Ireland, with 10% of the population reporting clinically significant depressive symptoms and a further 18% reporting "subthreshold" levels of depression in the TILDA study, with a large percentage of cases (78%) going undiagnosed (Barrett et al., 2011). As even subthreshold levels of depression lead to cognitive changes (Martinez-Aran et al., 2004) it was deemed important for the purpose of this study to assess self-reported depression and to explore its relationship with self-reported memory failures in otherwise healthy community dwelling older adults.

Research also demonstrates a relationship between self-reported anxiety and self-reported memory ability in community dwelling adults (e.g. Balash et al., 2013) as well as in clinical samples (e.g. Schilling & Jenkins, 2007). Higher PRMQ scores correlated with both higher self-reported depression and anxiety as measured by the DASS anxiety subscale in a study of community dwelling older adults followed for 3 years (Steinberg et al., 2013). Although the overall levels of depression and anxiety in the sample were considered low by normative standards in that study, the association persisted. Anxiety is known to negatively impacts objective cognitive performance (Eyesenck, Derakshan, Santos & Calvo, 2007) and the relationship between late-life anxiety and cognition appears to be reciprocal (Beaudreau & O'Hara, 2008) and has been proposed as strong predictor for future cognitive decline, either directly, or indirectly (via depression) (Sinoff & Werner, 2003). However, the effects of anxiety symptoms on cognition have been less well studied than depression, and findings regarding the predictive validity of anxiety for cognitive impairment and dementia have been inconsistent; for example, Gallagher et al., 2011 concluded that anxiety symptoms were not independent of cognitive function at baseline, and so may be a marker of severity of cognitive impairment rather than a risk factor.

In Ireland, the TILDA study revealed that anxiety and subthreshold anxiety are very common in the older general population, and anxiety is more common in this age group than depression. 13% of the TILDA sample reported clinical level anxiety, and 29% reported subclinical levels of anxiety. Like depression, anxiety also goes undiagnosed in many older Irish people. 85% of older Irish adults who presented with objective anxiety in the study did not report a doctor's diagnosis. Based on all the above findings, it was considered important to include anxiety as a variable for assessment in the present survey study, and to explore its relationship to self-reported memory.

2.5.1.7 Sleep: Difficulties sleeping are common across the lifespan (Stojanovski, Rasu, Balkrishnan & Nahata, 2007; Hayley et al., 2015) and are not an inevitable part of aging. Potential reasons for sleep difficulties include medical and psychiatric illness, the medications used to treat these illnesses, circadian rhythm changes, or other sleep disorders (Ancoli-Israel & Ayalon, 2006).

Sleep quality and quantity problems experienced by older adults include problems with sleep onset (being able to fall asleep quickly) and sleep maintenance (staying asleep throughout the night) (Hartescu, Morgan & Stevinson, 2016) as well as early morning arousal (Foley et al., 1995). Sleep disturbances are common in people with dementia (Grace, Walker & McKeith, 2000). Poor sleep quality and deficiency may be a risk factor for cognitive impairment and Alzheimer's Dementia (AD) (Codazo-Minguez & Cowburn, 2001), possibly because sleep deprivation induces more build-up of the protein Amyloid Beta in the brain, while adequate sleep reduces it. The build-up of Amyloid Beta may also cause disturbed sleep patterns and increased wakefulness (Ju, Lucey & Holtzman, 2014). Reflecting this, community-dwelling older individuals with early amyloid deposition but without MCI have been found to self-self-report cognitive problems (Spira et al., 2013).

A chronic sleep restriction experiment in younger adults demonstrated a dose-response effect of chronic restricted sleep periods of 4 to 6 hours per night over 14 consecutive days on cognitive performance (Van Dongen, Maislin, Mullington & Dinges, 2003). The inclusion in the present study of a self-report question assessing the self-perceived length of time older participants have been experiencing sleep difficulties enables exploration, if one wishes, of the cumulative subjective effects of sleep difficulties over an even longer time span (from less than 1 month to 11 or more years). Similarly, obtaining self-perceived reason(s) for these sleep difficulties help to clarify the relationship between subjective sleep problems and subjective memory complaints and to determine correlates or predictors of poor subjective sleep quantity and quality which may form targets for primary preventive intervention by primary care professionals.

2.5.1.8 Physical Conditions: The link between physical and cognitive health.

The search for early signs of cognitive decline, of which self-reported memory failures can be one part, has led also to increasing interest in the connection between adverse physical health and cognitive problems. Cognitive frailty is a recent construct referring to a heterogeneous age-related clinical syndrome wherein physical frailty co-occurs with reversible cognitive impairment (Ruan et al., 2017). Both physical frailty and cognitive impairment may interact with each other in a cycle of decline (Robertson et al., 2013). Chronic diseases and other health conditions of varying severity may act alone or in combination to exacerbate frailty, and vice-versa. Even treatment of pre-existing physical health conditions may have side-effects which further contribute to both physical frailty and/or the cognitive frailty syndrome (Weiss, 2011). Chronic diseases and other significant health conditions are therefore of interest in relation to the assessment of subjective and objective memory.

Weiss (2011) lists the chronic diseases that have been associated with frailty in published cohort studies of older adults such as the Women's Health and Aging Studies I and II, the Ivecchiare in Chianti Study and the Cardiovascular Health Study, all of which used standardised forms of disease ascertainment. These are; hypertension, chronic kidney disease, osteoarthritis, depressive symptoms, coronary heart disease, diabetes mellitus, chronic lower respiratory disease, myocardial infarction, rheumatoid arthritis, stroke, peripheral arterial disease, and congestive heart failure.

An association between self-reported physical ill health and subjective memory was demonstrated in a 6-year follow-up of the Amsterdam Longitudinal Study of Aging (LASA) cohort (Comijs et al., 2002), such that participants with memory complaints reported more chronic diseases at all three measurement occasions in the study. Montejo et al (2011) found that self-perceived health – over and above depression and anxiety – was an independent predictor of subjective memory complaints. Similarly, Cutler and Grams (1988) found that health was one of the best predictors of everyday memory problems.

Health conditions assessed in the questionnaire used in the present study are **cardiovascular disease:** hormonal problems, breathing problems, **diabetes,** chronic pain, a**rthritis:**, c**onditions arising from dysfunction of the enteric nervous system (ENS):** gastric problems, ulcerative colitis, Crohn's disease, thyroid disorders. For the interested reader, a very brief overview of these complaints is provided in Appendix A.

2.5.1.9: Alcohol

Ireland has one of the highest levels of alcohol consumption in the European Union (European Commission, 2010). It is well established that habitual excess alcohol intake is harmful to the brain and cognitive function (Chick et al., 1989), interfering for example with the ability to form new long-term memories (White, 2003). Long term excessive intake is associated with cognitive impairment and dementia (Kim et al., 2012). However, some studies have documented better cognitive test scores among moderate drinkers (e.g. Dufouil, Ducimetiere & Alperovitch, 1997; Stampfer, Kang, Chen, Cherry & Godstein, 2005). In terms of the association between alcohol use and self-reported memory failures, it was difficult to identify studies that reported specific findings on this relationship.

2.6 Conclusion and rationale for the current studies.

This chapter attempted to outline the importance of cognitive assessment, the need for earlier detection of subtle cognitive dysfunction in Primary Care, and some of the difficulties inherent in this endeavour. This chapter has provided an account of the various approaches and methods currently available for assessing cognitive function in a primary care context. It has also given an overview of the main strengths and limitations inherent in these assessment methods, as well as the issues crucial to the reliable and sensitive assessment of memory and other difficulties.

An issue of paramount importance is the relative neglect of PM assessment in clinical settings including in Primary Care. This is of both surprise and concern given the impact of PM impairments on the independent functioning of older adults, the evidence that PM impairment is in some cases an even more sensitive indicator of cognitive decline than is RM and since it has been evidenced that self-reported PM failures can predict subsequent cognitive decline and dementia in older adults. The current research project aimed to address this gap and to redress this lack of attention to the assessment of PM by exploring the extent to which PM failures are experienced by healthy Irish older adults, and by clarifying the relationship between PM failures and objective performance on recommended cognitive tests, including performance on an objective test of PM. Following on from these endeavours, the project aimed to develop a reliable, yet briefer assessment tool for measuring self-reported PM that might be a useful adjunct to brief objective cognitive assessment in Primary Care.

Finally, the chapter presented a brief description of sociodemographic and other important variables known to be associated with memory and cognitive problems and that are, therefore, imperative to consider in an assessment of cognitive impairment. More extensive knowledge of factors and conditions associated with cognitive and memory complaints may assist Primary Care professionals in the

identification of individuals potentially at risk of cognitive impairment and allow them to provide better tailor person-centred interventions to build cognitive resilience.

The next chapter, Chapter 3, will describe the general methods used to achieve the goals and aims of Study 1, Study 2 and Study 3.

Chapter 3: Overview of Methodology

For presenting the work undertaken as part of this thesis, an overview of the general methodology employed for **Study 1:** Self-Reported Memory Failure – Nature, Frequency and Correlates, **Study 2:** Self-reported and objective memory performance in older adults, **Study 3:** Construction of a short-form PRMQ and **Study 4:** Normative Data for Older Irish Adults are outlined in this chapter. More specific detail in relation to each study is presented in the relevant study chapter.

3.1 Study 1: Self-Reported Memory Failure – Nature, Frequency and Correlates

3.1.1 Study Design

To achieve its aims of determining the nature, prevalence and possible underlying causes of self-reported cognitive difficulties in older Irish adults, Study 1 employed a cross-sectional, correlational research design. An anonymous survey (see below), supplied in either electronic or hardcopy format was used to capture the required data.

3.1.2 Participant Recruitment and Eligibility Criteria

Healthy community-dwelling older adults, aged 50 years and above, were recruited using a snowballing technique, through a number of community–based organisations throughout Ireland. These community–based organisations included the DCU Intergenerational Learning Centre, active retirement groups, education groups (e.g. SAGE, Third Age), carer associations, an Alzheimer café, other social and recreational groups (e.g. choirs, beekeepers associations, bridge and sports clubs, men sheds, the Irish Countrywomen Association), parish newsletters and magazines, and through poster advertisement and word of mouth via local businesses, e.g. hair salon, coffee shop etc.

As the online questionnaire was easily accessed through an email link provided to the key personnel of these organisations (for onward distribution to potential participants), this ensured as wide a representation as possible of urban and rural community dwellers to this version of the questionnaire. However, because of the anonymous nature of the study, it was not possible to obtain a specific record of how and how often this email link was distributed. A concerted effort was, however, made to contact the heads of organisations and clubs from each of the counties in Ireland. The relevant heads of these organisations were contacted by email or telephone, briefed about the study and asked for their support in recruitment through advertising the study to potential participants (e.g. through their issuing a Call for Volunteers - see Appendix B - to their membership lists). Participants were also recruited by means of advertisement in strategic locations around DCU campus and public spaces in the wider

Dublin and Connemara area. Among the locations selected for placing the ads were public libraries and museums.

3.1.2.1 Inclusion and Exclusion Criteria

Only those older adults who provided informed consent were recruited and each of these was required to confirm that, to the best of their knowledge, they met the inclusion criteria for the study and did not suffer from any of the conditions detailed as exclusion criteria.

Inclusion criteria were:

- Age 50 years or over
    - as this represents the age cohort of interest and as this is the age range within which people tend to self-report increased levels of memory lapses and other cognitive changes.
- Fluency in English
    - as fluency in English was considered necessary for accurate comprehension and interpretation of survey questions.
- Able to read
    - as adequate literacy skill was considered necessary for accurate reading and understanding the survey questions.
- Healthy for age
    - Of note, potential participants were not excluded based on having one or more illnesses or medical conditions – provided they could be considered generally healthy for their age group.

Exclusion criteria, as outlined in the Study Plain Language Statement (PLS) (see Appendix C) were:

- Dementia diagnosis
- Parkinson's disease or another neurological condition
    - Memory and other cognitive functions are known to be impaired or impacted in Parkinson's disease (Aarsland et al., 2010) and other neurological conditions such as Multiple Sclerosis (Chiaravalloti & De Luca, 2008) and epilepsy (Giovagnoli & Avanzini, 1999).
- Significant psychiatric illness
    - Significant psychiatric illnesses were included as exclusion criteria as aspects of cognitive function are commonly impaired in psychiatric disorders such as clinical depression (Sweeney, Kmiec & Kupfer, 2000), schizophrenia (O'Carroll, 2000) and

clinical anxiety (Mantella et al., 2007). Drug treatments of psychiatric disorders also have known potential adverse effects on neurocognition (Moritz, Ferahli, & Naber, 2004). Self-reported difficulties with attention are also prevalent in people with clinical depression, anxiety and schizophrenia (Moritz et al., 2004). However, it is worth noting that many cases of depression and anxiety go undiagnosed in the older population in Ireland and elsewhere, and sub-threshold levels of depression and anxiety are also very common (Barret et al., 2011). The prevalence of these sub-clinical symptoms of anxiety and depression in the older adult population, and interest in their associations with self-reported memory lapses and other cognitive problems, precludes the exclusion of individuals with sub-threshold (or sub-clinical) levels of anxiety and/or depression from participating in this study.

- Learning disability
  - o Significant or severe learning disability was included as an exclusion criterion as severe learning disabilities are associated with a range of cognitive sequelae (Weintraub & Mesulam, 1983) that would impact negatively on memory and other aspects of cognition.

- Significant hearing or visual impairment
  - o Significant sensory impairment (visual or hearing) was included as an exclusion criterion as many aspects of cognition are dependent on efficient information processing (speed and accuracy), and a sensory impairment leads to deficient information encoding that is likely to negatively affect memory performance (Cutler & Grams, 1988). However, some degree of sensory impairment is common in older people (Barret et al., 2011) and people with less severe visual or hearing problems, corrected to normal (or near normal) by the use of reading glasses or hearing aids, were, therefore, permitted to take part in the study.

3.1.2.2 Final Sample

A convenience sample of 533 healthy participants aged 50 years and over was recruited, on a volunteer basis, from the community. The demographic characteristics of this study sample are described in detail in Chapter 4.

3.1.3 Study Procedure

3.1.3.1 Ethical considerations

All aspects of this study were approved by the DCU Research Ethics Committee (DCUREC) (Reference: DCUREC/2015/2016 - see Appendix D). In preparing and submitting the ethics application for this study

to DCUREC, the possibility that participants might become concerned about either their cognitive functioning or their emotional well-being as a result of completing a survey about their cognition and mood state was clearly recognised. To reduce the possibility of needlessly upsetting participants, all potential participants were briefed about this possibility in the PLS - for both the hard copy and the online versions of the survey (Appendix C) and in the online and hardcopy versions of the Consent Form (see Appendix E1 and E2 respectively). Potential participants were also advised to consider speaking with their GP or others before deciding whether or not to participate in the study.

All participants were advised in a Debriefing Statement at the end of the study survey (see Appendix F) to consider consulting with their GP should they have any concerns about their cognitive function and/or emotional well-being.

Study data were collected in an anonymous fashion. Neither the online nor the hardcopy versions of the questionnaires required participants to provide their names or address and no information was collected that could potentially identify participants (other than for the purpose of forwarding a hardcopy of the survey – where this was requested). Any personal data (name, address and phone number) collected for this purpose from participants who requested a hardcopy questionnaire was destroyed as soon as the hardcopy materials were dispatched to the potential participant, thereby ensuring anonymity of the returned data.

For those who elected to complete the online questionnaire, consent was documented through active endorsement of a number of statements. Hardcopy surveys, similar to the online format, did not request information that could identify the respondent and consent was documented through active endorsement of a number of questions.

Study questionnaires were made available in electronic (online) as well as hardcopy (paper) format to reach as large a number of older people as possible, including those who did not have access to email or were not computer-confident. The online questionnaire, comprising the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith et al., 2000), the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1982) and demographic questionnaires was built in the secure online survey platform Qualtrics (2018). Following the Call for Volunteers, potential participants who expressed an interest in the study were given the choice of receiving the online or paper versions of the questionnaire.

Potential participants who choose to complete the survey online were directed, via the Call for Volunteers, to go online to the secure survey site, Qualtrics, to obtain further information about the study, and, if interested, to provide consent and to complete the questionnaire. The electronic version

of the Call for Volunteers contained a direct link to the Qualtrics survey. Participants also had the option of entering the *URL* into Google or another search engine.

Potential participants who were not comfortable with computers or who did not have access to computer facilities, were invited to contact the research team, who then made a paper copy of the questionnaire available to them, alongside a hardcopy of the PLS and Informed Consent Sheet. Paper copies were mailed to those who requested them, together with a stamped addressed envelope (SAE), for convenient return of the completed questionnaire. This strategy was used to help obtain as representative a sample of older adults as possible.

Only those who provided consent, as evidenced through the active endorsement of the relevant statements, were recruited. Consent for the questionnaires was documented through a process of active endorsement of a number of statements that had to be addressed prior to gaining access to the online questionnaire and prior to completion of the hard copy version. All participants were required to confirm that, to the best of their knowledge, they met the inclusion criteria for the study and did not suffer from any of the conditions detailed as exclusion criteria.

Online questionnaires were distributed via an anonymised link through Qualtrics. Participants requesting postal/hardcopy questionnaires were assured, in the PLS, that all survey information would be collected in anonymised format – no identifying information was requested - and that they should return the questionnaire via the SAE to DCU. Because of the anonymous nature of the survey data, participants were informed, in the PLS and Informed Consent Sheet, that individual feedback could not be offered as routine practice. However, a one-page summary of the results of the study would be made available to interested participants following analysis of the data for submission as part fulfilment of a thesis.

3.1.3.2 Materials and Test Measures

An anonymous survey (see Appendix F) that included two standardised self-report measures and several other questions was administered in online and hardcopy format and obtained the following information:

- Self-reported memory failures – using the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith et al., 2000).

  - As noted in Chapter 2, the PRMQ is a self-report measure of prospective (PM) and retrospective (RM) memory failures in everyday life. It is the only self-report instrument assessing both PM and RM memory. The instrument consists of 16 items; half of these refer to PM failures (e.g. How often do you: "decide to do something in a

few minutes time and then forget to do it?") and half refer to RM failures (e.g. How often do you: *"fail to recognise a place you have visited before?").* The questions are categorised further into event-based/time-based and short-term/long-term memory tasks, with two questions in each of the eight categories (PM/RM x event-based/time-based x short-term/long-term).

The participant is asked to answer each of the 16 questions by rating the frequency with which they make the described error, e.g. How often do you: *"decide to do something in a few minutes' time and then forget to do it?"* Choice of response is in a Likert format, as follows; "very often" (score = 5), "quite often" (score = 4), "sometimes" (score = 3), "rarely" (score = 2), "never" (score = 1). Thus, across the 16 items (i.e. PRMQ Total), the minimum raw score is 16 while the maximum raw score is 80, with *higher raw scores* representing *poorer self-reported memory*. On each of the two subscales (PM and RM), the minimum raw score is 8 while the maximum raw score is 40, with *higher scores* again representing *poorer self-reported memory*. In total, the PRMQ takes less than 10 minutes to complete.

Crawford et al. (2003) established normative data for the PRMQ using 551 healthy participants aged 17 to 94 from the UK general community. Factor analyses of the PRMQ has generally found agreement for a tripartite factor structure consisting of a general memory factor which all items load on, and two orthogonal factors of PM and RM (Crawford et al., 2003; Ronnlund et al., 2008). Crawford et al. found good reliability estimates using Cronbach's alpha, of .89 for the PRMQ Total Scale, .84 for the PRMQ PM Scale and .80 for the PRMQ RM scale, and they calculated mean scores and standard deviations for each of the scales. Age and sex were not found to be significantly associated with performance on the PRMQ.

Typically, raw scores on the PRMQ scales are converted to T-scores. Here, raw scores are *'reflected'* such that when converted to T-scores (mean = 50, standard deviation = 10), *higher scores* now represent *better memory* (i.e. fewer self-reported memory failures).

A copy of the PRMQ is available for free download from a webpage hosted by the University of Edinburgh, on condition that it is used for the purpose of not-for-profit research and that the authors of the original article are cited in resulting publications; see **www.psy.ed.ac.uk/psy_research/PRMQ_authorisation.php**

- Mood state - using the self-report Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1982).
  - The HADS is one of the most widely used instruments for the assessment of anxiety and depression in older adults (Roberts, Fletcher & Merrick, 2014).

    It was originally developed to identify "caseness" (possible and probable) of anxiety and depression among patients in non-psychiatric wards (Zigmond and Snaith, 1983). Since then, its use has been extended to outpatient and community settings (Dunbar et al., 2000; Caci et al., 2003). The HADS is reported to be well-accepted (Hermann, 1997) and easy to use. It contains 14 items, divided into two subscales measuring either anxiety (HADA) or depression (HADD). It requires the self-assessment of symptoms of anxiety and depression over the preceding week, rated on a 4-point Likert scale. There is a maximum score of 21 on each subscale, and higher scores correspond to higher disease severity (Johnston, Pollard & Hennessy, 2000). It may be particularly suited to the detection of mood disturbance in the elderly because the measure does not contain any physical indicators of psychological distress that might lead to confounding of depression with somatic disorders (Hermann, 1997; Bjelland, Dahl, Haug & Neckelmann (2002). The "floor-effect" often seen with assessment of depression in non-psychiatric individuals is also avoided because items measuring severe psychopathology are also omitted. The HADS has good reported psychometric properties, with moderate to high internal consistency (Cronbach's alpha coefficients of 0.73 - 0.85; Helvik, Engedal, Skancke & Selbaek (2011) and good test-retest reliability over an average three-week period for the anxiety (0.89), depression (0.86) and total scales (0.91; Spinhoven et al., 1997).

    The research team holds a site license for use of this questionnaire.

- Sociodemographic Data
  - This aspect of the survey contained questions on participant demographics (age, gender, occupation, education), health status, alcohol use, sleep duration and sleep difficulties. The rationale for inclusion of each of these variables in the sociodemographic questionnaire derives from a review of the literature summarised in Chapter 2.

- o Data related to both **age and gender** were obtained because of the possible link between these variables and cognitive performance.
- o To address the possible effects of **education** on PRMQ and other test scores in an older Irish population, years of education, as well as highest level of education obtained, were included. Bands for education level were taken from the Irish Census of Population (www.cso.ie).
- o Data were also obtained in relation to **occupation**. The data collection format used to capture current or past occupation in this study differed from the free-text format used in the National Census. Here, a categorical format was chosen to facilitate easier analysis and cross-national comparison. Occupational categories used in this study were previously utilised in the European IN-MINDD (Innovative Midlife INtervetion for Dementia Deterrence) study (www.inmindd.eu). These categories were used in the In-MINDD study for the purpose of cross-national comparison. For the present research project, these predetermined categories of occupation were considered more manageable and interpretable from an analytic perspective than the free text format utilised, for example, in the Irish Census.
- Health related data (physical health conditions, alcohol drinking status)
  - o The physical conditions assessed in the present study are in harmony with those assessed by cohort studies of aging that demonstrated an association with objective frailty, and are not dissimilar to the somatic symptoms and chronic disease assessed via self-report in other population-based studies that also investigated subjective memory, such as The Irish Longitudinal Study of Aging (TILDA; Barrett et al., 2011), the Kungsholmen Project in Swededn (Frisioni et al., 2000) and the Amsterdam Longitudinal Study of Aging (LASA; Comijs et al., 2002).
  - o Physical health conditions self-assessed in the present study were chosen based on their prevalence in older people and on their potential or evidenced association with subjective or objective cognitive problems and physical frailty. The health conditions included for specific mention in the survey were:
    - ▪ Cardiovascular Disease
    - ▪ Hormonal problems
    - ▪ Breathing problems
    - ▪ Diabetes
    - ▪ Chronic pain
    - ▪ Arthritis

- Conditions arising from dysfunction of the Enteric Nervous System (ENS):

  Gastric problems, Ulcerative Colitis, Crohn's Disease and Thyroiditis

Participants also had space and opportunity to record any other physical conditions that they felt were noteworthy but that were not included in the list on the sociodemographic questionnaire. For all physical health conditions, participants were asked to record how long, in years and months, they have experienced the condition.

Participants were also asked about **alcohol consumption**. Here, all participants were required to respond Yes or No to the question as to whether they drink alcohol. Since alcohol problems may be unrecognised or under-reported, those participants who drink alcohol were also asked to respond Yes or No to the question of whether they ever felt they needed a drink ("eye opener") first thing in the morning. This question was used as a screening question for alcohol misuse and was taken from the CAGE questionnaire (Ewing, 1984) which is a popular self-report measure of alcohol use problems, developed originally to identify the hidden alcoholic in hospital settings (Magruder-Habib, Durand & Frey, 1991). It is commonly used as a screen for alcohol use disorder in the primary care setting (Volk, Cantor, Steinbauer & Cass, 1997). Use of all four CAGE questions in TILDA resulted in the identification of a higher percentage of alcohol misuse cases in the older Irish population than would be detected based purely on the basis of a formal diagnoses of alcohol use disorders (Cronin, O'Regan & Kenny, 2011). The specific question selected for use in this study reflects the most salient of the four CAGE questions in terms of alcohol use problems.

- Sleep data
  - In relation to **sleep,** participants were asked questions pertaining to difficulties falling asleep ("Do you generally find it difficult to fall asleep?"), difficulties staying asleep ("Do you ever wake up during the night?"), and problems with waking earlier than intended ("Do you wake up earlier than intended?"). Participants responding Yes to any of these questions were asked to indicate when the particular sleep problem began ("Less than 1 month ago; 1 – 2 months ago; 3 – 6 months ago; 7 – 12 months ago; 1 – 2 years ago; 3 – 5 years ago; 6 – 10 years ago; 11 or more years ago") and how often the sleep problem occurred (7 nights per week; 4 – 6 nights per week; 2 – 3 nights per week; 1 night per week). They were also asked to indicate self-perceived reason(s) for the particular sleep problem (i.e. anxiety, diet, caffeine, pain, physical condition,

inactivity or other reason(s)). If participants indicated "other reason(s)" they were asked to specify the reason(s).

- o Participants were also asked how many hours, on average, they slept per night. As with the preceding sleep questions, participants were then asked to indicate when this began to be the average number of hours slept per night, how often this was the number of hours slept per night, and to indicate the self-perceived reason for this being the average number of hours slept per night (an extra response choice to this question in addition to the response choices outlined as per the preceding sleep questions was "This is the amount of sleep my body needs to feel rested").

The choice of sleep questions was informed by studies in the literature that have reported that poor sleepers subjectively experience longer sleep latencies, frequent nocturnal awakenings or waking during the night, less total sleep time, more difficulty initiating and maintaining sleep, as well as excessive daytime sleepiness (Lugaresi, Cirignotta, Zucconi, Mondini, Luigi Lenzi & Coccagna, 1983; Morin & Gramling, 1989; Bilwise, 1992). An epidemiological, cross-sectional, study of Dutch community-dwelling older adults assessed participants on quality of sleep, sleep latency (length of time to sleep), night time awakenings (sleep maintenance) and excessive daytime sleepiness (which, arguably, may manifest in napping behaviours) as well as time spent in bed (which may approximate, though not map exactly, hours of sleep) (Middelkoop, Smilde-van den Doel, Neven, Kamphuisen & Springer, 1996). Together, the designs and findings of these studies were taken into consideration to guide the inclusion of the sleep questions in the sociodemographic questionnaire used in Study 1 and Study 2.

3.1.3.3 Pilot Study

The demographic questionnaire was piloted on a number of healthy volunteers of various ages prior to acceptance of the final edition for use in this study. Some of the amendments made to the questionnaire on the basis of the pilot feedback included wording and formatting changes, as well as an extra choice of possible reasons for the number of hours slept ("This is the amount of sleep my body needs to feel rested").

3.1.4 Data Analytic Strategy

Descriptive and inferential statistical analyses were performed on Study 1 data. The results of these analyses are described in greater detail in Chapter 5. Briefly, analyses of Study 1 data involved determination of the type and frequency of self-reported memory problems in the older Irish adult population. An investigation of the suitability of established normative data for the PRMQ for use in the older Irish population was also conducted. The relationship of self-reported memory failures as measures by the PRMQ with mood state, sleep, health and sociodemographic data was also examined via correlational and other inferential analyses.

3.2. Study 2: Self-reported and objective memory performance in older adults

3.2.1 Study Design

In order to achieve its goal of clarifying the relationships between self-reported memory problems and objective performance, taking into account relevant comorbidities and sociodemographic data, Study 2 employed a cross-sectional, correlational design involving a once-off face -to-face cognitive evaluation and administration of the same PRMQ, sociodemographic, health mood state and sleep questions as was administered in Study 1.

3.2.2 Participant Recruitment and Eligibility Criteria

PRMQ data and data on selected cognitive tests recommended for use in Primary Care (ICGP: 2014) were obtained from a separate and smaller sample ($n = 99$) of healthy community-dwelling older adults. Recruitment sites were similar to those detailed above for Study 1. Recruitment of healthy community-dwelling older adults aged 50 years and above was achieved using a snowball technique, through community-based organisations in the greater Dublin and surrounding areas. Recruitment efforts were confined to this geographical radius on practical consideration, as participants were required to travel, without monetary reimbursement, to DCU Sports Complex to complete a once-off, face-to-face, cognitive evaluation. Organisations contacted included active retirement groups, social clubs, bridge and other recreational groups, choirs, beekeeper associations, the Irish Countrywoman's Association (ICA), as well as parish newsletters and magazines.

As for Study 1, the relevant heads of these community-based organisations were first contacted and asked for their support in seeking volunteers (e.g., through their issuing a Call for Volunteers through their membership lists).

3.2.2.1 Inclusion and Exclusion Criteria

As with Study 1, inclusion criteria for Study 2 were; age 50 years and over, fluency in English, able to read and generally healthy for age. Exclusion criteria were a history of dementia, Parkinson's disease or other neurological condition known to impact cognition, significant psychiatric disability, learning disability and significant uncorrected hearing or visual impairment.

3.2.2.2 Final Sample

Because of incomplete data sets, two of those recruited to this study were subsequently dropped as not all of the cognitive data (which represented the core of this study) were available. Thus, the final sample consisted of 97 participants.

3.2.3 Study Procedure

3.2.3.1 Ethical considerations

Ethical approval for Study 2 was obtained from DCUREC at the same time as ethical approval for Study 1. In preparing and submitting the ethics application for this study to DCUREC, (Reference: DCUREC/2015/2016 see Appendix D). As for Study 1, following the Call for Volunteers (see Appendix G), only those who met the inclusion and exclusion criteria were recruited to take part in this study. Each of these participants were required to confirm that, to the best of their knowledge, they met the inclusion criteria for the study and did not suffer from any of the conditions detailed as exclusion criteria.

Participants were advised in the Study PLS and Consent Form (see Appendix H and Appendix I) that the estimated duration of the evaluation would be 70 – 90 minutes. Test breaks were offered throughout the session to avoid fatigue.

In anticipation of the possibility that participants might become concerned about either their cognitive function or their emotional wellbeing as a result of taking part in this study, participants were briefed about this possibility in the PLS and were advised to discuss their potential participation with others before deciding to volunteer for the study.

All participants were advised in person and, via the PLS and Consent Form, that although individual feedback could not be provided as a routine part of the research project, participants could request feedback on their individual test scores and could request a brief report for their GP. Participants were also informed as part of the consent process that their GP may request and would, following a written request, be provided with a summary report of their test scores.

Participants were also notified through the PLS and Consent Form that, in the event that an ostensibly healthy participant performed very poorly on any one or more of the cognitive screening tests, as determined with respect to the relevant cut-off scores, indicating severe memory problems, they would be advised to consult with their GP, while, at the same time, being advised that there are numerous potential explanations for poor performance and that poor performance should not be considered evidence of a significant medical problem. In such an event, the researcher would liaise with the participant to facilitate this GP contact by providing a copy of the test scores to the GP. Participants were further informed that their GP could be provided with information on participants' test performance by the research team if the GP required this information as part of routine general practice.

Both the PLS and the Consent Form detailed that, in the absence of a full clinical history and wider medical and neuropsychological assessment, test results could not be used in isolation for diagnostic purposes. All participants were informed in a debriefing statement (see Appendix J) that should they have any concerns about their memory and/or emotional well-being following participation in the study, they should consult with their GP.

Cognitive evaluation and completion of the self-report measures and sociodemographic questionnaires took place in the presence of the researcher. Therefore, this procedure was not strictly anonymous. Participants were assured, however, via the PLS and Consent Form that all information provided by them in the course of their evaluation would remain strictly confidential and that their information would be de-identified immediately upon completion of their evaluation. This de-identification was achieved by assigning ID numbers to each individual's questionnaire and cognitive test data.

Consent Forms containing the names of participants were subsequently stored securely in a locked filing cabinet in the research supervisor's office and these were stored separate to the data related to the individual. Only a unique ID number (linking the Consent Form to the data record sheets) was recorded with the test data and survey instrument. A record linking unique ID codes to each participant's data was stored securely and separately from the test data, and from the Consent Forms, in the research supervisor's office.

3.2.3.2 Materials and Methods

Participants were invited to come to DCU to undergo a once-off face-to-face cognitive evaluation and to complete the survey employed in Study 1. The PRMQ, the HADS and the questions relating to health, sleep and sociodemographic information employed in Study 1 were also administered as part of Study 2 (see above for details).

Objective cognitive assessment involved the completion of a number of objective cognitive tests selected for this study because:

1. they have been recommended for use in Primary Care, both here in Ireland, by the ICGP (see Foley & Swanwick, 2014 and Chapter 2) and in the USA, by the Alzheimer's Association (see Cordell et al., 2013 and Chapter 2) (Mini-Cog: Borson et al., 2000 and GPCOG, Brodaty et al, 2002)

   o *Note:* Although, as noted in Chapter 2, the Memory Impairment Screen (MIS) (Buschke et al., 1999; Kulansky et al., 2002) was also recommended by both the ICGP and by the Alzheimer's Association, it was not included in the test battery used in this Study as the assessment tool does not assess multiple domains of cognition. As noted in Chapter 2, the MIS assesses delayed verbal memory (word recall) only and does not, therefore, fulfil the requirements of a good assessment tool as outlined by Cullen et al. (2013).

2. because it represents the most widely used brief cognitive assessment tool (MMSE, Folstein, Folstein & McHugh, 1975)

3. because it assesses the often-neglected domain of prospective memory (PM) which was considered to be a limitation of many studies (Cambridge Prospective Memory Test, CAMPROMPT; Wilson & Wilson, 2005)

4. because it was required for interpreting CAMPROMPT scores (National Adult Reading Test, Second Edition, NART; Nelson & Wilson, 1991)

Each of these tests is described in detail next.

3.2.3.2.1 Mini-Cog (Borson et al., 2000)

The Mini-Cog takes 2-4 minutes to administer and consists of two items; a 3-word memory item and a clock-drawing test, allowing a maximum of score of 5. The clock-drawing task is scored by assigning 2 points to each correctly drawn clock or 0 points for an incorrect clock. Clock drawings are scored as normal if all numbers 1-12, each only once, are present in the correct order and direction (clockwise); two hands of any length are present, pointing to the correct time. Clock drawings lacking any of these elements are assigned 0 points, and refusal or inability to draw a clock was scored as abnormal. Delayed word recall is scored out of 3.

It is recommended that a cut-off point of <3 on the overall test, be used, with scores of 3-5 reflecting absence of obvious impairment. Scores of 0-2 are considered to be in the probably impaired range. Scoring criteria are as follows: 3 recalled words + normal clock: negative for cognitive impairment; 1-2 recalled words + normal CDT: negative for cognitive impairment; 1-2 recalled words + abnormal CDT: Positive for cognitive impairment; 0 recalled words: Positive for cognitive impairment (Borson, Scanlan, Brush, Vitaliano, & Dokmak, 2000; Borson, Scanlan, Chen, & Ganguli, 2003; Riley McCarten et al. (2012). It has a reported pooled sensitivity of 76% (which is lower than the MMSE; 79%) and, pooled specificity of 89% (similar to the MMSE). Therefore, although the Mini-Cog has good inter-rater reliability (0.93-0.95), and is shorter than the MMSE, it offers little advantage over the MMSE (Borson et al., 2003). The Mini-Cog also lacks test-retest reliability data, so is not useful for monitoring disease progression or rating severity (Velayudhan et al., 2014).

3.2.3.2.2 GPCOG (Brodaty et al., 2002)

Both the ICGP and the Alzheimer's Association have recommended the GPCOG. More recently, its use was further advocated by Yokomizo et al., (2014). Their review of screening instruments recommended the GPCOG as one of the instruments most reliable and suitable for the detection of dementia in primary care (Yokomizo et al., 2014).

As noted in Chapter 2, the GPCOG is a 6-item cognitive screening tool developed by Brodaty et al., (2002) as a brief, reliable screening tool suitable for administration in the busy primary care setting. It typically takes approximately 5 minutes to complete. There are two components: a cognitive assessment conducted with the patient, and an informant questionnaire, which is considered necessary only if the results of the cognitive section are equivocal, i.e. score of 5-8 inclusive). The test consists of an evaluation of time orientation (Max 1 point), a clock drawing task to evaluate visuospatial functioning and executive function processes (max 2 points), information retrieval (report of a recent news event) (max 1 point) and a delayed recall task (recall of a previously presented name and address)

(max score 5 points). Thus, scores can range from 0-9. For individuals requiring an informant questionnaire, a score of 3 or less out of 6 in the informant section indicates cognitive impairment (Brodaty, Kemp and Low, 2004). Areas covered in the informant interview include memory, word finding difficulties, trouble managing finances, difficulties managing medication independently and needing assistance with transportation.

GPCOG is considered to perform well within the primary care setting and is psychometrically robust and free of educational bias. Results >8 on the GPCOG patient section are assumed to reflect those of an individual who is cognitively intact whilst scores <5 indicates impairment and standard investigations are recommended.

It has a reported pooled sensitivity of 82-85%, a specificity of 83-86%, a positive predictive value (95% CI) of 0.71 and a negative predictive value of 0.92 and higher (Yokomizo, Sanz Simon and de Campos Bottino, 2014). While scores have been shown to be affected by depression and education in people with DSM-IV diagnosed dementia (Broadty, Kemp & Low, 2004), the GPCOG has been reported to be minimally affected by education, self-reported depression and gender (Brodaty et al., 2004, Yokomizo et al., 2014). A community-based study by Basic et al., (2009) found that GPCOG scores were influenced by depression as measured by the Geriatric Depression Scale (GDS). However, it is worth noting that in the sample of 151 participants, 58 (38.4%) had dementia, which may explain the significant predictive effect of depression on the GPCOG in that study.

In total, the GPCOG takes about 6 minutes to administer. It has strong performance on sensitivity and specificity *versus* MMSE in detecting dementia in a typical primary care population (Ismail et al., 2009). It was noted nonetheless that the GPCOG showed variation in diagnostic ability with age, gender and education (Brodaty et al., 2004). Moreover, it has been found to have a misclassification rate the same or less than that of the MMSE (Milne et al., 2008). There is little information to date about the diagnostic accuracy of the GPCOG for MCI. Overall, however, it is regarded as brief, easily administered, well-accepted by clinicians, efficient and minimally affected by education, sex and race (Milne et al., 2008). There is, however, a need for further study of the GPCOG in populations representative of a primary care setting (Holsinger et al., 2007).

3.2.3.2.3 MMSE (Folstein, Folstein & McHugh, 1975)

As indicated in Chapter 2, the MMSE is the most commonly used cognitive test tool in General Practice (>50% of GPs use it; see for example, Milne et al., 2008) and in clinical and research settings (Mitchell et al., 2009). It is regarded as a measure of global cognitive functioning and it has been validated in

both primary care and specialist settings. The original authors found it had high internal consistency, high test-retest reliability and high inter-observer reliability (Folstein et al., 1975).

The MMSE contains 11 items, measuring orientation, immediate memory, attention, calculation, recall, various aspects of language and visuospatial skills. It takes approximately 12 minutes to administer, thus it is reported by many GPs as too long for administration in the busy primary care setting (Glasser, 1993). It is scored on a scale from 0 to 30, with a score of <24 taken to be suggestive of dementia. Scores may, however, be difficult to interpret and the test shows age, cultural and educational bias (Cullen et al., 2007).

The limitations of the MMSE, particularly in relation to low sensitivity to mild cognitive deterioration were detailed in Chapter 2. Additional limitations include the lack of sensitivity in detecting early dementia, MCI, frontotemporal dementia (FTD) and dementia with Lewy Bodies (Velayudhan et al., 2014), as well as the absence of items testing executive functions. It is, nonetheless included here as a benchmark against which to judge the other assessment tools.

3.2.3.2.4 CAMPROMPT (Wilson & Wilson, 2002).

The CAMPROMPT represents one of just two commercially available standardised objective assessments of complex prospective memory (PM). This 25-minute test is comprised of three time-based and three event-based (one focal and two non-focal) items embedded within a series of attention-demanding puzzles that serve as an ongoing task, e.g. "when there are seven minutes left, remind me not to forget my keys" and "when you come to a quiz question about (television show), give me this book."

Participants are allowed to engage in any external strategies they like to help them remember, including taking notes, and are provided with a pen and paper. A digital countdown timer and analogue clock are used. The time intervals between being asked to do the task and responding properly are balanced across cueing conditions. Each item is scored between 0 and 6, therefore each scale (time; event) total is 18 and the maximum score for the test as a whole is 36, with higher scores reflecting better performance.

The exact procedures for administering the CAMPROMPT test were adhered to as outlined in the CAMPROMPT manual. During the test, the tester's responses to the participant's responses depend on whether the right action was carried out at the right time. The instructions on how to respond to the actions of participants on the CAMPROMPT test were adhered to as per the CAMPROMPT manual instructions. Each of the PM tasks was given a score according to the pattern of responding described

in the manual. On the record form, each pattern of response was recorded using the letters A to H, later translated into marks of 6, 4, 2, 1 or 0.

If an examinee spontaneously carried out the correct action at the correct time (Score A), this was awarded 6 marks. If an examinee needed a single prompt before carrying out the correct action (Score B or D), this was awarded 4 marks. If an examinee needed two prompts (whether to remember it is time for a task or to remember the correct task) this was awarded two marks (score C or E). If an examinee needed a prompt to remember it is time to do a task, then remembered that there is something to do, but still failed to carry out the task even after two prompts (Score F), or if an examinee failed to remember it is time to do a task even after prompting, and needs prompting to carry out the correct task (Score G), this is awarded a single mark. If an examinee failed to remember it is time to do a task even after being prompted twice, so that the correct task is still not carried out (Score H), this gains 0 marks. Thus, total score the three time-based tasks and three event-based tasks can range from $0 - 18$, and the total score for the six tasks can range from $0 - 36$.

The CAMPROPMPT has been reported to have very high inter-rater reliability of 0.998 (Pearson) and moderate test-retest reliability of 0.64 (Kendell's Tau-b; Wilson et al., 2005). Delprado et al., (2012) found moderate inter-item reliability, with a Cronbach's alpha coefficient of 0.75, indicating good internal consistency.

Of direct relevance to this Study, Foley (2007) found a significant negative relationship between CAMPROMPT performance and subjective ratings of memory using the PRMQ in people with dementia. Foley (2007) also found that cognitively impaired older adults in her study performed better on the CAMPROMPT than on the Rivermead Behavioural Memory tests of PM. It should be noted, however, that the sample of cognitively impaired older adults in her study were of heterogeneous etiology and likely at various stages of decline.

Delprado et al. (2012), in their study assessing the clinical utility of PM measures, including the CAMPROMPT, in predicting aMCI found that the CAMPROMPT had the ability to discriminate aMCI from healthy individuals and that the time- and event-based scales of the CAMPROMPT were equally good in their discriminative ability.

3.2.3.2.5 National Adult Reading Test, Second Edition (NART; Nelson and Wilson, 1991)

The NART assessment requires the participant to read aloud 50 increasingly irregular words, i.e. those that do not follow the general rules of grapheme-phoneme correspondence and, thus, the correct pronunciation cannot be reached without previous knowledge of the word. However, participants are advised beforehand that they are not required to know all the words listed. The assessment takes a

few minutes only to administer. The tester must, obviously, be familiar with the correct pronunciations of the words before administering the test, to score performance accurately. Scoring of the test provides a quick index of reading ability, thought to be relatively resistant to the effects of brain pathology and dementia (Nelson & McKenna, 1975). As such, it can provide an estimate of premorbid level of intellectual functioning in those with cognitive deterioration and, for the purpose of this study where significant deterioration is not suspected, an estimate of current levels of intellectual functioning.

In the original standardisation of the test, the NART was shown to have high reliability (Cronbach's alpha = .93) and the authors concluded that the test had high validity due to the finding that dementia had a negligible effect on reading ability (Nelson & O'Connell, 1978). Normative data for the NART were provided based on a sample aged 20 – 70 years.

An estimate of premorbid intellectual functioning (IQ) is required to quantify an individual's performance on the CAMPROMPT and NART scores were used as the index of IQ when the normative data for the CAMPROMPT were developed. This test was used, therefore, for accurate interpretation of performance on the CAMPROMPT.

3.2.3.2.6 Test Order

Questionnaires and objective cognitive tests were administered in the same sequence or order for all participants as follows; the PRMQ, HADS, socio-demographic, health and sleep-related questions were administered first, followed by administration of the cognitive tests commencing with the MMSE, then the Mini-Cog, GPCOG, CAMPROMPT and NART.

The rationale for ordering the administration of the subjective and objective cognitive tests in this manner was to ease participants into the testing situation. The subjective assessment was administered first and consisted of the administration of the sociodemographic questionnaire, followed by the PRMQ, since the subjective assessment was deemed to be less threatening to participants than the objective test assessment. Administration of the subjective assessment before objective assessments also allowed the examiner to build rapport through discussion about the aims of the study and clarification of, for example, sociodemographic and self-report memory questions. The order of administration of the objective tests themselves was based on perceived difficulty – combined with the need to avoid interference from one test to another. The MMSE, which is best at ruling out dementia, as opposed to detecting MCI, was expected to be the easiest for participants to complete successfully and was, therefore, administered first. The Mini-Cog and CGOCOG are both brief and both are recommended in key literature reviews for the detection of mild cognitive decline and were

administered next. The CAMPROMPT can be considered cognitively demanding since it requires remembering PM tasks in the context of an ongoing activity and takes longer than the other objective tests to complete (25 minutes). It was decided to administer the CAMPROMPT after participants had already completed the brief assessment tools typically administered in clinical practice as a core goal of the study was to examine the relationships between self-reported and objective performance on widely used tests.   Thus, these important data would be available even in cases where a participant did not complete the more demanding CAMPROMPT. Finally, in the context of this study, the NART score is required for the purpose of scoring the CAMPROMPT only. That fact, combined with the fact that people invariably commit a relatively high number of errors on the NART and may become upset by those errors, or have their confidence undermined by the errors, impacting on cognitive test performance, meant that this test was administered last.

3.2.4 Data Analytic Strategy

Participants were classified as either high self-reporters of memory difficulty (high forgetfulness) or low self-reporters of memory difficulty (low forgetfulness) on the basis of K-means and 2-step cluster analysis. The effectiveness of the objective cognitive tests for determining self-reporter status (i.e. group membership) - was then assessed using binary logistic regression and taking into account the influence of other variables such as physical health, mood state and sleeping difficulties known to impact cognition. The goal of the analyses was to determine the extent of the relationships between subjective and objective test performance.

3.3 Study 3: Construction of a short-form PRMQ Study 3

3.3.1 Study Design

In order to achieve the objective of constructing a briefer and improved self-report measure of memory, Study 3 adopted the Classical Test Theory (CTT) framework to conduct an item level analysis of the PRMQ. The assumptions of CTT are described in further detail in Chapter 6.

3.3.2 Study Sample

Due to the particular aims of Study 3, it was not necessary to recruit another sample of participants to achieve the objective of constructing a short-form PRMQ. Instead, item level analysis using the CTT framework was employed using Study 2 PRMQ data. These data rather than the larger Study 1 dataset were used because item scores could be evaluated relative to objective test scores. Study 1 PRMQ data were, however, used to verify the psychometric properties of the short-form PRMQ. The characteristics

of the sample recruited for Study 1 are described in Chapter 4 and the Study 2 sample characteristics are detailed in Chapter 5.

3.3.3 Study Procedure

3.3.3.1 Ethical considerations

There were no substantial ethical considerations pertaining specifically to the procedures adopted in Study 3, as Study 3 represented, primarily, an extension of the Study 2 data analysis and involved no additional direct contact with participants. Similarly, confirmatory factor analysis of the short-form PRMQ derived from these analyses was undertaken using the larger Study 1 anonymous dataset and, similarly, did not require further direct contact with participants.

3.3.3.2 Materials and Methods

Using the CTT framework of item level analysis, descriptive information such as means and standard deviations and statistical information such as difficulty indices (p-values), corrected item-total correlations and discrimination indices, were obtained for each item of the PRMQ from Study 2 data. Other item properties such as item reliability indices, item skew, and factor loadings derived from confirmatory factor analysis (CFA) were also examined. A brief outline of the rationale and use of these item statistics and techniques is provided next, followed by a brief description of their adoption in the present study.

3.3.3.2.1 Classical Item Analysis Techniques - Measuring Item Difficulty

Item means: In the context of a self-rating instrument where the answer is not binary (e.g. right or wrong), but rather an endorsement of a Likert-style response choice, such as is the case with the PRMQ that presents five answer options ranging from Never (=1) to Very Often (=5), item endorsement can be measured as the item mean. For example, on a scale of 1 - 5, a mean of 3 would be equivalent to an item-difficulty of .5. In the case of the PRMQ, the item mean is an expression of the frequency with which the everyday memory failure as represented by the item, is experienced. An alternative expression of the item mean is the item difficulty or item severity index, also known as the P-value.

P-values: It is acknowledged that the term p-value is most commonly used in relation to a binary item, which is an item where the response can only assume two values, typically either correct or incorrect, and the P-values of a binary item is the proportion of respondents in a sample having the item correct. However, it is also possible to calculate P-values for items with multiple response categories, otherwise known as polytomous or partial credit items. While the P-value for binary items is calculated as the

average value of all response values, the P-value in a polytomous data set is calculated as the relative average of all response values.

Ideally, scales should consist of a majority of items that present "optimum difficulty." Inclusion of such optimally difficult items helps to maximise the variability and, thereby, the reliability of a scale. The optimal difficulty value is described as slightly higher than midway between chance (1.00 divided by the number of response choices) and a perfect score (1.00) (Krishnan, 2013).

Using the formula set out in Krishnan (2013) for obtaining the P-value of optimum difficulty, for a five-alternative, multiple choice item;

- The random guessing level = 1.00/5 = 0.2
- The optimum difficulty level = 0.2 + (1.00-0.2)/2 = 0.6

Therefore, in the case of the PRMQ with its five-point Likert style response scale, an item with optimum difficulty would have a P-value of 0.6.

Ultimately, the ability level of the target population should be borne in mind when deciding on the ideal P-values of scale items. In general, tests are regarded as more reliable when P-values range from 0 to 1. Whatever the criterion used in determining a reasonable estimate for *P*, it is recommended that items with P-values above 0.90 and P-values below 0.20 warrant a careful evaluation as these may be measuring ability at too extreme an end of the continuum to be useful in the majority of cases. It should be noted that a P-value as an index of item difficulty is a characteristic of both the item and the sample responding to the measure.

3.3.3.2.2 Classical Item Analysis Techniques - Measuring Item Discrimination

Corrected Item-total Correlations: The power of an item to discriminate refers to the extent to which it is able to separate high levels of an underlying trait from low levels of the underlying trait on the basis of the responses to an item. As with the difficulty indices (means and P-values) described above, discrimination is a local property. Although there are several indices of discrimination available in CTT, the most relevant for this study is the corrected item-total correlation. This is a measure of the degree to which the item correlates with the total score on the instrument. The correlation is considered "corrected" since it is the correlation between the item and the rest of the scale with the item removed. This corrects the inflation that would arise if the item was included, by removing the component of the correlation that is the correlation of the item with itself. General rules of thumb recommend that acceptable corrected item-total correlations are at least 0.15 and preferably above 0.3 (Pallant, 2007). A positive item-total correlation indicates that the item measures the same thing that is being measured by the test – therefore items are homogeneous. Item-total correlations are directly related

to the reliability of a test, because the greater each item correlates with the test as a whole, the greater the likelihood that all items correlate with each other.

Inter-item correlations: As part of a thorough item analysis, inter-item correlations among the PRMQ items were examined. Inter-item correlations show the extent to which scores on one item are related to scores on all other items in scale. It provides an assessment of redundancy, that is, the extent to which items on a scale are assessing the same construct (Swerdlik & Cohen, 2005). Ideally, the average inter-item correlation for a set of items should be between .2 and .4, suggesting that while items are reasonably homogeneous in content they still collectively represent the depth and various facets of the construct to an acceptable degree (Piedmont, 2014). All inter-item correlations should be positive. Correlations between pairs of items that are lower than 0.15 suggest that the items in question do not really relate well to each other and might not be suitable for measuring a single construct. Inter-item correlations above .50 suggest that the items are very similar to each other and are almost redundant. Inter-item correlations outside the bounds of .15 to 5.0 in a uni-dimensional measure may raise questions as to the validity of the measure. However, theoretically, the PRMQ, consisting of a PM and RM subscale, measures two distinct but overlapping constructs. Therefore, an inter-item correlation slightly below the lower bound of .15 might be acceptable between a pair of items if each item is measuring different scale constructs (PM or RM). Moreover, the distribution of inter-item correlations will be a product of a number of somewhat independent processes including conceptual redundancy in items, overlap in response distributions and sampling variability.

3.3.3.2.3 Classical Item Analysis Techniques - Item Reliability Index

The Item Reliability Index (IRI) is the product of an item's standard deviation (SD) and its corrected item-total correlation. A large SD and large corrected item-total correlation is ideal. The IRI is a measure of an item's contribution to the internal consistency of the test. Although there are no generally agreed upon cut-off values for the IRI, by selecting the items with the highest values, one will construct the most reliable test.

3.3.3.2.4 Classical Item Analysis Techniques - Descriptive Item Assessment

In considering items for selection, attention should also be paid to the following aspects;

Standard Deviations (SDs): Alongside the means, the SD of an item can provide fundamental clues about which items are useful for assessing the concept of interest. Cappelleri, Lundy & Hays (2014) state that, generally, the higher the variability of the item scores and the closer the mean score of the item is to the centre of the distribution (i.e. the median), the better the item will perform in the target population.

Distribution across response categories (item skewness): For items with ordinal response categories that have more than two categories, an equal or uniform distribution across response categories (i.e. items displaying least skew) yields the best differentiation. However, Cappelleri, Lundy & Hays (2014) also note that that such an ideal uniform distribution of an item is difficult to obtain.

3.3.3.2.5 PRMQ item ability to discriminate performance levels on objective cognitive tests

The ability of each of the PRMQ items to discriminate between performance levels on each of the objective cognitive tests used in Study 2 was then examined, with particular emphasis given to those items that showed positive discriminative ability on those tests recommended for use in Primary Care; the MMSE, Mini-Cog and GPCOG. Performance levels on the objective cognitive tests were delineated as perfect performance (represented by a group of high performers who obtained a perfect total tests score) and less than optimal performance (represented by a group of lower performers who obtained a less than perfect total test score). The ability of each PRMQ item to distinguish between groups of high and lower test performers was reflected by its discrimination index (DI), obtained by subtracting the difficulty index (P-value) of the perfect performing group from the difficulty index of the low performing group.

3.3.4 Data Analytic Procedure

As noted above, CTT as well as explorations of the ability of individual PRMQ items to discriminate between perfect and poorer performance on objective cognitive tests was used to determine the items for inclusion in the short-form PRMQ. The final set of short-form PRMQ items was, therefore, selected based on their psychometric properties and their ability to discriminate between levels of objective performance on recommended objective cognitive tests. Preliminary exploration of the reliability of this short-form PRMQ was then conducted via a confirmatory factor analysis using the data set from Study 1.

The methods adopted in the item analysis of the PRMQ and the construction of the final short-form PRMQ is further described in Chapter 8: Study 3 - Construction of a short-form PRMQ.

3.4 Study 4: Normative Data for Older Irish Adults

3.4.1 Study Design

In order to achieve the objective of deriving normative data for an older Irish population, Study 4 revisited the dataset collected for Study 1. These data were then used to construct normative data for both the full and short-form PRMQ .

3.4.2 Study Sample

Due to the aims of Study 4, it was not necessary to recruit another sample of participants to achieve the objectives. Instead, the dataset from Study was used to calculate the normative data for an older Irish sample on the full PRMQ and on the short-form PRMQ constructed in Study 3. As noted previously, the characteristics of the sample recruited for Study 1 are described in Chapter 4.

3.4.3 Study Procedure

3.4.3.1 Ethical considerations

There were no specific ethics issues in relation to this study as it represented an extension of the data explorations of the anonymous dataset from Study 1. No further direct contact with participants was required.

3.4.3.2 Materials and Methods

For the purpose of this Study, the PRMQ raw score data (PRMQ Total, PM Scale and RM Scale) from Study 1 (n=533) were used to calculate T-scores, reflected such that higher scores represented better self-reported memory (PRMQ Total T-score, PRMQ PM T-score, PRMQ RM T-score), on the full-length PRMQ. Thus, normative data were obtained for the original full-form PRMQ that were directly relevant for older Irish adults.

The items constituting the short-form PRMQ derived in Study 3 were converted to short-form PRMQ raw scores for each scale (short-form PRMQ Total, short-form PM scale and short-form RM scale) for each of the Study 1 participants and these data were then converted to T-scores (reflected such that higher scores represented better self-reported memory).

3.4.4 Data Analytic Strategy

For the purpose of developing normative data, the procedures adopted by Crawford et al., (2003) were followed.

Additional analyses were then performed to seek to determine the relative merits of adopting these normative data, particularly for the short-form, in helping to identify those whose self-reported memory complaints were atypical and to link these to their performance on objective tests.

Chapter 4: Study 1: Self-Reported Memory Failure – Nature, Frequency and Correlates

4.1 Study Background

As noted in Chapter 1, the first study in this three-part thesis set out to establish the benchmarks from which self-reports of everyday memory functioning in older Irish adults might be interpreted. More specifically, this study set out to investigate the nature and frequency of occurrence of both self-reported prospective and retrospective memory (PM and RM) failures, as assessed by the widely-used Prospective and Retrospective Memory Questionnaire (PRMQ; Smith, Maylor, Della Sala and Logie, 2000). These self-reports were then benchmarked against the normative data derived by Crawford and colleagues (2003) from a large UK non-clinical sample so that they might be interpreted in a clinical context.

Study 1 also set out to explore potential correlates of self-reported memory failures. Within the context of this study, the relationships between self-reported memory failures and sociodemographic variables of age, gender and education were explored as were the relationships between self-reported memory and aspects of mood state, physical health, alcohol use and sleep (quality and quantity). These relationships were explored because of the known or suspected impact of these variables on memory performance.

Ultimately, the goal of this study, which took the form of an anonymous survey of older adults, was to examine the potential utility of the PRMQ as a screening tool for detection of atypical but potentially relevant levels of self-reported memory problems in older adults. Presented below is an overview of the study goals, study design and study methodology.

4.2 Study Goals

This study used an anonymous questionnaire-based design to achieve the following research aims:

1. To profile the type and prevalence of self-reported PM and RM memory failures in generally healthy older adults aged 50 years and above.
2. To determine whether, in the Irish general population aged 50 years and above, the variables of age, gender, education, mood state, physical health, alcohol use and sleep quality and quantity influence self-reported PM and RM.

4.3 Methodology:

4.3.1 Study Design

The research design of this study is described in Chapter 3.

4.3.2 Ethics Approval

Ethical approval for this study was obtained from DCU Research Ethics Committee (reference: DCUREC/2015/2016). Following a Call for Volunteers (see Appendix A), only individuals without a history of dementia or other neurological or psychiatric conditions were permitted to take part in this study. In this way, the possibility of recruiting substantial numbers of individuals with significant memory difficulties was reduced. Ethical considerations regarding the study are described in detail in Chapter 3.

4.3.3 Study Materials

For the purpose of this study, participants were asked to complete an anonymous survey that included an assessment of self-reported memory failures and current mood state. Self-reported memory was assessed using the PRMQ (Smith et al., 2000), whilst mood state was assessed using the Hospital Anxiety and Depression Scale (HADS: Zigmond and Snaith, 1983).

The PRMQ was described as a set of questions about minor memory mistakes that everyone makes from time to time. Participants were asked to rate how often these memory mistakes happen to them on a 5-point Likert scale where responses were: Very Often, Quite often, Sometimes, Rarely, Never. All PRMQ data were subsequently assigned numerical values of 5 (Very often) to 1 (Never), resulting in minimum and maximum possible total scores of 16 and 80 respectively. Higher raw scores represented greater degrees of forgetfulness.

The HADS was described as questions asking participants to choose the reply closest to how they have been feeling in the past week. Participants were asked not to take too long over their replies, and that their immediate response is usually the best. Participants indicated the extent to which they experienced specified symptoms of anxiety or depression on a 4-point scale, ranging from 0 to 3, resulting in minimum and maximum scores of 0 to 42 respectively. Items in the online version of HADS were automatically assigned chronological values of 1 to 4 within the Qualtrics survey platform. These online HADS data were subsequently downloaded to SPSS, and recoded in SPSS so that each item was assigned the correct corresponding numerical value ranging from 0 to 3. In both online and hardcopy data, items 2,4,6,7,12 and 14 were reverse-scored as per the HADS instruction manual.

In addition, participants were asked to complete a range of questions designed to obtain demographic and background information. Details of the survey are presented in Chapter 3: General Methods and a copy of the survey is available in Appendix F.

4.3.4 Participants: Recruitment and Sample Characteristics

Between October 2015 and February 2016, more than 20 community-based organisations around Ireland were contacted with information about the study - including an electronic version of the Call for Volunteers that contained a link to the online Qualtrics survey. Because these organisations then notified their membership about the study, it is not possible to ascertain the final number of email links distributed. As a result, it is not possible to determine the participation rate from amongst those who became aware of the study and were eligible to take part. In addition, approximately 160 hardcopy versions of the study questionnaires were sent, with stamped-addressed return envelopes, to potential participants who contacted the researcher following seeing or receiving a copy of the Call for Volunteers to express an interest in the study and an interest in receiving a paper-based copy of the questionnaire.

Ultimately, a convenience sample of 533 generally healthy participants aged 50 years and over was recruited, on a volunteer basis, from the community using a snowball technique. Only those older adults who provided informed consent were recruited and these were required to confirm that, to the best of their knowledge, they met the inclusion criteria for the study and did not suffer from any of the conditions detailed as exclusion criteria. These inclusion and exclusion criteria are listed in Chapter 3.

In total, 140 participants returned completed hardcopy versions of the questionnaires and 393 people completed the online version (total n = 533). Because of the nature of the online survey, there were no missing data, as progression through the online survey was dependent on the participant having responded definitively to each and all the preceding questions. In contrast, missing data was a potential problem in terms of the hardcopy questionnaires. Thus, hard copy data were visually inspected for missing data. Missing value analysis of the hardcopy data was performed in SPSS for each of the variables of interest, including PRMQ, HADS and demographic variables. Regarding the PRMQ data, a missing values analysis revealed that a full PRMQ dataset was missing in just over 2% of cases (n=15). Given the study aims to investigate the nature and prevalence of subjective memory complaints in older Irish adults alongside recommendations from the literature (e.g. Pigott, 2013; Dong and Peng, 2013; Fidell and Tabachnick, 2013), it was decided to exclude those participants with any missing PRMQ data and to proceed with the data analyses using the Complete Case Analysis approach. This resulted in 518 completed questionnaires being available for subsequent analysis. Table 4.1 presents summary demographic data for this Irish sample (n=518).

Table 4.1: Basic demographic data for the study sample

Variable	N (%)
Gender	518 (100)
Males	189 (36.5)
Females	329 (63.5)
Marital status	518 (100)
Single	63 (12.2)
Married	350 (67.6)
civil partnership	1 (0.2)
Cohabiting	11 (2.1)
Separated	30 (5.8)
Divorced	14 (2.7)
Widowed	49 (9.5)
Education (highest level obtained)	511 (98.6)
Primary	36 (7.0)
Inter/Junior Certificate	46 (9.0)
Leaving Certificate	75 (14.7)
Post Leaving Certificate	67 (13.1)
Vocational training apprenticeship	23 (4.5)
Third level degree	129 (25.2)
Higher diploma	63 (12.3)
Masters	52 (10.2)
PhD	20 (3.9)
Education (years)	510 (98.4)
0-6 years	11 (2.2)
7-10 years	46 (9.0)
11-13 years	121 (23.7)
14-17 years	183 (35.9)
18-19 years	89 (17.5)
20+ years	60 (11.8)
Occupation	471 (90.9)
Manager	80 (17.0)
Professional	170 (36.1)
Technician	22 (4.7)
Clerical Support	75 (15.9)
Services & Sales	31 (6.6)
Skilled agriculture/forestry/fisheries	12 (2.5)
Crafts and Trades	12 (2.5)
Plant/Machine Operator/Assembler	4 (0.8)
Elementary occupation	14 (3.0)
Other occupation	51 (10.8)
Drinks alcohol	400 (77.7)
Non-drinkers	115 (22.3)

N = number of available cases; % = percentage

The mean age of this sample was 62.49 years, range 50-99 years. As can be seen from this table, there were 329 females (63.5%) and 189 males (36.5%) in the final sample. Overall, 67.6% of the sample were married, 12.2% were single, 9.5% were widowed, almost 5.8% were separated, almost 2.7% were divorced, and 0.2% were in a civil partnership.

In terms of education, 25.2% had a Third Level Degree, 14.7% had completed their Leaving Certificate, nearly 13.1% had a Post-Leaving Certificate qualification, 12.3% had a Higher Diploma, 10.2% had a master's degree, 9.0% were educated to Inter-certificate/Junior Certificate level, 7.0% had completed Primary level education, 4.5% held a vocational training apprenticeship, and almost 3.9% had a PhD.

In terms of occupation, a high proportion described themselves as professionals (36.1%). In terms of occupational status, the next most common categories were Managers (17.0%), followed by Clerical Support Workers (15.9%), other occupations (10.8%) and Services and Sales Workers (6.6%). A smaller percentage identified occupation as Technician or associated professional (4.7%), Skilled Agriculture, forestry and fishery occupations (2.5%), Elementary occupation (3.0%), Craft and related trades occupations (2.5%) and finally Plant or Machine Operator/Assembler contained the fewest number of older individuals (0.8%). 77.8% of the sample reported that they consumed alcohol but only a very small number appeared to be problem drinkers (n = 10; 2.3%).

Regarding physical health of the sample, the prevalence and type of self-reported chronic health conditions is presented in Table 4.2.

Table 4.2: Prevalence and type of self-reported physical health conditions in the sample

Physical Condition	n (%)
Cardiovascular Disease (CVD)	41 (7.9)
Hormonal Problems	15 (2.9)
Breathing Problems	40 (7.7)
Gastric Problems	46 (8.9)
Diabetes	18 (3.5)
Chronic Pain	23 (4.4)
Arthritis	109 (21)
Ulcerative Colitis	10 (1.9)
Thyroiditis	47 (9.1)
Crohn's Disease	6 (1.2)

As the table highlights, the most commonly endorsed physical health condition was arthritis (20.8%), followed by cardiovascular disease (16.5%) and breathing problems (8.4%). The least commonly endorsed health conditions were Crohn's disease (1.1%) and ulcerative colitis (2.7%).

While heterogeneous definitions of multimorbidity abound, the World Health Organisation (2006) and The Academy for Medical Science (2018) propose a definition of multimorbidity as the co-existence of

two or more chronic conditions. Based on this definition, 83 participants (16.0% of the overall sample) identified multimorbidity.

In order to determine the extent to which the sample recruited to this study is representative of the general older Irish population, comparisons were drawn, in-so-far as was possible, with the Irish Longitudinal Study on Ageing (TILDA) and data from the Central Statistics Office (CSO) Irish census in 2016 (www.cso.ie).

TILDA is a large prospective cohort study of ageing, which includes an assessment of the social, economic and health circumstances of community-resident older people living in Ireland. The sampling frame in TILDA was the Irish Geodirectory, a comprehensive and up-to-date listing and mapping of all residential addresses in the Republic of Ireland compiled by the Irish postal service ("An Post") and Ordnance Survey Ireland. The self-completion questionnaire (SCQ) was administered to 8507 individuals, including 8178 respondents aged 50 years and above, and 329 younger partners of eligible individuals. The response to the SCQ was approximately 84% and a report of preliminary findings was made available in May 2011 (see Barrett, Savva, Timonen & Kenny, 2011). Comparable demographic variables collected across TILDA waves pertain to marital status, marriage history and education. An assessment of physical health in TILDA included an assessment of self-rated health, including cardiovascular and non-cardiovascular diseases, depression and anxiety, sleep and alcohol intake.

Findings from the TILDA report following analysis of Wave 1 data showed that 48% of participants were men and 52% women. Similarly, in the present Study 1 sample, the broad trend of a higher proportion of older females than older males was replicated. In the current study, however, there were, proportionally fewer males (36.5%) and more females (63.5%). In terms of age profile, TILDA reported that the greater proportion of people (58%) aged 50 years and over in Ireland are in the 50-64 age group. In the Study 1 sample, also, a greater proportion (63.5%) of the sample were between 50 and 64 years of age. Thus, both studies are comparable.

In the TILDA Wave 1 report, which reported marriage *history* as opposed to current marital status, almost 10% of people aged 50 years and above had never been married, and men were more likely to never have been married than women (13% men; 7% women). In Study 1, which ascertained current marital status (as opposed to marital history), 67.6% currently self-identified as married. 12.2% self-identified as single, 9.5% self-identified as widowed, 5.8% as separated.

Regarding education, the TILDA study reported that most older adults (62%) have achieved at least secondary education. This compares to 83.9% of older adults with at least secondary education in our Study 1 sample. The Study 1 sample can, therefore, be considered as having obtained a relatively higher level of education than the general population (as reflected in the TILDA cohort).

Self-reported depression in the TILDA study is assessed with the Centre for Epidemiologic Studies Depression Scale (CES-D). Scores equal to or above 16 on the CESD-D were categorised as clinically depressed and individuals with scores between 8 and 15 were categorised as having subthreshold depression. In terms of self-reported depression, the TILDA study found that 10% of the population aged 50 years and above reported clinically significant depressive symptoms, with a further 18% reporting subthreshold levels of depression. By comparison, in the present Study 1 sample, the HADS-D subscale of the HADS (Zigmond and Snaith, 1983) was used to assess self-reported depressive symptoms. Using the recommended cut-off scores for the HADS subscales, as recommended by the HADS authors, none of the Study 1 participants could be classified as clinically depressed and just 6.2% reported what is considered to represent mild/subthreshold depression. When using a cut-off of 10/11, as used in Crawford et al., (2001), just under 2% of the Study 1 sample could be classified as potential cases of clinical depression. Thus, the sample in Study 1 can be considered low in self-reported depressive symptoms relative to the general population aged 50 years and above.

Similar to the present study, the TILDA study, used the HADS to assess self-reported anxiety, allowing a more direct comparison of self-reported anxiety between the current sample and TILDA sample. A score of greater than or equal to 11 on the HADS_A subscale was classified in TILDA as anxious and a score between 8 and 10 was taken to indicate borderline anxiety. Among the older adults in the TILDA sample at Wave 1, 13% reported clinically significant anxiety symptoms and 29% reported subthreshold levels of anxiety. Applying the same cut-offs as used in TILDA to the Study 1 sample, 39 (8.1%) of the sample scored greater than 10 on the HADS_A subscale and can be classified as potential cases of anxiety and 84 (17.7%) could be considered as having subthreshold levels of anxiety. The present study sample, therefore, can clearly be considered as low in self-reported anxiety symptoms relative to the general population aged 50 years and above.

Using Zigmond and Snaith's recommended cut-offs, only 5 participants could be classified as severely anxious, while 87 (17.7%) could be classified as having mild or subthreshold levels of anxiety. Of note, like the TILDA study, levels of self-reported anxiety in the present Study 1 sample were higher than levels of self-reported depression, mirroring the findings of the TILDA study.

In terms of physical health, in the TILDA study, more than 1 in 3 older adults at Wave 1 (36%) were affected by pain. This did not vary by age and the level of pain reported did not change substantially in subsequent waves. Self-reported cardiovascular diseases in the TILDA study comprised hypertension, diabetes, heart attack, angina, stroke, transient ischaemic attack (TIA) and heart failure. In terms of cardiovascular disease, there was an increased prevalence between Waves 1 and Waves 4 of hypertension (35% to 38%), diabetes (8% to 11%), heart attack (4% to 6%), stroke (1% to 2%) and

transient ischaemic attack (2% to 4%). At Wave 4 (the most recent wave of data collection), diagnosed Type 2 diabetes prevalence was 8.4% and was higher among men (10.3%) than women (6.6%). In terms of non-cardiovascular disease, there was an increased prevalence of arthritis (26% to 39%), osteoporosis (9% to 17%), lung disease (4% to 5%) from Wave 1 to Wave 4. Arthritis was also reported to be higher among women than men in the TILDA study. At Wave 4 of TILDA data collection, the most prevalent conditions among adults aged 50 years and older in Ireland were hypertension (38% at Wave 4), arthritis (39% at Wave 4) and pain (35% at Wave 4). In the present Study 1 sample, the physical health conditions assessed for were broadly similar, but groupings of conditions were not identical to the categories used in the TILDA study. For example, Study 1 contained an umbrella category for all/any cardiovascular diseases. As can be seen in Table 4.2, the prevalence of cardiovascular diseases in the present Study 1 sample is 7.9%. However, it is not clear to what extent specific problems such as hypertension and diabetes were perceived as a cardiovascular disease by respondents in the present study, and diabetes was included as a separate health condition for self-selection, which may lead to a potential underestimation of the prevalence of cardiovascular diseases in the present sample compared to the TILDA sample and hence the general population. Diabetes alone had a prevalence rate of 8% at Wave 1 and 11% at Wave 4 in the TILDA sample, compared to a prevalence of 3.5% in the Study 1 sample. Comparing non-cardiovascular diseases in-so-far as possible between studies, it is seen also from Table 4.2 that the prevalence of chronic pain in the present sample (4.4%) was much lower than the prevalence of pain reported in the TILDA sample, although the prevalence level of arthritis in Study 2, at 21%, is much closer to that reported in Wave 1 of TILDA (26%). Osteoporosis was not a prespecified category in the present study and neither was lung diseases specifically or explicitly assessed for. However, the prevalence of breathing problems (which is likely to incorporate lung diseases and other conditions of the airways such as Chronic Obstructive Pulmonary Disease) was 7.7%, which is slightly higher than the prevalence of lung disease (5% at wave 4) in the TILDA sample. Overall, the TILDA study reported that the most commonly reported physical health conditions among people aged 50 years and above in Ireland at Wave 1 were hypertension (35%), arthritis (26%) and osteoporosis (9%), and at Wave 4 were arthritis (39%), followed by hypertension (38%) and osteoporosis (17%). In the present Study 1 sample, by comparison, the most prevalent physical health conditions were arthritis (21%), (in line with TILDA findings), followed by thyroiditis (9.1%) and gastric problems (8.9%), which diverge from TILDA findings regarding the most prevalent self-reported diagnosed physical health conditions.

The TILDA study used all four questions of the CAGE questionnaire to screen for problematic alcohol use. The prevalence of problem alcohol use in older adults was 13% at Wave 1 and prevalence had decreased only marginally at Wave 4 to 12%. Problem alcohol use was more prevalent in men than women (15% versus 9% at Wave 4). In the present Study 1 sample, in which participants were required to respond to

only one of the four CAGE questions, out of 435 valid cases, 10 (2.3%) were indicated as problematic alcohol users; 5 (3.1%) were males and 5 (1.8%) were females.

The Irish Census 2016 reported that were 978 males for every 1,000 females in the state in April 2016. Among the older age group of 65 years and over, there are consistently more females than males, as is the case in Study 1**.** Regarding education, 18.9% of older adults aged 65 years and over had a third level qualification and the proportion educated to primary level only for those aged 65 plus was 39.7%. By comparison, 24.9% of those aged 65 years and over in Study 1 had a third level qualification and the proportion in this age group educated to primary level was 13.3%. Among persons aged 60 years and over, the difference between men and women in terms of when they finished full-time education was less notable, with 60.8% of females and 62.8% of males having ceased their education aged 17 years or under. Within this older age group, more males (15.4%) than females (12.7%) stayed in education until at least the age of 22 years.

 Census 2016 data also highlighted that the more educated a person is, the more likely they are to be married. However, amongst individuals aged between 55 and 64 years, those with either lower secondary or third level degree or higher qualification had a similar likelihood of getting married (71.3% -v- 72.6%). For comparison purposes, the marital status across categories of highest education level attained by Study 1 participants aged between 55 and 64 years was examined. Similar to the 2016 Census data, those with lower secondary education (Inter-/Junior Certificate) had a similar likelihood of being married as those whose highest level of education was Third Level Degree (66.7% -v- 68.9%) and a Higher Diploma (69%), though slightly lower than those with a master's degree (72.4%). An equal percentage of those aged between 55 and 64 years in Study 1 who had obtained only Primary Schooling (60%) were married as those who had obtained a PhD (60%).

The 2016 Irish Census data showed that the peak age for persons separated or divorced was 53 years. Moreover, for persons aged 65 years and over, there were 4% more women than men separated or divorced. Across, the entire Study 1 sample, more females were also separated (6.4%) and divorced (3.3%) than were males (4.8% separated and 1.6% divorced). In the age group 65 years and over, more females were currently separated (4.3%) than were males (1.4%), while 2.6% of females and 0% of males were divorced. This gap between the genders was smaller in the 50 – 64 years age group, although the overall rate of divorce and separation were higher than in those aged 65 years and above in both sexes. Specifically, 7.5% of women were separated and 3.8% were divorced, while 6.9% of men were separated and 2.6% were divorced. This pattern corresponds broadly to the census data showing that the peak age in Ireland for separation or divorce is 53 years, and to the trend apparent in the census data of higher rates of separation and divorce in females than males.

Interestingly, separation and divorce in the 2016 Irish census data were higher in those who were educated to primary level only, with the rate generally falling with increased educational attainment. This trend was not observed in the Study 1 sample. Indeed, none of those who had obtained primary schooling as the highest level of education across the entire sample (age 50 years and above) in Study 1 were divorced or separated and the highest percentage of separation was seen in those who had a Post-Leaving Certificate (10.4%), while the highest percentage of divorce was observed in those whose highest educational attainment was third level degree (5.3%). Therefore, a pattern of either divorce or separation as a function of highest educational attainment is not as clearly discernible in the Study 1 sample.

In terms of occupations, in the 2016 census, workers were classified to 328 separate categories and available published occupational statistics are not divided by age bands. The category sales and retail assistants, cashiers and checkout operators comprised the most prevalent occupational type (although it was noted that workers still only represented 4.5% of those at work which indicated the diversity among the different professions in modern Ireland). "Farmers" was the next largest group, accounting for 3.5% of the national work force, followed by the category "Other administrative occupations", which includes administrative assistants, clerks and office administrators, and represents 3% of the workforce. While occupational categories were much broader and fewer in number in the Study 1 sample, also bearing in mind that the study 2 sample consisted of older adults aged 50 and above, some broad comparisons in terms of occupational groupings can be made. In contrast to 2016 census data, the category "Services and Sales" in Study 1 was the fourth most prevalent occupational category (6.6%) and skilled agriculture, forestry and fishery workers were also less prevalent in the current sample (2.5%). However, the category "Clerical Support Workers", which comprises the third most prevalent category in Study 1 at 15.9%, may be seen to equate with the 2016 Census category of "Other administrative occupations", also third place in terms of prevalence, although this group of workers, perhaps owing to the great number of occupational categories in the census, comprised only 3% of the national population across the lifespan.

In summary, the current Study 1 sample comprises a convenience sample of volunteers and not a randomised sample. It is, therefore, difficult to estimate the true representativeness of the sample. However, it can be seen that the current study sample is relatively highly educated and low in self-reported depression and anxiety compared to the general population.

4.3.5 Data Processing and Data Analysis

All data were collected in anonymous fashion and, in the case of the online version of the questionnaire, downloaded from Qualtrics or, in the case of hardcopy versions, transcribed from the hardcopy and entered into SPSS for statistical analysis.

As noted above, the online questionnaire was formatted within Qualtrics in such a way that participants could only proceed to the next question if all preceding questions were answered, thereby ensuring submitted online questionnaires were fully completed (i.e. had no missing data). Profiles with missing PRMQ data (n=15) on the hardcopy versions of the questionnaire were excluded from subsequent analysis.

Prior to the detailed data analyses, some variables were recoded to adhere to adhere to the test administration guidelines. Brief details of test scoring procedures can be found in Chapter 3, with full details available in the specific testing manuals. Following the relevant scoring and re-coding, the software package PASW Statistics 21 (Predictive Analytic Software) (IBM SPSS Inc.) was used to carry out most of the statistical analyses. Confirmatory Factor Analysis (CFA), employed to examine the underlying structure of the PRMQ, was completed using the Lavaan programme (Rosseel, 2013), in R Version 3.4.4 for Windows (R Core Team, 2018). Unless otherwise stated, complete case analysis was performed.

The PRMQ and HADS data were first screened for normality and outliers. Data analysis then focused on descriptive statistics (PRMQ, HADS and demographic questionnaire data) and measures of centrality and dispersion of the scores. The factor structure of the PRMQ was then examined in detail.

Subsequent analyses focused on an examination of PRMQ T-scores (mean of 50 and a standard deviation of 10) derived based on the normative data provided by Crawford et al. (2003), and on examining the relationships between self-reported memory failures and the sociodemographic, mood, health and sleep variables. As recommended by Crawford (2004), Crawford, Venneri & O'Carroll, (1998) and Lezak (1995), T-scores (reflected so that higher T-scores represent better memory) rather than raw scores were used for analysis of the PRMQ scale and subscale data to permit ready comparison with other studies and ready comparison of RM and PM subscale performance levels.

For the purpose of these analyses, procedures such as correlations (parametric and non-parametric as appropriate), t-tests, ANOVAs and non-parametric equivalents, where appropriate, were used. Additional inferential analyses controlled for levels of self-reported anxiety and depression (partial correlations and ANCOVAs). Finally, regression analyses (Stepwise) were employed to determine the relative contribution of a number of variables to PRMQ Total and PRMQ subscale scores.

Effect sizes (Cohen's d) were computed for comparisons between PRMQ Total and subscale T-scores. These effect sizes were interpreted according to the criteria outlined by Cohen (1969). The guidelines for interpreting effect sizes are 0.2 = small effect, 0.5 = moderate effect, and 0.8 or above = large effect.

4.4 Results

4.4.1 Data screening: missing data, normality and outliers

As noted above, there were no missing data from online surveys, as progression through the online survey was dependent on the participant having responded definitively to each and all of the preceding questions. Missing value analysis of the data obtained in hardcopy format was performed in SPSS for each of the variable of interest, including PRMQ, HADS and demographic variables. Regarding the PRMQ data, a missing values analysis revealed that PRMQ data was missing in 15 cases. Although a relatively small proportion of the overall data set, it was decided to exclude those participants with any missing PRMQ data and to proceed with data analysis using the Complete Case Analysis approach.

All retained datasets (n = 518) were assessed to determine whether individual variables of interest departed significantly from the assumptions of normality and equal variance. Normality was assessed visually using histograms and normal probability Q-Q plots, as well as statistically, using the Shapiro-Wilks test. Although these tests are useful for indicating any significant departure from normality, they do not confirm whether the deviation is large enough to bias statistical analyses. Skewness and kurtosis values for all data were, therefore, also examined.

To begin, skewness and kurtosis indices for the PRMQ Total Scale, PM Subscale and RM Subscale data of .554, .553 and .615 respectively were converted to z-scores by dividing the skewness and kurtosis values by their respective standard errors. Because the sample size was >200, values greater or lesser than 2.58 were taken as establishing normality of the data, as recommended by Ghasemi and Zahediasl (2012).

Z-scores were all above 2.58, indicating positive skewness. However, sample skewness fell just outside .5 as the outer bound of approximate normality, suggesting the sample was approximately normal to mildly skewed. Although Shapiro-Wilks test results indicated that the sample departed from normality, the sample size can be considered quite large. Furthermore, significant results from normality tests can be expected even with small deviations from normality (Field, 2009, p.822; Oztuna, Elhan & Tuccar, 2006). Of relevance, such a small deviation should not affect the results of a parametric test (Oztuna et al., 2006). Thus, for analysis purposes, parametric procedures were considered sufficiently robust for analysis of PRMQ data.

Tukey's Box Plots were used to screen for univariate outliers in the PRMQ data set. In line with recommendations from High (2000), those observations that fell outside the inner fences and the outer

fences (1.5 IQR and 3 IQR) were noted as possible outliers and their characteristics examined. According to Seo (2006), this method can be effective when working with large continuous datasets that are not highly skewed. Using this method, no cases were flagged as probable or extreme outliers across the PRMQ Total Scale, RM Scale or PM Scales, although a handful of cases were identified as potential outliers on each of Total Scale, RM Scale and PM Scale, having raw scores between the upper inner and upper outer fences - indicating poorer self-reported memory. There were six potential upper outliers on the PRMQ Total Scale, five potential upper outliers on the PRMQ RM subscale and four potential upper outliers on the PRMQ PM subscale.

Demographic, HADS and health information data pertaining to these outlying cases were examined to see if there was noteworthy information associated with the outlying cases. This inspection did not reveal any specific reasons for the high scores – with each of the cases reflecting a complex presentation. For example, one of these probable outlying cases indicated by Tukey's Box Plot was a 63-year-old male, non-drinker, with breathing problems, with high self-reported depression and anxiety (HADS D=16 and HADS A=19) who also experienced difficulty falling asleep, reported waking during the night and waking earlier than expected, averaging 4 hours sleep per night and who took naps during the day.

Subsequent calculation of Mahalanobis D on the data revealed three cases to be multivariate outliers, p<.001. However, identification of an outlier does not automatically suggest removal, and not all outliers are influential. Therefore, to help decide whether to retain or remove the three multivariate outliers signalled by Mahalanobis D, Cook's D was calculated for all observations to determine which, if any, of these cases would be expected to exert an influence in correlational or regression analyses. Using the cut-off rule for Cook's D values that cases >1 should be considered influential outliers (see Cook and Weisberg, 1982), none of the multivariate outliers identified based on Mahalanobis distance were judged to be influential and so these cases were retained in future analyses.

Demographic information and mood state associated with these three multivariate, albeit non-influential, outliers were examined. For each of the three cases, high HADS scores, equal to or greater than the recommended cut-off of 11 (Crawford et al., 2001), was noted in either the anxiety or depression subscale. None of the potential univariate or the three multivariate outliers were flagged for potential alcohol problems, as determined by their response to the alcohol screening question.

4.4.2 PRMQ Scale Reliability and Scale Structure – Irish Sample

Cronbach's alpha reliability coefficient and confidence intervals were calculated for the overall PRMQ scale, as well as for the PM and RM subscales. Cronbach's alpha coefficient for the PRMQ Total scale was .91 (CIs: .89 - .92.). Cronbach's alpha for the PM subscale was .87 (CIs: .85 - .88) and was .81 (CIs .78 -

.83) on the RM subscale. Based on these results, the PRMQ can be considered a reliable measure for this Irish sample.

To examine further the potential reliability and validity of PRMQ use with older Irish adults, the underlying factor structure of the questionnaire was investigated in this Irish sample. For this investigation, Confirmatory Factor Analyses (CFA; robust maximum likelihood) were performed on the variance-covariance matrix of the PRMQ items, using the Lavaan programme (Rosseel, 2013), in R version 3.4.4 for Windows (R Core Team, 2018).

Drawing on the CFA procedures and findings of Crawford et al., (2003), Ronnlund et al., (2008), Piauilino et al., (2010) and Zimprich, Kliegel and Rast (2011), a sequence of increasingly complex factor models was estimated. This sequence of models started with a general one-factor model because although a one-factor model is not theoretically plausible in the case of the PRMQ, due to the overlap but established dissociability of PM and RM (Crawford et al., 2003), the fit statistics from this model are useful in characterising the degree of superiority of a rival multifactor model (Thompson, 2004). This was followed by two different two-factor models, each accounting for the categorization of PRMQ items in PM and RM, albeit differing in relation to the relationship between factors (orthogonal or correlated). Subsequently, a higher-order, or tripartite, model consisting of one general memory factor and separate PM and RM factors was investigated. Most prior studies investigating the factor structure of the PRMQ have found support for this tripartite model to account for self-reported PM and RM failures assessed by the PRMQ.

Finally, a restricted bi-factor model of the PRMQ was tested. This consisted of a general factor of memory problems, on which all items were allowed to load. Items were also allowed to load on one of two specific domains; PM and RM. The bi-factor model can be considered a nested version of the tripartite (higher-order) model, but whereas the tripartite model can be said to force a somewhat artificial distinction between general memory and specific domains of memory, the bi-factor model allows the correct or actual separation of general and domain-specific items (Reise, Moore & Haviland, 2010). Here, the goal was to investigate which of the constructs, PM or RM was the most salient in the PRMQ, once general memory problems were accounted for. Such an investigation can be helpful for providing a picture of the extent to which the PRMQ subscales reflect a general construct of memory or a more conceptually narrow construct (PM or RM). This is also of interest considering the theorised complexity of PM as a memory construct.

Based on findings from previous authors (Crawford et al., 2003; Ronnlund et al., 2008, Piauilino et al., 2010), other categorisations of PRMQ items (self-cued versus environmentally-cued PM and RM items; short-term versus long-term PM and RM items) were not included in the specified models, as previous

studies showed that these categorisations did not contribute meaningfully to PRMQ model fit and latent structure.

4.4.2.1 CFA: Underlying assumptions and pre-analysis of data

Distribution of data: CFA is particularly sensitive to the effects of violations to the assumption of a normal distribution (West, Finch & Curran, 1995). An analysis of the distribution of the raw PRMQ data was, therefore, undertaken prior to conducting the CFA. Skewness and kurtosis values of individual PRMQ items and of the PRMQ Total scale and subscales were inspected and were found to be within the normal range generally accepted in the literature as all of the values were within the bounds of plus or minus 2 for skewness and an absolute value of 7 for kurtosis. It was noted that one of the PRMQ items, item 2 (How often: *"Do you fail to recognise a place you have visited before?"*) displayed a markedly higher skew value (1.46) and kurtosis value (2.68) in comparison to the remaining PRMQ items. The skewness value of the PRMQ Total scale (0.51) was ever-so-slightly outside the margin of approximate normality (0.5), which is not unusual in psychological data (e.g. Micceri, 1989).

As already noted, the presence of univariate outliers was examined via box plots and standardised z-scores in IBM SPSS prior to import of data into R for CFA analyses. As reported, none of the z-scores fell outside the cut-off rule of z>3.29 (p<.001). Three multivariate outliers (PRMQ Total, PM and RM subscale scores), were identified and, although retained for other analyses, these were removed from the dataset prior to CFA analyses. This left a final N of 515 for CFA analyses purposes.

Sample size: The final sample size of 515 falls within the range of the oft-cite N:q rule and so is deemed sufficient for the purposes of model identification in CFA.

4.4.2.2 CFA Analysis – Choice of Estimator and Fit Indices

Choice of estimator: The widely-used statistic, Maximum Likelihood (ML), can perform badly when data are not multivariate normally distributed (Hu, Bentler & Kano, 1992; Curran, West & Finach, 1996), resulting in downward-biased standard errors and parameter estimates and inflated Type 1 error rates. Although the data examined here can be considered only mildly skewed, CFA is particularly sensitive to the effects of non-normality. Thus, Robust Maximum Likelihood ("MLR" in *R*) was used for the CFA analyses. MLR specifically uses maximum likelihood estimation with robust (Huber-White) standard errors and a scaled test statistic that is (asymptotically) equal to the Yuan-Bentler test statistic. It is suitable for use with both complete and incomplete data. It is recommended to use a robust estimator with skewed and/or kurtotic data because its Type 1 error rates are not as inflated as rates derived from non-robust estimators. Robust ML still obtains the parameter estimates using the asymptotically unbiased ML estimator, but the standard errors are statistically corrected to enhance the robustness of

ML against departures from normality. The robust correction also transforms the test statistic to follow a chi-square distribution so that the estimated p-value will yield approximately normal Type 1 error rates.

MLR is more frequently used than other robust variants of ML estimation – such as MLM (maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic) (Li, 2014) and MLMV (maximum likelihood estimation with robust standard errors and a mean and variance adjusted test statistic – using a scale shifted approach (www.lavaan.ugent.be). It is generally considered commendable in practice to compare the performance of available estimators with data across an array of CFA models (Thompson, 2004). To further support the choice of MLR as estimator for the CFA analyses undertaken here, therefore, its performance in model identification was compared with the performance of traditional ML, as well as ML with bootstrapped standard errors, and with weighted least squares methods (WLSMV), a robust variant of a diagonally weighted least squares estimator designed specifically, and recommended for use with ordered categorical data (such as Likert scale data). As a result of these comparisons, MLR was deemed most suitable for analysis of this data set. For the interested reader, very similar results were obtained from bootstrapped ML as MLR, although final fit statistics and parameter estimates (standard errors) were marginally better in MLR estimated models. The CFA results derived from MLR as a robust variant of ML are reported here.

Fit Indices: In line with previous factor analytic studies of the PRMQ (Crawford et al., 2003: Ronnlund et al., 2008; Piauilino et al., 2010; Zimprich et al., 2011), fit of the CFA models was assessed with the following fit statistics; the chi-square statistic (X^2), the Comparative Fit Index (CFI), the standardised root mean square residual (SRMR), and the root mean squared error of approximation (RMSEA).

Smaller chi-square values suggest the model is a good one for the data (Hu & Bentler, 1998). However, it is well known to be sensitive to sample size (McIntosh, 2006) and so a significant chi-square value is to be expected with the present large sample size. It is recommended that to protect against Type 1 and Type 2 errors under various conditions, a combination of at least one relative fit index, such as the CFI or the Tucker Lewis Index (TLI) and the SRMR and the RMSEA (see Hu & Bentler, 1999) is used. The CFI is not sensitive to sample size (Fan, Thompson & Wang, 1999) and measures whether the model fits the data better than a more restricted baseline model (the null model). Higher values indicate better fit, with an acceptable fit >.9 and a good fit indicated by >.95 (Bentler & Mooijart, 1989). Similar to CFI, the TLI measures whether the model fits the data better than a restrictive baseline model. However, it also penalises overly complex models, making it more conservative than CFI.

Both CFI and TLI are influenced by the average size of the correlations among variables. If the average correlation between variables is not high, then these fit values will not be very high. Instead of comparing to a baseline model, the RMSEA measures how closely the model reproduces data patterns (i.e. the

covariances among indicators). The RMSEA penalises models that are not parsimonious and is sensitive to mis specified factor loadings (Hu & Bentler, 1998). An RMSEA <0.06 is taken as indicating good fit (Hu & Bentler, 1999). Confidence limits are generally reported with RMSEA values, and in a well-fitting model the lower limit is close to 0 while the upper limit should be less than 0.08 (Hooper, Coughlan & Mullen, 2008). The SRMR is sensitive to mis specified factor covariances. An SRMR of <0.08 is regarded as indicating good fit (Hu & Bentler, 1999). It should be noted that SRMR will be lower when there is a high number of parameters in the model and in models based on large sample sizes (Hooper et al., 2008). In general, it is important to bear in mind that fit indices may suggest a well-fitting model even when parts of the model may fit poorly or display localised areas of strain (Tomarken & Waller, 2003). Therefore, careful examination of the parameter estimates (standardised factor loadings, standard errors), residual variances and any suggested changes to model parameters indicated by modification indices is important.

4.4.2.3 CFA Analysis - Scaling and Models Tested

Scaling: Model identification requires that the measurement scale (i.e. the variance or the standard deviation) of each latent variable is specified or constrained, because latent variables, by definition, have no intrinsic scaling. The two common ways of identifying CF models consist of either fixing any factor coefficient on each factor to a set number (usually "1"), or alternatively constraining any of the latent construct variances to any plausible number (also usually "1"). Choice of either strategy will not affect model parameters or fit statistics. However, an advantage of the latter choice, constraining the latent construct variances to 1 means that the pattern coefficients for a factor can be interpreted as correlations, making it "easier to compare apples with apples as to how well each measured variable reflects the underlying construct." (Thompson, 2004, p.120). For this reason, a decision was made to override the default behaviour of the Lavaan package in R, to set the first factor indicator (item) to a value of 1, and a command was placed in R during each of the model analyses to constrain the variances of the latent constructs to 1 instead.

Models Tested: As Crawford et al., (2003) outline, a model is considered to be nested within another model if it differs only in imposing additional constraints on the relationships between variables specified in the initial model. The difference between chi-square for nested models is itself distributed as chi-square with *k* degrees of freedom (df), where *k* equals the df for the more constrained model minus the df for the less constrained model. Because of this, it is possible to test directly whether more constrained models have significantly poorer fits than the less constrained models.

The first model to be evaluated (**Model 1**) was a single factor model that expressed the hypothesis that the variance in the PRMQ in the Irish sample can be partitioned into one general factor plus error

variance associated with each individual item (true variance of the item that is independent of the factor, plus random error).

Model 2 expressed the hypothesis that the PRMQ contains two uncorrelated factors, PM and RM.

Model 3 hypothesised two constructs, PM and RM, but constrained these to be correlated.

Model 4 hypothesised that the PRMQ in the Irish sample has a tripartite (higher order) structure, parameterised so that all 16 items are indicators of a common factor representing general self-rated memory. In addition, the eight PM items are also indicators of a factor reflecting the variance specific to PM, and the eight RM items are indicators of a specific RM factor. The specific factors are constrained to be orthogonal to each other and to the common factor. According to Thompson (2004), uncorrelated factor models are more parsimonious when there are two or more factors, yet there may be a trade-off between model parsimony and obtaining good fit.

4.4.2.4 CFA Results

The fit statistics for each of these CFA models are presented in Table 4.3.

The one-factor (general) model (**Model 1**) converged after 24 iterations. Overall, it showed poor fit; the robust chi-square value is large and the Robust CFI is acceptable. The Robust TLI is, however, low. Nevertheless, the RMSEA value is acceptable and the SRMR value is good.

The item loadings on this factor were statistically significant and most fell within the acceptable range (see Appendix H: Table H.1). Apart from PRMQ item 2 (How often *"Do you fail to recognise a place you have visited before?"*), which had a standardised loading of 0.298, standardised loadings on the general factor ranged from 0.4 to 0.7, satisfying general consensus for good loadings (Kline, 2005). This, while a one-factor model of the PRMQ is not theoretically plausible, the range in factor loadings show substantial common variance among the items, and support the subsequent testing of models with more than one factor.

Model 2, which expressed the hypothesis that the PRMQ consists of two independent or orthogonal constructs, PM and RM converged with 23 iterations. The fit of this model was poor, and global and comparative fit indices were considerably worse than that of the one-factor model. Robust chi square is large and CFI and TLI are low. However, robust RMSEA and SRMR values are very low, and lend some support to the presence of at least two factors in the PRMQ. Apart from a standardised factor loading of 0.348 for RM PRMQ item 2 (How often *"Do you fail to recognise a place you have visited before?"*) and a standardised loading of 0.380 for PRMQ item 6 (How often *"Do you fail to recognise a character in a radio or television show, from scene to scene?"*), standardised loadings on the RM and PM factors

can be considered acceptable, ranging from 0.4 to 0.6. Again, all standardised factor loadings on the respective latent constructs were significant (see Appendix H: Table H.2).

The alternative, correlated, version of the two-factor model (**Model 3**), converged with 32 iterations. As seem in Table 4.3, the robust chi-square was significant but much smaller than the chi-square value of the orthogonal two-factor model (**Model 2**). Robust CFI and Robust TLI, robust RMSEA, and SRMR values were all in the acceptable range. Although all factor loadings were statistically significant, again, two of the PRMQ items (item 2 and item 6) loading on the RM construct had standardised factor loadings below the desired cut-off of 0.4 (0.322 and 0.321 respectively). The remaining PRMQ items were in the moderate range of 0.4 to 0.6 (see Appendix H: Table H.3).

Since the uncorrelated two-factor model (Model 2) can be considered nested within the correlated two-factor model (Model 3), a statistical Chi-square difference test was used to compare these nested models statistically. From Table 4.4, it can be observed that the two-factor correlated model (Model 3) had significantly better fit (*p<0.001*) than its independent counterpart (Model 2), supporting the hypothesis that independence of the RM and PM scales is not feasible.

Table 4.3: Fit indices for confirmatory factor analytic models of the PRMQ (best fitting model in bold)

Model	Robust X^2	df	Robust CFI	Robust TLI	Robust RMSEA	SRMR
1. Single memory factor	372.783 $p = 0.000$	104	0.900	0.884	0.076 (0.068 - 0 .085)	0.048
2. Two-factor Model: PM and RM as orthogonal factors	738.067 $p = 0.000$	104	0.765	0.729	0.117 (0.109 - 0.125)	0.238
3. Two-factor Model: PM and RM as correlated factors	342.264 $p = 0.000$	103	0.911	0.896	0.072 (0.064 - 0.081)	0.046
4. Tripartite model (general memory + orthogonal PM and RM)	353.712 $p = 0.000$	102	0.908	0.891	0.075 (0.066 - 0.083)	0.048

CFI = Comparative Fit Index; TLI = Tucker Lewis Index; SRMR = root mean square residual; RMSEA = root mean squared error of approximation.

Table 4.4: Differences between Nested CFA Models of the PRMQ

Comparison				
More constrained	*Less constrained*	*Difference in X^2*	*df*	*p*
Model 2 (orthogonal PM and RM)	Model 1 (general memory factor)	26.30	1	<.001
Model 2 (orthogonal PM and RM)	Model 3 (correlated PM and RM)	696.53	1	<.001
Model 4 (tripartite model; general memory and orthogonal RM and PM factor)	Model 1 (general memory factor)	52.55	2	<.001

It was noted, however, that the model of two correlated factors of PM and RM (Model 3) had a large chi-square value, and that despite exceeding the recommended minimal criteria for a practical or acceptable level of fit, the CFI and TLI are still relatively modest. Next a tripartite model (**Model 4**) consisting of one general self-rated memory factor and separate orthogonal PM and RM factors was tested. The model converged successfully with 62 iterations. The CFI, TLI, RMSEA, and SRMR show values above the recommended cut-offs for acceptable to good fit. As mentioned previously, a model with an SRMR value ≥0.8, or RMSEA equal to or smaller than 0.06 indicates good fit. While the chi-square test is significant, it is smaller than that of the chi-square of preceding models tested.

While fit statistics in Table 4.3 appear to suggest a similar level of fit provided by the single factor (Model 1) and tripartite models (Model 4), Table 4.4 demonstrates the models to be significantly different in terms of fit. This is similar to findings from Crawford et al (2003), who found that the one-factor model was very similar to the tripartite model in terms of fit. This is because the one-factor model is nested within the tripartite model, meaning that the higher-order models and the corresponding first-order models are the same, when there are fewer than four first-order factors for a given second-order factor. However, Thompson (2004, p.147) points out that the tripartite model offers additional insight because if allows the correlations of measured variables and first-order factors with higher-order constructs to be quantified. Crawford et al pointed out that because there was a highly significant difference in fit between the one-factor and uncorrelated two-factor models in their CFA, that this latter result provided satisfactory evidence that the PRMQ is not simply measuring a unitary factor (i.e. Model 1 should not be accepted).

Table 4.5 presents the parameter estimates (standardised and unstandardized factor loadings and standard errors) of the tripartite model (Model 4). As can be seen in the table, all factor loadings on their respective subscales were significant.

Table 4.5: Standardised and Unstandardised Coefficients for Tripartite Model of PRMQ (Model 4)

PRMQ Item	Latent Construct	Standardized coefficients	Unstandardized coefficients	SE	P-value
PRMQ1	PM	0.584	0.191	0.025	.000
PRMQ3	PM	0.634	0.207	0.027	.000
PRMQ5	PM	0.589	0.193	0.026	.000
PRMQ7	PM	0.648	0.213	0.029	.000
PRMQ10	PM	0.618	0.203	0.025	.000
PRMQ12	PM	0.575	0.189	0.024	.000
PRMQ14	PM	0.494	0.162	0.022	.000
PRMQ16	PM	0.608	0.200	0.026	.000
PRMQ2	RM	0.335	0.096	0.016	.008
PRMQ4	RM	0.673	0.194	0.023	.004
PRMQ6	RM	0.352	0.102	0.020	.016
PRMQ8	RM	0.659	0.190	0.023	.005
PRMQ9	RM	0.487	0.140	0.016	.003
PRMQ11	RM	0.578	0.167	0.015	.002
PRMQ13	RM	0.482	0.139	0.020	.008
PRMQ15	RM	0.534	0.154	0.021	.007
PM	GM	0.951	3.074	0.436	.000
RM	GM	0.951	3.085	1.176	.009

PM: Prospective Memory; RM: Retrospective Memory

Table 4.6 presents the correlations between PRMQ items in the tripartite model (Model 4) and, for ease of presentation, Table 4.7 presents the correlations between the latent variables of PM, RM and the general memory factor and each of the PRMQ items.

Table 4.6: Correlations for PRMQ items in Tripartite Model (Model 4)

PRMQ Item	1 PM	3 PM	5 PM	7 PM	10 PM	12 PM	14 PM	16 PM	2 RM	4 RM	6 RM	8 RM	9 RM	11 RM	13 RM	15 RM
1 -PM	1.00															
3 -PM	.454	1.00														
5 - PM	.387	.405	1.00													
7 -PM	.461	.483	.411	1.00												
10 -PM	.480	.503	.429	.510	1.00											
12 -PM	.448	.469	.400	.476	.496	1.00										
14 -PM	.403	.422	.360	.428	.446	.416	1.00									
16 -PM	.477	.500	.426	.507	.529	.493	.444	1.00								
2 -RM	.270	.283	.241	.287	.299	.279	.251	.297	1.00							
4 -RM	.418	.438	.373	.444	.463	.432	.388	.460	.318	1.00						
6 -RM	.250	.262	.223	.266	.277	.259	.232	.275	.190	.295	1.00					
8 -RM	.430	.450	.384	.457	.476	.444	.393	.473	.327	.506	.303	1.00				
9 -RM	.334	.350	.298	.355	.370	.345	.310	.368	.254	.394	.235	.404	1.00			
11 -RM	.356	.373	.318	.378	.395	.368	.331	.392	.271	.420	.251	.431	.335	1.00		
13 -RM	.409	.429	.365	.435	.454	.423	.380	.451	.311	.482	.289	.496	.385	.411	1.00	
15 -RM	.340	.356	.303	.361	.376	.351	.316	.374	.258	.400	.239	.411	.320	.341	.392	1.00

PM: Prospective Memory; RM: Retrospective Memory

Table 4.7: Correlations among PRMQ items and latent factors in the Tripartite Model (Model 4)

Item / Latent factor	1 PM	3 PM	5 PM	7 PM	10 PM	12 PM	14 PM	16 PM	2 RM	4 RM	6 RM	8 RM	9 RM	11 RM	13 RM	15 RM	PM	RM	Ge
PM	.660	.695	.578	.693	.727	.680	.615	.723	.400	.630	.357	.645	.509	.568	.617	.504	1.00		
RM	.603	.635	.528	.633	.664	.621	.562	.660	.437	.690	.391	.706	.518	.621	.675	.552	.913	1.00	
Ge	.629	.661	.550	.660	.692	.647	.585	.688	.420	.662	.375	.678	.535	.596	.648	.530	.952	.960	1.0

PM: Prospective Memory; RM: Retrospective Memory, Ge: General Memory

Table 4.8: Fit indices for CFA Model 5

Model	Robust X^2	df	Robust CFI	Robust TLI	Robust RMSEA	SRMR
Model 5: Bi-factor model (a general memory factor and uncorrelated residual group factors- RM and RM)	213.293 p = 0.000	88	0.955	0.938	0.056 (0.46 - 0.65)	0.033

PM: Prospective Memory; RM: Retrospective Memory; CFI = Comparative Fit Index; TLI = Tucker Lewis Index; SRMR = root mean square residual; RMSEA = root mean squared error of approximation.

Examination of the residuals in each of the one-factor, two-factor uncorrelated and two-factor correlated, and the tripartite models revealed negative residual variances. Since the present sample size can be regarded as sufficiently large, and outliers have been removed from the data, it is possible that such negative residual variances reflect skewed variables or floor effects.

Modification indices for each of the specified models suggested fixing covariances between many of the PRMQ items. However, adding or freeing model parameters as suggested by modification indices must be carried out on substantive theoretical grounds and doing so also moves the analysis from a confirmatory to an exploratory one. Therefore, no modifications were made to the models in the above CFA analyses. However, these indices may reflect the possibility that item covariances are somewhat mis specified in the CFA models investigated.

Finally, a bi-factor model (**Model 5**) positing one general factor of self-reported memory problems combined with two factors accounting for the PM and RM categorisations of the PRMQ items was tested. The goal here was to investigate which one of the PRMQ constructs had the most salient domain-specific factor loadings once the factor of general memory was accounted for. Summary data for this final Model are presented in Table 4.8. As can be seen from this table, this bi-factor model fits the data well. The chi-square value, though significant, was smaller than the preceding models and the fit values of robust CFI (0.955) and robust TLI (0.938) are considered good and are higher than preceding models. Robust RMSEA, 0.056 (0.46 – 0.65) was lower than preceding models, indicating better fit, and the lower bound of the associated confidence interval was closer to zero, as further support for closer fit. The SRMR of 0.033 is the smallest SRMR value of all the tested models. Inspection of the parameter estimates shows that item 2 had the lowest standardised loading on the general factor (0.219), while item 3 had the highest standardised loading (0.653).

Standardised loadings (see Appendix H: Table H.4) of the PM items on the PM construct were lower in range; the highest loading item was item 12 (0.312), but most items had standardised loadings below 0.1, and items 1, 3 and 10 actually displayed negative loadings, suggesting the tendency to load in a direction opposite to theoretically expected. In general, the much higher loadings of the PM items on the general factor than the specified PM factor likely points to the complexity of PM as a construct of memory; successful prospective remembering is posited to involve a host of processes such as executive function and working memory. On the RM construct, item 6 loaded the highest (0.407). Although the RM items loaded higher than the PM items on their respective domain, apart from item 6, the remaining RM items had standardized loadings below 0.4, and one RM item, item 11 had a negative loading (-0.002). Indeed, inspection of the residuals for the bifactor model showed that there were many negative

residuals and many large or outlying residual values that were larger in absolute value displayed by the next best-fitting model, the tripartite model (**Model 4**).

Given the importance of considering parameter estimates and residual variances in model evaluation as well as the fit statistics (Thompson, 2002), together with the need to consider the substantive theory and prior empirical evidence for a tripartite model of one general memory factor and two distinct (but overlapping) PM and RM factors, the tripartite model (Model 4) appears to be the most suitable and parsimonious CFA model to explain the data in this study. For this reason, subsequent data analyses examine the PRMQ Total Score, as well as the PRMQ PM and the RM subscale scores.

A schematic representation of the standardised solution for the tripartite model (Model 4) is shown in Figure 4.1 below.
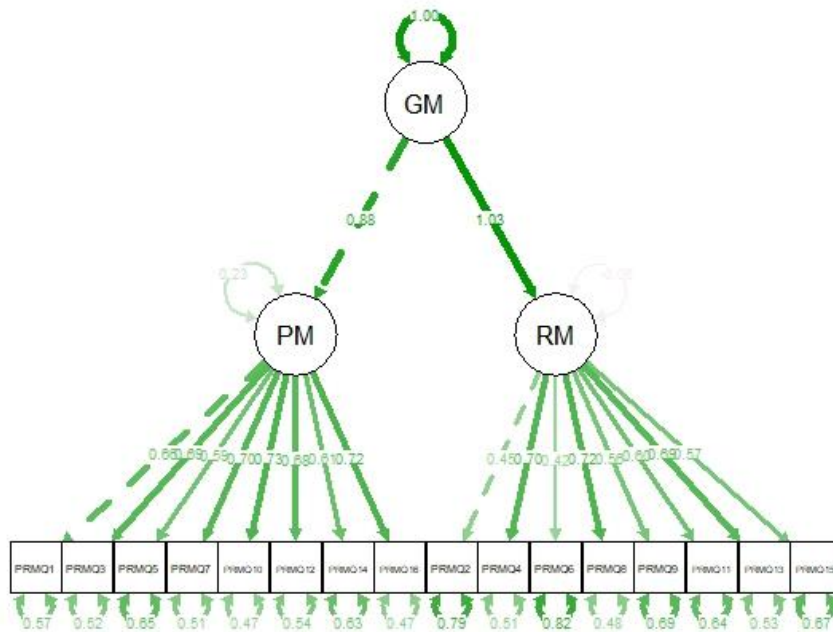
Figure 4.1: Schematic representation of the standardised solution for the tripartite model of PRMQ

4.4.3 PRMQ Self-reported Memory Failures in the Irish Sample

In order to explore the PRMQ data, the frequency of self-reported difficulty across the test protocol (PRMQ Total, PRMQ PM and RM subscales as well as individual items) were obtained and examined. Table 4.9 summarises the means, standard deviations and ranges for the PRMQ Total scale and subscales.

Table 4.9: Summary sample data for the PRMQ

Scale		M (SD)	N (%)	Range
PRMQ	PRMQ Total (Raw Score*)	34.56 (9.05)	518 (97.2)	16-64
	PM total (Raw Score*)	18.59 (5.10)	518 (97.2)	8-36
	RM total (Raw Score*)	15.97 (4.55)	518 (97.2)	8-33

*Higher raw scores reflect poorer memory; PRMQ: Prospective and Retrospective Memory Questionnaire; PM: Prospective memory; RM: Retrospective Memory; M; Mean; SD: Standard Deviation; N: number

Table 4.10 presents a summary of the reported frequency of occurrence per PRMQ item for the Irish sample. A range of responses occurs , reflecting wide inter-subject variability within and between items.

Table 4.10: Reported frequency of occurrence per PRMQ item – Irish sample

Item	Type	How often:	Very often	Often	Sometimes	Rarely	Never
1	PM	Do you decide to do something in a few minutes time and then forget to do it?	4.1	10.7	47.5	31.1	6.6
2	RM	Do you fail to recognise a place you have visited before?	0.6	1.7	7.2	36.0	54.6
3	PM	Do you fail to do something a few minutes later, even though it's there in front of you, like take a pill or turn off a kettle?	1.5	4.3.	25.0	40.5	28.6
4	RM	Do you forget something you were told a few minutes earlier?	2.3	6.2	33.7	35.4	22.4
5	PM	Do you forget appointments, if you are not prompted by someone else, or by a reminder, such as a calendar or a diary?	3.0	8.1	28.6	37.7	22.5
6	RM	Do you fail to recognise a character in a radio or television show, from scene to scene?	0.6	2.3	14.1	31	52.1
7	PM	Do you fail to but something you had planned to buy, such as a birthday card, even when you see the shop?	1.7	6.2	29.7	39.9	22.5
8	RM	Do you fail to recall things that have happened to you in the last few days?	0.6	4.9	24.2	36	34.3
9	RM	Do you repeat the same story to the same person on different occasions?	0.9	4.0	28.8	40.9	25.4
10	PM	Do you intend to take something with you, before leaving a room or going out, but minutes later, leave it behind, even though it's there in front of you?	2.1	9.2	46	34.3	8.5
11	RM	Do you mislay something that you have just put down, like a magazine or glasses?	4.5	15.3	42.6	28.4	9.2
12	PM	Do you fail to mention or give something to a visitor that you were asked to pass on?	0.9	3.6	27.5	45.1	27.8
13	RM	Do you look at something without realising you have seen it moments before?	0.2	0.9	8.5	32.3	58
14	PM	If you tried to contact a friend or relative who was out, would you forget to try again later?	0.4	1.9	22.6	43.6	31.5
15	RM	Do you forget what you watched on television on the previous day?	0.9	4.9	21.2	35.2	37.8
16	PM	Do you forget to tell someone something you had meant to mention a few minutes ago?	1.5	5.6	43.3	37.3	12.2

PM: Prospective Memory; **RM:** Retrospective Memory

In all cases, the frequency of occurrence ranged from "never" to "very often". This wide inter-subject variability suggests that self-reported difficulty remembering, in and of itself, might well reflect "normal" variation in memory performance rather than a clinical problem.

Table 4.11 presents a rank order of item difficulty. Of interest, while PM items are generally identified as more difficult (as defined by higher rates of occurrence) than are RM items, the memory mistake most frequently reported as occurring "very often" or "often" was the RM item, *"How often do you mislay something that you have just put down, like a magazine or glasses?"*

Table 4.11: PRMQ item difficulty – rank ordered based on "very often" or "often" occurring

Item	Type	How often:	"Very often" or "Often"	"Rarely" or "Sometimes"	Never
			Frequency of occurrence		
11	RM	Do you mislay something you have just put down, like a magazine or glasses?	19.8	71.0	9.2
1	RM	Do you decide to do something in a few minutes time and then forget to do it?	14.8	78.6	6.6
10	PM	Do you intend to take something with you, before leaving a room or going out, but minutes later, leave it behind, even though it's there in front of you?	11.3	80.3	8.5
5	PM	Do you forget appointments if you are not prompted by someone else, or by a reminder, such as a calendar or diary?	11.1	66.3	22.5
4	RM	Do you forget something you were told a few minutes earlier?	8.5	69.1	22.4
7	PM	Do you fail to buy something you had planned to buy, such as a birthday card, even when you see the shop?	7.9	69.6	22.5
16	PM	Do you forget to tell someone something you had meant to mention a few minutes ago?	7.1	80.6	12.2
3	PM	Do you fail to do something a few minutes later, even though it's there in front of you, like take a pill or turn off the kettle?	5.8	65.5	28.6
15	RM	Do you forget what you watched on television the previous day?	5.8	56.4	37.9
8	RM	Do you fail to recall things that have happened to you in the past few days?	5.5	60.2	34.3
9	RM	Do you repeat the same story to the same person on different occasions?	4.9	69.7	25.4
12	PM	Do you fail to mention or give something to a visitor that you were asked to pass on?	4.5	72.6	22.8
6	RM	Do you fail to recognise a character in a radio or television show, from scene to scene?	2.9	45.1	52.1
15	PM	If you tried to contact a friend or relative who was out, would you forget to try again later?	2.3	66.2	31.5
2	RM	Do you fail to recognise a place you have visited before?	2.3	43.2	54.6
13	RM	Do you look at something without realising you have seen it moments before?	1.1	40.8	58.0

PM: Prospective Memory; **RM:** Retrospective Memory

The memory failures that occurred the least frequently by most of the sample appear at the bottom of the table as reflected by the higher percentages of the "Never" response category endorsed. The PRMQ items between the two red lines in the table reflect memory mistakes that are generally experienced sometimes or rarely by respondents.

Table 4.12 presents the PRMQ scores obtained in the current sample of older Irish adults, together with those obtained by Crawford et al. (2003) for their UK standardisation sample and by Rönnlund et al. (2008) for a Swedish sample of adults aged 35-90 years.

Table 4.12: Summary statistics for PRMQ scores for Irish, UK and Swedish samples

Sample / Scale	n	Mean	SD	Range
Irish sample	518			
PRMQ Total score	518	34.56	9.05	16-64
PM subscale	518	18.59	5.10	8-36
RM subscale	518	15.97	4.55	8-33
UK sample (Crawford et al., 2003)	551			
PRMQ Total score	551	38.88	9.15	17-67
PM subscale	551	20.18	4.91	8-35
RM subscale	551	18.69	4.98	8-33
Swedish sample (Rönnlund et al., 2008)	540			
PRMQ Total score	540	32.65	8.33	
PM subscale	540	17.90	4.74	
RM subscale	540	14.76	4.18	

PRMQ: Prospective and Retrospective Memory Questionnaire; PM: Prospective Memory; RM: Retrospective Memory; SD: standard deviation

Inspection of the mean values for the PRMQ scales (raw scores) show that the Irish sample differed systematically from the UK and the Swedish normative samples. Lower mean raw scores across all three aspects of the PRMQ, reflecting less self-reported difficulty, was observed in the Irish sample compared to the UK sample. Specifically, the Irish sample reported a lower frequency of memory failures both on the PM and RM subscales (M = 18.59 and M = 15.97) vs PM and RM scores of M = 20.18 and M = 18.69 respectively in the Crawford et al. study. However, Irish participants reported a higher frequency of memory failures, both on the PM and RM subscales, than did the Swedish sample (M = 17.90 and M = 14.76 respectively).

Cohen's D effect size values of the difference between the Irish and the UK and Swedish sample means were obtained by using the sample means and standard deviations as outlined in Table 4.12 above. While the difference between the Irish and Swedish sample means appear to be of low practical significance (d = 0.14), a difference corresponding to a low-moderate effect size between the Irish and UK samples (d = 0.3; Cohen, 1988) might be considered noteworthy. These differences were then explored further using T-score comparisons. Using the free downloadable PRMQ scoring software available from Crawford and colleagues, raw scores for the Irish sample were converted to T-scores (with a mean of 50 and a SD of 10) so that PRMQ Total and subscale T-scores could be compared directly with the UK normative sample.

Table 4.13 presents summary statistics for the Irish sample T-scores (derived from UK normative data) and compares these to the UK normative data (mean = 50). One sample t-tests showed that the difference in mean T-scores between the current Irish sample of older adults and the UK normative sample were statistically significant across all three aspects of the PRMQ (PRMQ Total T-score, PM T-score, RM T-score).

Table 4.13: Irish sample PRMQ T-scores and comparisons with UK normative data.

PRMQ T-score	n	Mean T-Score*	SD	*one-sample t-test***	*p*	95% CI Difference	*Cohen's d*
Total	518	55.16	9.91	11.85	.000	4.30 - 6.01	0.52
RM scale	518	55.02	9.16	12.47	.000	4.23 - 5.81	0.55
PM scale	518	52.87	10.23	6.38	.000	1.98 - 3.75	0.28

*Higher T-scores reflect better self-reported memory; **hypothesised test value: T=50.

Results of the one-sample t-tests show that, in all cases, the current sample mean T-Score was higher than the hypothesised test value of T=50, reflecting the fact that the Irish sample reported *less* difficulty with their memory than did the UK normative sample. Although representing an older sample overall (age 50+), the Irish sample reported *better* memory than did the UK sample, raising questions about the suitability of the published normative data for these older Irish adults.

There was, however, some difference between the UK normative sample and the Irish sample studied here, likely accounting for at least some of the difference between the Irish and UK samples in terms of self-reported memory difficulty.

Mean years of education was 13.22 (SD = 3.38); range 4 to 20 years in the UK sample whilst levels of education were marginally higher in the Irish sample. Although the mean age was similar across the two samples, the UK sample had a wider age range (UK sample: Mean age = 63.62 (SD = 15.59); range 17-94 years; Irish sample: Mean age = 62.49 (SD = 9.24); range 50 – 99 years). Figure 4.2 represents a summary of the age profile of the Irish sample (n=518) relative to that of the UK normative study (n = 551).

Given these sample differences, there was little evidence that separate normative data (T-scores) were required for this Irish sample. Thus, Crawford et al's (2003) T-score calculations for the PRMQ, were used with the present cohort.
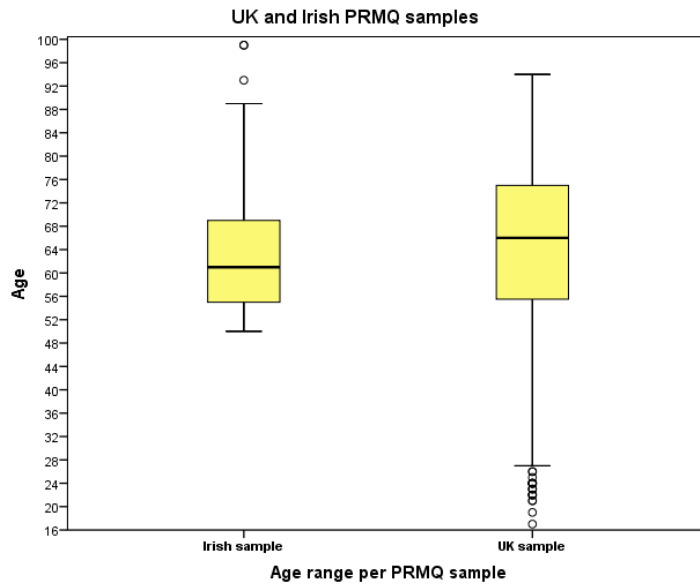
Figure 4.2: Age profile Irish sample compared with UK PRMQ normative sample.

4.4.3.1 Reliability of the difference between PM and RM T-scores

Crawford and colleagues suggest that in addition to standard normative data, it would also be useful for users to have some means of evaluating discrepancies between an individual's PM and RM scores. They advocated the formulae proposed by Stanley (1971), Silverstein (1989) and others, which uses estimated true scores rather than obtained scores. Critical values are obtained for the difference between an individual's estimated true scores on the PM and RM subscales by first calculating the standard error of the difference:

$$SE_{D_t} = \sqrt{SEM_{x_t}^2 + SEM_{y_t}^2},$$

Where $SEMx_t$ and $SEMy_t$ are the standard errors of measurement for true scores. True scores are obtained using following formula:

$$\text{True score} = r_{xx}(X - \overline{X}) + \overline{X},$$

Critical values are obtained by multiplying the standard error of the difference for true scores (SED_t) by the value of z (a standard normal deviate) corresponding to the required significance level (i.e. 1.96 for the 0.05 level). Critical values for the UK dataset are presented in Table 4.14.

Table 4.14: Critical values for significant (i.e. reliable) differences between estimated true scores on the PM and RM scales in the UK normative samples.

UK sample				
	Significance level			
	.15	.10	.05	.01
Two-tailed critical value	7	8	10	13
One-tailed critical value	5	6	8	11

Estimated true scores for the Irish population aged 50 and above on the Prospective and Retrospective scales should be obtained from Columns 3 of and 4 of Tables 7.2 and 7.3 respectively.

Using this information, therefore, if an individual obtained a raw score of X on the PM scale and raw score of Y on the RM scale, Crawford et al's (2003) normative tables can be consulted to obtain their respective true scores, and to determine the discrepancy between the two true scores. If, for example, the discrepancy exceeds the critical value (9) for significance at the 0.05 level (two-tailed) as depicted in Table 7.4, one can conclude that the discrepancy between PM and RM scores reflects a genuine difference in self-rated memory rather than the effects of measurement error, i.e. it is a reliable difference. One-tailed values for assessing the reliability of difference between true scores are also presented in Table 7.4 as it may be desirable to use these if the researcher or clinician wished to test a directional hypothesis.

Examination of the PM - RM True-score comparisons for this Irish sample revealed that a total of 47 individuals exhibited a statistically significant difference between PM and RM scores.

4.4.3.2 Abnormality of the difference between PM and RM scores

The distinction between the reliability of a difference between PM and RM scores and the abnormality of such difference is an important one (Crawford et al., 2003). Many individuals may rate their PM as better than their RM and vice versa. Therefore, Crawford et al (2003) emphasise that a reliable difference need not be unusual or rare and that, in clinical settings, a reliable difference need not necessarily be a cause for concern. To this end, information on the actual abnormality of the difference should accompany information on the reliability of differences between scores. Crawford and colleagues made available a simple computer programme for PCs to automate scoring and the analysis of an individual's PRMQ data. This uses the following formula to obtain a quantity that is distributed as *t:*

$$t = \frac{|T_x - T_y|}{\sqrt{[S_x + S_y - S_x S_y r_{xy}]\left(\frac{N+1}{N}\right)}},$$

where T_x and T_y are the individual's T-scores on the two scales being compared, S_x and S_y are the standard deviations (10 in the present case as T-scores are used), r_{xy} is the correlation between the scales and N is the size of the normative sample. The percentile point corresponding to the *t* obtained from this formula

is then found and multiplied by 100 to provide an estimate of the percentage of the population equalling or exceeding the observed discrepancy.

To obtain the percentage equalling or exceeding the observed discrepancy, regardless of the sign of the discrepancy, the percentile point is multiplied by two before being multiplied by 100.

The reliability and abnormality values for each of the participants were obtained using Crawford's free scoring software, based upon information from a UK based normative sample. A chi-square test of independence was conducted to test the null hypothesis that two-tailed reliable differences between participants' PM and RM scores were independent of whether differences were abnormal. Since one of the cells had an expected count less than five, Fisher's Exact Test was carried out. Results showed that for a statistically significant proportion (63.8%) of the 47 (9.1%) participants with a significantly reliable discrepancy between their PM and RM scores, this discrepancy between scores was classifiable as an abnormal difference (p < 0.001, Fisher's Exact Test).

4.4.4 Correlates of self-reported memory failures

To investigate the extent to which demographic, mood state, health status and sleep variables, as measured by the study questionnaire, were related to self-reported memory failures, correlational and other statistical tests were conducted. Unless otherwise stated, correlations were two-tailed and considered significant at p < 0.05. PRMQ T-scores, derived from Crawford et al (2003), rather than PRMQ raw scores, were used in the analyses. The main findings of interest are now reported.

4.4.4.1 Influence of age on PRMQ: Pearson product-moment correlations were carried out to investigate relations between T-scores on the PRMQ scales and age. No significant effects of age were found for the PRMQ Total T-score, r (518) = -.021, *p* =.639, the PRMQ PM subscale T-score, r (518) = .020, *p* = .655, or the PRMQ RM subscale T-score, r (518) = -.064, *p* = .146.

4.4.4.2 Influence of gender on PRMQ: To explore the potential effect of gender on PRMQ Total and subscale T-scores, independent samples t-tests were conducted. Homogeneity of variances across the two groups were confirmed by Levene's tests. No significant differences between males and females were found in terms of PRMQ Total T-scores [males: M = 55.39, SD = 9.57; females: M = 55.02, SD = 10.11, t (516) = .406, *p* = .681]. Similarly, no significant gender differences were found on either the PRMQ PM or RM subscales [PM: males - M = 53.71, SD = 9.74; females - M = 52.38, SD = 10.48, t(516) = 1.431, p = .153; RM: males - M = 54.60, SD = 9.02; females - M =55.26, SD = 9.25, t(516) = -.793, p = .428].

4.4.4.3 Influence of education: In this study, education level can be considered a ranked categorical variable, ranked in the following order; Primary (1), Intermediate Certificate/Junior Certificate (2), Leaving Certificate (3), Post Leaving Certificate (4), Vocational Apprenticeship (5), Third Level Degree (6), Higher Diploma (7), Masters (8), PhD (9). There were no significant differences between the groups in terms of self-reported memory slips, as reflected by PRMQ Total T-scores; Welch's F (8, 142.60) = .493, p =.860. Years of education, as distinct from highest level achieved, is, for the purpose of this study, a ranked categorical variable comprising categories 0-6 years, 7-10 years, 11-13 years, 14-17 years, 18-19 years, 20+ years. Welch's F-test revealed no significant difference in total self-reported memory failures, as reflected by PRMQ Total T-scores across years of education, Welch's F (5, 82.37) = 2.168, p = .066. No significant between-group differences were detected in PM subscale scores: Welch's F (5, 82.214 = 1.702, p = .143. However, there were significant between group differences detected in RM subscale scores: Welch's F (5, 83.380) = 2.371, p = .046. Games-Howell post-hoc test showed that the groups with 7- 11 years of education had significantly lower RM T-scores, indicating poorer subjective memory than those with 18-9 years of education (Mean difference = -5.276, SE = 1.641), and this difference was significant at p <.05 level. However, this latter relationship was no longer significant after depression was controlled for in an ANCOVA, [F (5, 134.75) = 1.779, p = .116] and after anxiety was controlled for in a separate ANCOVA [F (5, 164.57 = 2.123, p = .062].

4.4.4.4 Influence of Mood State on PRMQ: Summary statistics for the HADS are shown in Table 4.15 below. Inspection of these data suggest relatively low levels of both anxiety and depression in this sample but, as expected, there was a spread of scores. The means and standard deviations of the Irish sample on the HADS Total (M = 8.75, SD = 5.19), HADS Anxiety (M = 5.76, SD = 3.26) and HADS Depression scales (M = 3.45, SD = 2.59) are lower than those derived from a large UK-based community-dwelling normative study sample (HADS Total: M = 9.82, SD = 5.98; HADS Anxiety: M = 6.14, SD = 3.76; HADS Depression: M = 3.68, SD = 3.07) (Crawford, Henry, Crombie and Taylor, 2001). In that study, mean age was 41.5 (SD = 15.9; range 18-91 years), representing a younger cohort of individuals.

Table 4.15: Summary statistics for HADS (Total, Anxiety and Depression)

Scale	n (%)	Mean	SD	Range	SEM	Skewness	Kurtosis
HADS Total (Raw Score)	499 (96.3)	8.75	5.19	1-35	.23	.99	1.68
HADS Anxiety (Raw Score)	482 (93.0)	5.76	3.26	1-19	.15	.81	.97
HADS Depression (Raw Score)	471 (90.9)	3.45	2.59	0-16	.12	1.36	1.95

*Higher scores reflect higher self-reported depression and anxiety; HADS: Hospital Anxiety and Depression Scale; M; Mean; SD: Standard Deviation; n: number

There were 36 missing observations from the self-reported anxiety data and 47 missing observations from the depression data. Of the intact data observed, using the cut-off point recommended by HADS authors, Zigmond & Snaith (1994) of ≥16 for severe cases of anxiety and/or depression, 5 (1.1%) participants obtained scores that fall within the severe range for anxiety symptoms, while no participants obtained a score suggesting severe depression. 33 (6.8%) participants had anxiety scores in the range 11 – 15, indicating moderate anxiety, while 8 (1.7%) people had depression scores between 11 and 15, indicating moderate depression. 84 (17.7%) participants had anxiety scores in the range 8 – 10, indicating mild anxiety, and 29 (6.2%) people had depression scores between 8 and 10 indicating mild depression.

Using the alternative HADS cut-off suggested by Crawford et al., (2001) of 10/11, 39 individuals (8.1%) of the sample scored greater than 10 and could be classified as potential anxiety cases (compared to 12.6 % in Crawford et al., 2001), and 9 individuals (1.9%) of the sample could be classified as potential depression cases (compared to 3.6% in the Crawford et al. 2001 sample). Comparison of sample data with the normative sample in Crawford and colleagues' study shows that the current sample can, as a whole, be considered low in anxiety and depression. Acknowledging that comorbidity between anxiety and depression is common, participants in the current sample reported higher anxiety than depression.

Because QQ-plots, normality plots and skewness and kurtosis statistics showed HADS data to be moderately positively skewed (reflecting the generally low scores), Spearman's rho correlations (2-tailed) were computed when examining the relationships between mood state and self-reported memory (see Table 4.16 below).

Table 4.16: Correlations between PRMQ T-scores and HADS Scores: Spearman's rho

Score	PRMQ Total T-Score	PRMQ RM T-Score	PRMQ PM T-Score	HADS Total	HADS Anxiety	HADS Depression
PRMQ Total	1					
PRMQ RM T-Score	.927**	1				
PRMQ PM T-Score	.936**	.927**	1			
HADS Total	-.314**	-.281**	-.302**	1		
HADS Anxiety	-.255**	-.216**	-.258**	.872**	1	
HADS Depression	-.248**	-.220**	-.233**	.774**	.407**	1

* p<.05; **p< 0.01

Inspection of these data reveal that levels of anxiety and depression, as measured by HADS, were both significantly, and negatively, related to PRMQ Total T-scores (-.255 and -.248 respectively) and PM (-.258 and -.233) and RM subscale T-scores (-.216 and -.220), reflecting greater memory difficulty with increased mood disturbance. Self-reported memory failures increased in line with higher levels of anxiety and depression symptoms.

4.4.4.5 Influence of sleep on PRMQ: A series of t-tests (unequal variances) and correlations were carried out to investigate the potential influence of sleep-related factors on self-reported memory failures. Table 4.17 below shows the PRMQ summary statistics and results of t-tests looking at differences in mean PRMQ T-scores based on whether participants experienced difficulty falling asleep, wake during the night, wake earlier than intended, take naps during the day, and take medication or alcohol to help them sleep. Inspection of the data reveals no significant differences in terms of self-reported memory between those who do and those who do not have difficulty falling asleep. In contrast, the subgroup of participants who wake during the night exhibited significantly lower scores, reflecting poorer memory, on PRMQ-Total, as well as on the PM subscale. Waking earlier than expected, napping during the day and taking medication or alcohol to help fall sleep were also seen to impact negatively on self-reported memory.

People who *take naps during the day* reported significantly higher scores across the entire PRMQ test protocol. Total frequency of perceived memory mistakes was higher among people who take naps during the day (M = 53.55, SD = 9.76) than those who do not (M = 56.30, SD = 9.79), unequal variances t(428.83) = -3.122, p = .002 . Those who nap have significantly more complaints about their PM (M = 51.40, SD = 10.30) than non-nappers (M = 53.83, SD = 10.07), unequal variances t(420.57) = -2.650, p = .008, and nappers also had more RM complaints (M = 53.59, SD = 9.08) than non-nappers (M = 56.14, SD = 8.96), unequal variances t(423.53) = -3.097, p =.002.

People who took *alcohol or medication specifically to help them sleep* at night reported significantly higher levels of memory failures across the three PRMQ scales. PRMQ total failures were significantly higher amongst those who take alcohol or medication to aid sleep (*M* = 52.86, *SD* = 10.11) than amongst those who do not (*M* = 55.70, *SD* = 9.82), unequal variances *t*(148.01) = -2.53, *p* = .012 . PM failures were significantly more frequent in those who take alcohol or medication to help them sleep (*M* = 50.00, *SD* = 10.53) compared to those who do not (*M* = 53.34, *SD* = 10.14), unequal variances *t*(147.06) = -2.26, *p* = .025. RM failures were also significantly more frequently reported by people who take alcohol or medication to help them sleep (*M* = 53.18, *SD* = 9.29) compared to those who do not (*M* = 55.49, *SD* = 9.10), unequal variances *t*(148.89) = -2.24, *p* = .027.

Table 4.17: Comparison of PRMQ means between groups on sleep related variables

	PRMQ Total T-Score		PM T-Score		RM T-Score	
	M (SD)	**t-value**	**M (SD)**	**t-value**	**M (SD)**	**t-value**
Difficulty falling asleep						
Yes	53.64 (11.58)	-1.73	51.11(12.03)	-1.92	53.98 (XXXX)	-1.33
No	53.63 (9.29)		53.40 (9.56)		55.35(XXX)	
Wakes during night						
Yes	54.77 (9.92)	-2.68*	52.42(10.23)	-2.94*	54.80(9.17)	-1.51
No	58.43 (9.03)		56.53(9.23)		56.84(8.92)	
Wakes earlier than expected						
Yes	53.36 (10.34)	-4.17**	50.88(10.47)	-4.39**	53.70(9.67)	-3.36**
No	56.94(9.09)		54.77(9.59)		56.39(8.38)	
Naps during the day						
Yes	53.55 (9.76)	-3.12*	51.40(10.30)	-2.65*	53.59(9.08)	-3.11*
No	56.32 (9.79)		53.85(10.07)		56.13(8.98)	
Takes medication or alcohol to help sleep						
Yes	52.86 (10.11)	-2.53*	50.70(10.53)	-2.26*	53.18(9.29)	-2.24*
No	55.70(9.82)		53.34(10.14)		55.49(9.11)	

Note. t-values are derived from unequal variances t-tests; *significant at $p < .05$; **significant at $p < .001$.

Significant correlations between increasing average number of hours slept and higher T-scores (reflecting better subjective memory) on all three aspects of the PRMQ were observed (Pearson product moment correlations: 1-tailed). Specifically, there was a positive and significant correlation between PRMQ Total T-scores and average numbers of hours slept, $r = .124$, $p = .003$. There was also a significant positive correlation between PM T-scores and average number of hours slept, $r= .130$, $p = .002$ and a significant a positive correlation between RM T-scores and average number of hours slept, $r = .097$, $p = .015$.

Relationship between napping and other sleep variables: Chi-square and Fisher exact tests were conducted to examine the extent to which the likelihood of napping during the day relates to reported difficulties with sleeping (difficulty falling asleep, waking during the night and waking earlier then intended). A t-test (unequal variance) was also conducted to assess whether significant differences in the average number of hours of daily sleep existed in nappers versus non-nappers. Nappers were not significantly more likely to report difficulties falling asleep than were non-nappers, $X^2(1) = 1.299$, $p =.254$ (2-tailed). Nappers were also not significantly more likely to report waking during the night than were non-nappers, $X^2(1) = 2.704$, $p =.100$ (2-tailed). Neither were nappers significantly more likely to report waking earlier than intended, $X(1) = .314$, $p = .575$ (2-tailed).

Finally, there was no significant difference in the average number of hours of daily sleep between those who nap (M = 6.84, SD = 1.24) and those who do not (M = 6.78, SD = 1.25), $t(497)=.519$, p = .604.

Relationships between sleep and mood state: Since sleep-related factors have been associated with mood state (e.g. Rodin, McAvay & Timko, 1988; Wiegand, Rieman, Schreiber, Lauer and Berger, 1993; Spoormaker & Van den Bout, 2005), the relationship between sleep variables and self-reported anxiety and depression (as measured by the HADS) was investigated in this sample using t-tests (unequal variances). These results are detailed below. In the case of a significant association between HADS scores and the sleep variable, an analysis of covariance was carried out to adjust for the potentially confounding influence of mood in the relationship between self-reported sleep difficulties or sleep behaviour and memory failures.

Comparison of the subgroup that has *difficulty falling asleep* and the subgroup that does not revealed a significant difference in HADS Anxiety scores, such that those experiencing difficulty falling asleep reported greater overall levels of self-reported anxiety, (*Mdn* = 7) than did those who do not (*Mdn* = 5), *U* = 14305.00, *p* <.001. Similarly, those who have difficulty falling asleep reported a significantly higher HADS depression score (*Mdn* = 4) than did those who do not (*Mdn* = 2), *U* = 14858.00, *p* <.001

Comparison of the subgroup that *wakes during the night* and the subgroup that does not revealed a significant difference in the distribution of HADS Anxiety scores, such that those who wake during the

night report higher levels of anxiety (*Mdn* = 6) than do those who do not (*Mdn* = 4), *U* = 7212.50, *p* = .002. There was also a significant difference in HADS depression scores between those who reported waking during the night and those who did not, such that those who wake during the night report higher levels of depression (*Mdn* = 3) than those who do not (*Mdn* = 2), *U* =6775.50 , *p* = .028.

Comparison of the subgroup that *wakes earlier than expected* and the subgroup that does not revealed a significant difference in HADS Anxiety scores, with those who wake earlier than intended having greater levels of self-reported anxiety (*Mdn* = 6 –v- *Mdn* = 5), *U* = 20148.00, *p* <.001. HADS depression scores also differed significantly. Those who wake earlier than intended had higher self-reported levels of depression (*Mdn* = 3) than did those who did not (*Mdn* = 2), *U* = 21091.00, p <.001.

Napping during the day was associated with higher HADS Anxiety scores, [*Mdn* = 6 –v- *Mdn* = 5), *U* = 2383.30, *p* = .045. Daytime napping was also associated with higher HADS Depression scores [*Mdn* = 3 –v- *Mdn* = 2), *U* = 22076.50, *p* = .006. In addition, there was a significant negative Spearman's rho correlation between the a*verage number of hours of sleep* and self-reported anxiety (*r* = -.194, *p* < .001), depression (*r* = -.143, *p* < .001) (one-tailed), such that levels of self-reported symptoms increased with decreasing number of average hours of sleep obtained.

Considering the significant differences in self-reported anxiety and depression levels between groups that differed on sleep variables, a series of analyses were conducted to investigate whether the differences detected earlier on PRMQ Total T-scores between sleep variable subgroups remained after controlling for levels of self-reported depression and anxiety. Accordingly, ANCOVAs were carried out to control for the influence of both anxiety and of depression. The results of these analyses are reported below. See Table 4.17 for unadjusted and adjusted means related to each analysis.

4.4.4.6 Impact of sleep on PRMQ when controlling for mood state

As reported previously (see Table 4.17), participants who *wake during the night* reported a greater frequency of overall total memory failures as well as PM failures than did those who do not.

An ANCOVA, with group (*wakes during the night* versus *does not wake during the night*) as the IV, PRMQ Total T-scores as the DV and HADS Anxiety as the covariate revealed a significant main effect of Anxiety on PRMQ Total T-scores, $F (1, 476) = 43.12$, *p* < .001, partial eta squared = .083. Notably, no significant main effect of group remained after adjusting for the effect of Anxiety, $F (1, 476) = 2.09$, *p* = .149, partial eta squared = .004.

An ANCOVA with group (*wakes during the night* versus *does not wake during the night*) as the IV, PRMQ Total T-scores as the DV and HADS Depression as the covariate revealed a significant main effect of Depression, $F (1, 464) = 43.67$, *p* < .001, partial eta squared = 0.086. As with Anxiety, the main effect of

group was no longer significant after Depression was controlled for, F (1, 464) = 2.56, p = .110, partial eta squared = .005.

To investigate whether an effect of *waking during the night* on PM scores remained after anxiety was controlled for, an ANCOVA with group (*wakes during the night* versus *does not wake during the night)* as the IV, PM T-scores as the DV and HADS Anxiety as the covariate was conducted. This revealed a significant main effect of Anxiety on PM T-scores, F (1,476) = 43.12, p < .001, partial eta squared = .083. Of interest, no significant main effect of group remained after adjusting for the effect of anxiety, F (1,476) = 2.80, p = .095, partial eta squared = .006.

ANCOVA with group (wakes during the night versus no) as the IV, PM Total T-scores as the DV and HADS Depression as the covariate revealed a significant main effect of HADS Depression on PM T-scores, F (1, 464) = 36.69, p < .001, partial eta squared = .073. It also revealed that no significant main effect of group remained after adjusting for the effect of Depression, F (1,464) = 3.05, p = .081, partial eta squared = .007.

Since there were no significant difference in RM scores between those who wake during the night and those who do not, it was not necessary to carry out an ANCOVA with those variables.

As shown in Table 4.17, those participants who wake earlier than intended reported a greater frequency of memory failures across the PRMQ scales. Thus, separate ANCOVAs controlling for the influence of self-reported anxiety and depression respectively were carried out to investigate if the between groups differences in PRMQ T-scores remained adjusting for HADS anxiety and depression scores.

An ANCOVA with group (*wakes earlier than intended* versus *does not wake earlier than intended*) as the IV, PRMQ Total T-scores as the DV and HADS Anxiety as the covariate revealed a significant main effect of Anxiety, F (1, 474) = 36.41, p < .001, partial eta squared = 0.71 and revealed that the main effect of group remained significant after adjusting for the influence of Anxiety, F (1, 474) = 6.43, p = .012, partial eta squared = .013. However, it should be noted that the assumption of homogeneity of variance was violated, F(1, 475) = 3.94, p = .048.

Table 4.18: Unadjusted and adjusted mean PRMQ T-scores of sleep variable subgroups following ANCOVA controlling for HADS Anxiety and Depression.

	Wakes during the night?		Wakes earlier than intended		Naps during the day		Takes medication/ alcohol to help sleep	
	Yes	No	Yes	No	Yes	No	Yes	No
PRMQ Total Scale T-Scores								
Unadjusted mean	54.50	57.89	53.06	56.67	53.15	56.08	53.02	55.83
Adjusted mean (controlling for HADS-A)	54.62	56.76	53.73	55.99	53.48	55.86	54.37	54.99
Unadjusted mean	54.43	58.05	53.36	56.36	53.18	55.93	52.78	55.28
Adjusted mean (controlling for HADS-D)	54.52	57.03	53.92	55.73	53.63	55.63	53.93	55.00
PRMQ PM subscale T-Scores								
Unadjusted mean	52.16	56.00	50.62	54.49	51.03	53.60	50.80	52.98
Adjusted mean (controlling for HADS-A)	52.28	54.84	51.30	53.79	51.37	53.37	52.21	52.63
Unadjusted mean	52.08	56.00	50.82	54.23	51.07	53.41	50.59	52.90
Adjusted mean (controlling for HADS-D)	52.17	55.02	51.35	53.63	51.50	53.12	51.69	52.63
PRMQ RM subscale T-Scores								
Unadjusted mean	n/a	n/a	53.43	56.18	53.23	55.95	53.40	55.16
Adjusted mean (controlling for HADS-A)	n/a	n/a	53.95	55.64	53.49	55.78	54.44	54.90
Unadjusted mean	n/a	n/a	53.76	55.86	53.23	55.87	53.15	55.17
Adjusted mean (controlling for HADS-D)	n/a	n/a	54.25	55.31	53.61	55.61	51.15	54.92

An ANCOVA with group (*wakes earlier than intended* versus *does not wake earlier than intended*) as IV, PRMQ Total T-scores as the DV and HADS depression as the covariate revealed a significant main effect of Depression, F (1, 463) = 39.05, p <.001, partial eta squared = .078. The main effect of group was remained significant after Depression was controlled for, F (1, 463) = 4.09, p = .044, partial eta squared = .009. It is, however, important to note that that the assumption of homogeneity of variance was violated, F(1, 464) = 5.016, p = .026, with the larger variance associated with the group who report waking earlier than expected. Consequently, there is the increased risk of incorrectly rejecting the null hypothesis, so the results of this ANCOVA should be interpreted with caution.

ANCOVA with group (*wakes earlier than intended* versus *does not wake earlier than intended*) as the IV, PM T-scores as DV and HADS Anxiety as the covariate revealed a significant main effect of Anxiety, F (1,474) = 35.80, p <.001, partial eta squared = .070. It also revealed that the main effect of group remained significant after Anxiety was controlled for, F (1, 474) = 7.31, p = .007, partial eta squared = .015. ANCOVA with group (*wakes earlier than intended* versus *does not wake earlier than intended*) as the IV, PM T-scores as the DV and HADS Depression as the covariate revealed a significant main effect of Depression, F (1,463) = 31.84, p <.001, partial eta squared = .064. The main effect of group remained significant after depression was controlled for, F (1, 463) = 6.02, p = .015, partial eta squared = .013.

ANCOVA with group (*wakes earlier than intended* versus *does not wake earlier than intended*) as the IV, RM T-scores as the DV and HADS Anxiety as the covariate revealed a significant main effect of Anxiety, F (1,474) = 25.69, p <.001, partial eta squared = .051 and it revealed that the main effect of group remained significant after Anxiety was controlled for, F (1, 474) = 4.05, p = .045, partial eta squared = .008. The assumption of homogeneity of variance was violated, Levene's F(1,475) = 3.99, p = .046, so results should be interpreted with some caution. An ANCOVA with the same IV and DV but with HADS Depression as the covariate revealed a significant main effect of Depression, F (1,463) = 33.79, p <.001, partial eta squared = .068. Of interest, the main effect of group was no longer significant after controlling for depression, F (1, 463) = 1.61, p = .205, partial eta squared = .003.

To investigate whether the effects of napping during the day on PRMQ remained significant after controlling for the influence of HADS anxiety and HADS depression, ANCOVA was first conducted with group (*takes naps during the day* versus *does not takes naps during the day*) as the IV, PRMQ Total T-scores as the DV, and HADS Anxiety as the covariate. Results showed a significant main effect of HADS Anxiety, F (1,471) = 44.00, p <.001, partial eta squared = .085. The main effect of group remained significant after controlling for Anxiety, F (1, 471) = 7.21, p = .008, partial eta squared = .015. ANCOVA with the same IV (*takes naps during the day* versus *does not takes naps during the day*), PRMQ Total T-scores as the DV, but this time with HADS Depression as the covariate showed a significant main effect

of Depression, F (1, 461) = 41.19, p <.001, partial eta squared = .082. The ANCOVA also revealed that the main effect of napping during the day remained significant after the effects of Depression was accounted for, F (1, 461) = 5.04, p =.025, partial eta squared = .011.

ANCOVA with group (*takes naps during the day* versus *does not takes naps during the day*) as the IV, PM T-scores as the DV, and HADS Anxiety as the covariate showed a significant main effect of Anxiety, F (1,471) = 43.82, p <.001, partial eta squared =.085. The main effect of group remained significant after adjusting for the influence of Anxiety, F (1, 471) = 4.73, p =.030, partial eta squared = .010. ANCOVA with the same IV (*takes naps during the day* versus *does not takes naps during the day*), and PM T-scores as the DV, but with HADS Depression as the covariate showed a significant main effect of Depression, F (1, 461) = 35.45, p <.001, partial eta squared =.071. However, the main effect of group was no longer significant after adjusting for the influence of Depression, F (1, 461) = 2.96, p =.086, partial eta squared = .006.

ANCOVA with group (*takes naps during the day* versus *does not takes naps during the day*) as the IV, RM T-scores as the DV, and HADS Anxiety as the covariate showed a significant main effect of Anxiety, F (1,471) = 30.58, p <.001, partial eta squared =.061 and the main effect of group remained significant after adjusting for the influence of Anxiety, F (1, 471) = 7.72, p =.006, partial eta squared = .016. ANCOVA with the same IV (*takes naps during the day* versus *does not takes naps during the day*) and DV (RM T-scores) but with HADS Depression as the covariate showed a significant main effect of Depression, F (1,461) = 33.66, p <.001, partial eta squared =.068. of interest, the main effect of group remained significant after adjusting for the influence of Depression, F (1,461) = 5.83, p =.016, partial eta squared = .012.

ANCOVA with group *(takes alcohol or medication to help sleep versus does not),* PRMQ Total T-score as the DV and HADS Anxiety as the covariate revealed a significant main effect of Anxiety, F (1,473) = 44.41, p <.001, partial eta squared = .086. The main effect of group was, however, no longer significant after anxiety was controlled for, F (1,473) = .306, p = .580, partial eta squared = .001. ANCOVA with the same IV *(takes alcohol or medication to help sleep versus does not)* and DV (PRMQ Total T-scores) but with HADS Depression as the covariate revealed a significant main effect of Depression, F (1,462) = 36.06, p <.001, partial eta squared = .072. As with Anxiety, the effect of group was no longer significant following adjustment for Depression, F (1,462) = .883 p = .348, partial eta squared = .002.

ANCOVA with group (*takes alcohol or medication to help sleep* versus *does not*) as the IV, PM T-scores as the DV, and HADS anxiety as covariate revealed a significant main effect of Anxiety, F (1,473) = 46.17, p <.001, partial eta squared = .089. The main effect of taking alcohol or medication to help sleep was, however, no longer significant once self-reported anxiety was controlled for, F (1,473) = .128, p =.721, partial eta squared = .000. ANCOVA with the same IV *(takes alcohol or medication to help sleep versus*

does not) and DV (PM T-scores) but Depression as the covariate revealed a significant main effect of Depression, $F(1,462) = 30.05$, p <.001, partial eta squared =.061. The effect of group was, however, no longer significant following adjustment for Depression, $F(1,462) = .619$, $p = .432$, partial eta squared = .001.

ANCOVA with group (*takes alcohol or medication to help sleep* versus *does not*) as the IV, RM T-scores as the DV, and HADS Anxiety as covariate revealed a significant main effect of Anxiety, $F(1, 473) = 30.08$, p <.001, partial eta squared = .060. The main effect of was no longer significant once self-reported anxiety was controlled for, $F(1, 473) = .19$, $p =.662$, partial eta squared = .000. ANCOVA with the same IV (*takes alcohol or medication to help sleep* versus *does not*) and DV (RM T-scores) but depression as the covariate revealed a significant main effect of depression, $F(1,462) = 31.16$, p <.001, partial eta squared = .063. As with HADS Anxiety, the effect of group was no longer significant following adjustment for Depression, $F(1, 462) = .563$, $p = .464$, partial eta squared = .001.

Partial correlations (1-tailed) controlling for HADS scores were carried out to see if the associations between self-reported memory and average hours slept remained after self-reported depression and anxiety were controlled for. Results showed that the correlation between PRMQ Total T-scores and average hours slept were no longer significance after HADS Total score was controlled, $r = .041$, $p = .181$. The correlation between PM T-scores and average hours slept similarly was no longer significance once HADS Total score was controlled, $r = .051$, $p = .132$. Finally, there was no significant association between RM T-scores and average hours slept after controlling for HADS Total scores, $r = .021$, $p = .325$.

However, in order to see whether depression and anxiety differentially influence the correlation between average number of hours of sleep and PRMQ T-scores, partial correlations were next carried out, controlling for the HADS Anxiety and HADS Depression subscales separately. While results still showed a lack of a significant relationship between average number of hours of sleep and PRMQ Total, PM and RM scale T-scores after Anxiety was controlled for, the relationship between average number of hours of sleep and PM T-scores remained significant after depression was controlled for, $r = .082$, $p = .040$.

4.4.4.7 Impact of alcohol consumption on PRMQ: In relation to PRMQ scores, there was a significant difference between those who reported that they drink alcohol versus those who do not drink alcohol across the entire PRMQ protocol, as shown by a series of unequal variances t-tests. Interestingly, the subgroup that drinks alcohol reported significantly *fewer* PM failures ($M = 53.45$, $SD = 9.83$) than did the subgroup that reported no alcohol consumption ($M = 50.86$, $SD = 11.37$), unequal variances $t(166.04) = 2.211$, $p = .028$. The subgroup that drinks alcohol also reported *fewer* RM failures ($M = 55.59$, $SD = 8.64$) than did the subgroup that does not drink alcohol ($M = 53.17$, $SD = 10.62$), unequal variances $t(159.85)$

= 2.24, *p* = .027. Of interest, these reported differences cannot be explained by differences in mood state. There was no significant difference between those who drink alcohol (*Mdn* = 6) and those who do not drink alcohol (*Mdn* = 5) on HADS anxiety scores, as demonstrated by Mann-Whitney U test, *U* =18642.00, *p* =.465. Similarly, there was no significant difference between people who drink alcohol (*Mdn* = 5) and those who do not drink alcohol (*Mdn* = 3) on HADS depression scores, as demonstrated by Mann-Whitney U test, *U* = 17173.50, *p* =.173. Neither can the differences be explained by differences in gender breakdown. In the overall sample, the ratio of drinkers versus non-drinkers of alcohol was similar in males (79.8% vs 20.2%) and females (76.5% vs. 23.5%) and earlier analyses indicated no evidence of gender differences in self-reported memory failures.

Analyses involving the use of alcohol or medication for sleep purposes (i.e. the potential relationships between alcohol and sleep disturbances) is presented later in the Chapter.

4.4.4.8 Impact of Physical Health on PRMQ: Analyses of whether the subset of participants with multimorbidity experienced significantly greater subjective cognitive impairment than those with no more than one chronic health condition revealed significant between group differences. Unequal variances t-tests showed significant differences in PRMQ T-scores between the groups with and without multimorbidity. Those with self-reported multimorbidity reported significantly more PM failures, as reflected by lower PM T-scores (*M* = 48.78 , *SD* = 12.87), than those without multimorbidity (*M* = 53.65, *SD* = 9.46), *t*(99.56) = -3.277, p =.001. Similarly, those with self-reported multimorbidity also reported significantly more RM failures, as reflected by lower RM T-scores (*M* = 52.66, *SD* = 9.67), than those without multimorbidity (*M* = 55.47, *SD* = 9.00), *t*(110.78) = -2.45, p =.016.

> **Physical Health (multimorbidity) and Sleep:** A Chi-Square test showed that multimorbidity and difficulty falling asleep were not independent X^2(1) = 17.163, *p* =.000. Those who had multimorbidity were less likely to report difficulty falling asleep. Multimorbidity and night-time awakening were independent, X^2(1) = 2.550, *p* =.110 and Fisher's exact test showed that multimorbidity and waking earlier than expected were independent, *Fisher's exact* = 7.079, *p* = .069.

4.4.4.9 Impact of Mood State and Physical Health (Multimorbidity) on PRMQ: As demonstrated by a Mann-Whitney U test, there was a significant difference in the spread of anxiety subscale scores, such that those with multimorbidity reported significantly higher levels of anxiety symptoms (Mdn = 6.00) than those without multimorbidity (Mdn = 5); U = 12162.00, p =.003. There was also a significant difference in the spread of HADS depression subscale scores, such that those with multimorbidity reported significantly higher levels of depressive symptoms (Mdn = 4.00) than did those without multimorbidity (Mdn = 3.00); U = 11950.50, p =.001.

Given the significant relationships between multimorbidity and self-reported depression and anxiety, a series of ANCOVAS were carried out to investigate whether significant relationships between self-reported memory ability and multimorbidity remained after mood state was taken into account. Homogeneity of variance across the multimorbidity status groups was satisfied for RM T-Scores, and so the results from those ANCOVAS can be interpreted with confidence. In contrast, unequal variances of PM T-Scores across the multimorbidity status groups meant that Levene's test statistic was significant and the assumption of homogeneity of variances was violated. As a result, ANCOVAS with PM T-Scores as the DV should be interpreted with caution.

The levels of the covariate, anxiety, were not equal across groups (multimorbidity vs. no), indicating that the assumption of homogeneity of regression slopes did not hold. Specifically, those with multimorbidity had higher levels of anxiety than those without. Therefore, an interaction term specifying the interaction of multimorbidity with anxiety was specified and included in the models. Results showed a significant interaction effect of anxiety and multimorbidity on PRMQ Total T-scores, $F(1,478) = 8.91$, p = .003, partial eta squared = .018, however the main effect of multimorbidity was no longer significant after the interaction between anxiety and multimorbidity was controlled for. The assumption of homogeneity of regression slopes was upheld in the case of the covariate depression. An ANCOVA with multimorbidity status as the IV, PRMQ T-Scores as the DV and HADS Depression scores as the covariate showed that the significant difference in self-reported total PRMQ Tscores between those with multimorbidity and those without multimorbidity remained after the significant main effect of depression was controlled for, $F(1,468) = 4.02$, $p =.046$, partial eta squared = .009.

Regarding PM ability, an ANCOVA with multimorbidity status as the IV, PM T-scores as the DV and an interaction of HADS Anxiety with multimorbidity as the covariate showed a significant interaction effect of anxiety and multimorbidity on PM T-scores, $F(1,478) = 8.93$, p = .003, partial eta squared = .018. However, the main effect of multimorbidity on PM ability was no longer significant after the influence of this interaction was adjusted for, $F(1,478) = 1.70$, $p =.192$, partial eta squared = .004. An ANCOVA with multimorbidity status as the IV, PM T-scores as the DV and HADS Depression scores as the covariate showed that the significant difference in PM T-scores between those with multimorbidity and those without remained after the significant main effect of depression was controlled for, $F(1,468) = 46.84$, $p =.009$, partial eta squared = .014.

Turning to RM, an ANCOVA with multimorbidity status as the IV, RM T-scores as the DV and an interaction of HADS Anxiety with multimorbidity as the covariate showed that the main effect of multimorbidity was no longer significant once the interaction of self-reported anxiety with multimorbidity was statistically controlled for, $F(1,478) = 2.79$ $p = .096$, partial eta squared = .006. ANCOVA with multimorbidity status

as the IV, RM T-Scores as the DV and HADS Depression as the covariate showed that the difference in self-reported RM ability between those with multimorbidity and those without was no longer significant after self-reported depression was accounted for, $F(1,468) = 1.14$, $p = .287$, partial eta squared = .002.

4.4.10. Relationships between Mood State and other variables

Relationships between HADS Anxiety and Depression and particular sleep, alcohol and medication use variables have been reported earlier in the Chapter. The influence of gender, age and education on mood state were examined with non-parametric tests and are outlined next.

Gender: A Mann-Whitney U test revealed a significantly greater self-reported anxiety in women (*Mdn* = 6), than in men (*Mdn* = 5), U = 22301.00, p = .002. By contrast, there was no significant gender difference in self-reported depression between (Men: *Mdn* = 3; women *Mdn* = 3), U = 23505.50, p = .096).

Education: Previous studies have indicated a link between lower education and current depression, when education is used as one proxy for socioeconomic status (e.g. Teychenne and Salmon, 2012) or as a correlate in and of itself (Bjelland et al., 2007). The potential relationship between HADS Anxiety and Depression scores and highest education level obtained was examined in separate Spearman's r correlations. No significant correlation was found between the levels of self-reported anxiety and highest level of education obtained, Spearman's r = -.045, p = .331. Neither was the correlation significant between depression and highest level of education obtained, Spearman's r = -.015, p = .749. While years of education was not significantly correlated with depression, as previously reported, levels of depressive symptoms mediated the relationship between years of education and RM scores, such that the relationship between self-reported RM and education was no longer significant after self-reported depression was controlled for.

Age: There was a significant negative correlation between age and HADS Total scores, *Spearman's r* (508) = -.181, p <001, such that increasing age was associated with greater overall levels of self-reported negative mood as measured by the HADS. In order to examine whether depression and anxiety were differentially related to age, separate correlations were carried out next. These revealed no significant correlation between age and HADS Depression scores, Spearman's r (479*) = -.050, p* = .283, but there was a significant negative Spearman's rho correlation between HADS Anxiety scores and age, such that self-reported Anxiety decreased as age increased, r (490) = -.225, *p* <. 001.

Since there was a significant correlation between HADS Total scores and PRMQ scores, and a significant correlation between HADS Anxiety scores and age, a partial correlation was computed between PRMQ Total T-scores and HADS Anxiety scores, holding constant, or controlling, for age. Results showed that the association between self-reported anxiety and self-reported PRMQ Total T-scores remained significant after controlling for the influence of age, r (477) = -.319, p <. 001.

Mood and Alcohol Consumption: There was no significant difference on HADS Anxiety scores between those who drink alcohol (*Mdn* = 6) and those who do not drink alcohol (*Mdn* = 5), U =18642.00, p =.465. Similarly, there was no significant difference on HADS depression scores between people who drink alcohol (*Mdn* = 5) and those who do not (*Mdn* = 3); U =17173.50, p =.73.

4.4.5 Correlates of Self-Reported Memory Problems – Relative Contributions

Based on the analyses presented above, a number of variables are clearly associated with PRMQ performance levels. Chief among these factors are mood state, as assessed here by the HADS Anxiety and Depression scales. Also of importance are a number of variables related to sleep quality and quantity. In addition, the presence or absence of multimorbidity impacts on PRMQ scores - specifically, the impact of multimorbidity on PM remained significant after depression was taken into account (although it no longer exerted a significant influence on PM after the interaction of multimorbidity with anxiety was adjusted for).

In order to determine the relative contributions of variables that are correlates of self-reported memory status, a number of stepwise multiple regression analyses was computed in order to identify the relative contribution of these variables.

In order to reduce the number of potential predictors, only those variables that were identified in the earlier analyses as independent predictors of PRMQ Total T-score, PRMQ PM T-score or PRMQ RM T-score were entered into the regression analyses. The criterion variables were: PRMQ Total T-score, PRMQ PM T-score and PRMQ RM T-score. The results of each of these three analyses are presented below.

4.4.5.1 Criterion variables: PRMQ Total T-score.

For the purpose of this analysis, the potential predictor variables were identified as: HADS Anxiety and Depression total scores, multimorbidity, whether or not one wakes earlier than intended, presence or absence of napping during the day, average number of hours sleep per night and whether or not alcohol is consumed (yes/no). Based on this analysis, HADS Anxiety, HADS Depression, daytime napping and alcohol consumption were significant combined and independent predictors of memory scores. Self-reported memory decreased with increased anxiety and depression and with the presence of daytime

napping. In contrast, self-reported memory was *better* with reported alcohol consumption. Average number of hours sleep was not, however, a significant predictor when these other variables were accounted for. Table 4.19 summarises the data for this regression analysis. Model summary statistics are presented in Table 4.20 and the summary statistics for the final regression model (Model 4) are presented in Table 4.21.

Table 4.19: Summary statistics for stepwise regression: criterion variable = PRMQ Total T-score.

Model		Sum of Squares	df	Mean Square	F	Sig.
			ANOVA[a]			
1	Regression	3201.70	1	3201.70	35.63	.000[b]
	Residual	38280.55	426	89.86		
	Total	41482.24	427			
2	Regression	4257.52	2	2128.76	24.30	.000[c]
	Residual	37224.72	425	87.59		
	Total	41482.23	427			
3	Regression	4883.33	3	1627.78	18.86	.000[d]
	Residual	36598.91	424	86.32		
	Total	41482.24	427			
4	Regression	5240.68	4	1310.17	15.29	.000[e]
	Residual	36241.56	423	85.68		
	Total	41482.24	427			

a. Dependent Variable: TScores Total PRMQ UK (low score = poor memory)
b. Predictors: (Constant), HADS Total Depression Score
c. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score
d. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score, Drinks alcohol
e. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score, Drinks alcohol, Naps?

Table 4.20: Model summary statistics: criterion variable PRMQ Total T-score

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Sig. F Change
					Change Statistics				
1	.278[a]	.077	.075	9.479	.077	35.630	1	426	.000
2	.320[b]	.103	.098	9.359	.025	12.055	1	425	.001
3	.343[c]	.118	.111	9.291	.015	7.250	1	424	.007
4	.355[d]	.126	.118	9.256	.009	4.171	1	423	.042

a. Predictors: (Constant), HADS Total Depression Score
b. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score
c. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score, Drinks alcohol
d. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score, Drinks alcohol,
Do you ever take naps during the day?
e. Dependent Variable: TScores Total PRMQ UK (low score = poor memory)

Table 4.21: Summary statistics for stepwise regression: criterion variable = PRMQ Total T-score.

	Coefficients[a]						
	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
4 (Constant)	60.526	2.240		27.02	.000		
HADS Depression	-.664	.195	-.175	-3.40	.001	.776	1.288
HADS Anxiety	-.514	.156	-.169	-3.30	.001	.785	1.274
Drinks (No/Yes)	-2.991	1.109	-.123	-2.70	.007	.989	1.012
Takes Naps (No/Yes)	1.884	.923	.094	2.04	.042	.980	1.020

a. Dependent Variable: PRMQ Total T-Scores (low score = poor memory)

Inspection of the standardised beta coefficients shows that with each unit increase in depression scores, self-reported memory decreases by a factor of -.175 (p<.001) and that with each unit increase in anxiety scores, self-reported memory decreases by a factor of -.169 (p<.001). The results also indicate that consumption of alcohol (where consumption is recorded simply as does not consume alcohol / does consume alcohol, without reference to frequency or amount consumed) is associated with better self-reported memory (*p*=.007) and finally, taking naps during the day is associated with significantly poorer memory (p<.05). Together, these four variables accounted for 12% of the variance in self-reported PRMQ Total T-scores.

4.4.5.2 Criterion variables: PRMQ PM T-score.

For this analysis, the potential predictor variables were identified as: HADS Anxiety and Depression total scores, multimorbidity, presence or absence of napping during the day, whether or not one wakes earlier than intended, average number of hours sleep per night and whether or not alcohol is consumed (no/yes). Based on this analysis, HADS Anxiety, HADS Depression, multimorbidity, alcohol consumption and waking earlier than intended were significant combined and independent predictors of memory scores. As with the PRMQ Total T-scores, self-reported memory decreased with increased anxiety and depression, decreased with multimorbidity, decreased with waking earlier than intended, and increased with reported alcohol consumption. Daytime napping, was not, however, a significant predictor of self-reported PM when these other variables were accounted for. Table 4.22 summarises the data for this regression analysis. Model summary statistics are presented in Table 4.23 and the summary statistics for the final regression model (Model 3) are presented in Table 4.24.

Table 4.22: Summary statistics for stepwise regression: criterion variable = PRMQ PM T-score.

Model		Sum of Squares	df	Mean Square	F	Sig.
		ANOVA[a]				
1	Regression	3122.20	1	3122.20	32.01	.000[b]
	Residual	41555.67	426	97.55		
	Total	44677.88	427			
2	Regression	4117.86	2	2058.93	21.57	.000[c]
	Residual	40560.02	425	95.44		
	Total	44677.88	427			
3	Regression	4753.44	3	1584.48	16.83	.000[d]
	Residual	39924.43	424	94.16		
	Total	44677.88	427			
4	Regression	5141.86	4	1285.47	13.75	.000[e]
	Residual	39536.01	423	93.47		
	Total	44677.88	427			
5	Regression	5516.43	5	1103.29	11.90	.000[f]
	Residual	39161.45	422	92.80		
	Total	44677.88	427			

a. Dependent Variable: TScore PM UK (low score = poor memory)
b. Predictors: (Constant), HADS Total Anxiety
c. Predictors: (Constant), HADS Total Anxiety, HADS Total Depression Score
d. Predictors: (Constant), HADS Total Anxiety, HADS Total Depression Score, Multimorbidity
e. Predictors: (Constant), HADS Total Anxiety, HADS Total Depression Score, Multimorbidity, Drinks alcohol
f. Predictors: (Constant), HADS Total Anxiety, HADS Total Depression Score, Multimorbidity, Drinks alcohol, Wakes earlier than intended

Table 4.23: Model summary statistics: criterion variable PRMQ PM T-score

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Sig. F Change
					Change Statistics				
1	.264[a]	.070	.068	9.877	.070	32.007	1	426	.000
2	.304[b]	.092	.088	9.769	.022	10.433	1	425	.001
3	.326[c]	.106	.100	9.704	.014	6.750	1	424	.010
4	.339[d]	.115	.107	9.668	.009	4.156	1	423	.042
5	.351[e]	.123	.113	9.633	.008	4.036	1	422	.045

a. Predictors: (Constant), HADS Total Anxiety Score
b. Predictors: (Constant), HADS Total Anxiety Score, HADS Total Depression Score
c. Predictors: (Constant), HADS Total Anxiety Score, HADS Total Depression Score, Multimorbidity
d. Predictors: (Constant), HADS Total Anxiety Score, HADS Total Depression Score, Multimorbidity, Drinks alcohol
e. Predictors: (Constant), HADS Total Anxiety Score, HADS Total Depression Score, Multimorbidity, Drinks alcohol, Wakes earlier than intended
f. Dependent Variable: TScore PM UK (low score = poor memory)

Table 4.24: Summary statistics for stepwise regression: criterion variable = PRMQ PM T-score.

Model		Unstandardised Coefficients B	Std. Error	Coefficients[a] Standardised Coefficients Beta	T	Sig.	Collinearity Statistics Tolerance	VIF
3	(Constant)	61.393	1.672		36.72	.000		
	HADS Anxiety	-.508	.164	-.162	-3.11	.002	.769	1.300
	HADS Depression	-.529	.205	-.134	-2.58	.010	.763	1.311
	Multimorbidity	-2.940	1.283	-.107	-2.29	.022	.951	1.051
	Drinks (no/yes)	-2.356	1.169	-.094	-2.02	.045	.963	1.039
	Wakes earlier	-1.940	.966	-.095	-2.01	.045	.932	1.073

a. Dependent Variable: PRMQ PM T-score (low score = poor memory)

Inspection of the standardised beta coefficients shows that with each unit increase in anxiety scores, self-reported prospective memory decreases by a factor of -.162 (p = .002) and that with each unit increase in depression scores, self-reported memory decreases by a factor of -.134 (p=.010). The results also indicate that multimorbidity is associated with poorer self-reported prospective memory (p=.022) consumption of alcohol (where consumption is recorded as does or does not consume alcohol) is associated with better self-reported memory (p=.045). Finally, waking earlier than intended is also associated with poorer self-reported prospective memory (p=.045). Together, these five variables accounted for 11% of the variance in self-reported PRMQ PM T-scores.

4.4.5.3 Criterion variables: PRMQ RM T-score.

For the purpose of this analysis, the potential predictor variables were, like in the case of PRMQ PM T-scores, identified as: HADS Anxiety and Depression total scores, presence or absence of napping during the day and whether or not alcohol is consumed (no/yes). Based on this analysis all four predictor variables were significant combined and independent predictors of memory scores. As with the PRMQ Total T-scores and PRMQ PM scores, self-reported memory decreased with increased anxiety and depression. Self-reported memory scores also decreased with daytime napping and increased with reported consumption of alcohol. Table 4.25 summarises the data for this regression analysis. Model summary statistics are presented in Table 4.26 and the summary statistics for the final regression model (Model 3) are presented in Table 4.27.

Table 4.25: Summary statistics for stepwise regression: criterion variable = PRMQ RM T-score.

Model		Sum of Squares	df	Mean Square	F	Sig.
		ANOVA[a]				
1	Regression	2526.72	1	2526.72	32.52	.000[b]
	Residual	33872.84	436	77.69		
	Total	36399.56	437			
2	Regression	3160.19	2	1580.09	20.68	.000[c]
	Residual	33239.37	435	76.41		
	Total	36399.56	437			
3	Regression	3534.25	3	1178.08	15.56	.000[d]
	Residual	32865.31	434	75.73		
	Total	36399.56	437			
4	Regression	3899.22	4	974.81	12.99	.000[e]
	Residual	32500.34	433	75.06		
	Total	36399.56	437			

a. Dependent Variable: TScore RM UK (low score = poor memory)
b. Predictors: (Constant), HADS Total Depression Score
c. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score
d. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score, Drinks alcohol
e. Predictors: (Constant), HADS Total Depression Score, HADS Total Anxiety Score, Drinks alcohol, Do you ever take naps during the day?

Table 4.26: Model summary statistics: criterion variable PRMQ RM T-score

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Sig. F Change
				Model Summary[e]					
1	.263[a]	.069	.067	8.814	.069	32.523	1	436	.000
2	.295[b]	.087	.083	8.741	.017	8.290	1	435	.004
3	.312[c]	.097	.091	8.702	.010	4.940	1	434	.027
4	.327[d]	.107	.099	8.664	.010	4.862	1	433	.028

a. Predictors: (Constant), HADS Depression
b. Predictors: (Constant), HADS Depression, HADS Anxiety
c. Predictors: (Constant), HADS Depression, HADS Anxiety, Drinks (no/yes)
d. Predictors: (Constant), HADS Depression, HADS Anxiety, Drinks, Takes Naps (no/yes)
e. Dependent Variable: PRMQ RM T-scores (low score = poor memory)

Table 4.27: Summary statistics for stepwise regression: criterion variable = PRMQ RM T-score.

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
4	(Constant)	58.831	2.082		28.26	.000		
	HADS Depression	-.620	.181	-.176	-3.41	.001	.774	1.292
	HADS Anxiety	-.391	.144	-.139	-2.71	.007	.782	1.278
	Drinks (no/yes)	-2.258	1.021	-.101	-2.21	.028	.990	1.010
	Takes Naps (no/yes)	1.882	.854	.101	2.20	.028	.979	1.022

a. Dependent Variable: PRMQ RM T-scores (low score = poor memory)

Inspection of the standardised beta coefficients shows that with each unit increase in depression scores, self-reported retrospective memory decreases by a factor of -.176 (p=.001) and that with each unit increase in anxiety scores, self-reported retrospective memory decreases by a factor of -.139 (p=.007). The results also indicate that consumption of alcohol (where consumption is recorded as does or does not consume alcohol) is associated with better self-reported retrospective memory (p=.028). Taking daytime naps is associated with decreased self-reported retrospective memory function (p=.028) Together, these four variables accounted for almost 11% of the variance in self-reported PRMQ RM T-scores.

4.5 Interim Summary and Discussion:

4.5.1 Nature and prevalence of memory failures: older adult Irish sample

Self-reported memory failures, as assessed by the PRMQ, were found to be common in this sample of older Irish community-dwelling adults. The range of responses to each of the PRMQ items indicated the wide variability in experienced forgetfulness. This variability suggests that reporting of a memory failure in and of itself may well reflect "normal" variation in memory performance rather than a clinical problem.

Older adults experienced difficulty with both PM and RM items. However, in general, PM items were identified as more difficult (as reflected by higher rates of reported occurrence) than RM items. This appears to lend credence to the argument that when people complain about their memory, they are usually complaining about their prospective, as opposed to retrospective memory (Mantyla, 2003). Given the importance of PM for everyday independent functioning, it is perhaps not surprising that older adults would be aware of failures to remember planned intentions.

Comparison of sample T-scores and published T-scores obtained by Crawford and colleagues from a UK based sample showed subtle differences between the two samples, with the Irish sample reporting less overall difficulty with their memory. These differences, however, were quite small, and, for the purpose of Study 2, where self-reported and objective test performance was to be compared, the original normative data as obtained by Crawford and colleagues were judged reliable and appropriate for use with the older Irish population. By using these published data, direct comparisons with other studies would be possible.

The CFA showed that the previously established tripartite structure of the PRMQ, consisting of a general memory factor on which orthogonal PM and RM factors load– was supported in an older Irish sample. These CFA findings also point to the usefulness of all three scales of the PRMQ; the PRMQ Total Scale, PM subscale and RM subscale for the assessment of memory failures and their relationships to cognitive test scores and other variables.

4.5.2 Correlates of self-reported memory failures

This study supports the extant literature by demonstrating that self-reported memory failures were associated with several other covariates, both independently and in combination with each other. Univariate analyses revealed that depression and anxiety were significantly associated with scores on the PRMQ Total scale, PRMQ PM scale and PRMQ RM scale. This finding is in line with many studies demonstrating that self-reported memory failures are strongly correlated with subthreshold or sub-clinical levels of depression and anxiety in older adults without cognitive impairment (e.g. Balash et al., 2013; Steinberg et al., 2013) and are more strongly correlated with these variables than with objective cognitive impairment (e.g. Cipoli et al., 1996).

Of note, some of the remaining covariates that showed significant associations with self-reported memory failures were no longer significantly associated once anxiety and depression were accounted for, indicating that anxiety and depression also play a role in the relationship of other covariates to self-reported memory problems. High or low education has been associated with subjective memory in contrasting ways in the literature, with some studies reporting higher levels of reported memory problems with low education (e.g. Luaner et al., 1999) and others with high education (e.g. Comijs et al, 2002; Blazer et al.,1997). In the current sample, lower education (7-10 years) was associated with poorer RM compared to individuals who reported higher education (18-19 years), but this association was no longer significant after self-reported depression was taken into account. Lower educational level was not significantly associated with either the PRMQ Total score, or with PRMQ PM scores. This finding might speak to the hypothesis that those with lower levels of education often experience increased exposure to risk factors for subjective and objective cognitive impairment such as higher levels of depression and

anxiety due to greater stress and financial difficulties, while simultaneously having reduced access to opportunities believed to confer a protective effect for brain health such as optimal nutrition, healthcare, academic and certain recreational opportunities (Hogervorst & Clifford, 2013).

Similarly, the specific sleep problems of difficulty falling asleep, and of waking during the night were no longer significantly associated with poorer subjective prospective or retrospective memory after depression and anxiety were accounted for. However, the problem of waking earlier than intended continued to exert a significant negative influence on subjective PM after the influence of both anxiety and depression were adjusted for. Waking earlier than intended also continued to exert a negative effect on RM after anxiety was adjusted for, even though this main effect of waking earlier than intended lost significance after depression was controlled for. These findings echo other studies in the literature demonstrating the association of mood state with reported sleeping problems (e.g. Rodin, McAvay & Timko, 1988; Wiegand, Rieman, Schreiber, Lauer & Berger, 1993; Spoormaker & Van den Bout, 2005). It also aligns with literature reporting an association between subjective sleep complaints and complaints about one's memory (e.g. Kang et al, 2017; Weber, Mapstone, Staskiewicz & Maki, 2012).

The relationship between having multiple chronic health conditions and depression and anxiety found in this sample also aligns with findings in the literature (Gunn et al., 2010; Pedro, Mercedes, Ramon & Borja, 2016; Aarts et al., 2011). Older adults with multimorbidity may report higher levels of forgetfulness due to the negative effects of increased symptoms of depression and anxiety on their memory. Arguably, this would explain the lack of a significant relationship in this sample between multimorbidity and subjective *RM* after levels of depression and anxiety were taken into account. In contrast, a significant negative effect of multimorbidity on self-reported *PM* ability was still observed after depression was controlled for (though the violation of the assumption of homogeneity of variance suggests the statistical result should be interpreted with caution). A statistically significant interaction between anxiety and multimorbidity was indicated by investigation of the regression slopes of anxiety as the covariate across the two categories of multimorbidity as the categorical predictor variable. When investigating whether multimorbidity significantly influences PM after adjusting for this interaction of anxiety by multimorbidity, the main effect of multimorbidity on subjective PM was no longer significant.

More generally, other factors, of course, may also play a role in an association between multimorbidity and self-reported memory failures. For example, medications were not assessed in the current study, but older adults with multimorbidity may also experience forgetfulness as a side effect of medications to treat their physical conditions.

Of interest, taking naps during the day remained significantly related to RM ability after both depression and anxiety were accounted for, and significantly associated with PM after depression (but not anxiety)

was accounted for, such that nap-taking was associated with more frequent self-report memory failures. The finding that napping retained its significant association with greater reported memory failures, in light of its independence of other reported sleep problems in the current sample, encourages food for thought. There is a growing literature on sleep problems, particularly insomnia, in older adults. However, relatively less attention has been given to the specific behaviour of daytime napping. Although several biological pathways might underlie the association between sleep and cognitive function, these pathways are not yet well understood, although Yaffe, Falvey & Hoang (2014) presents evidence that the sleep-wake cycle plays a crucial part in brain aging. It may be that that napping behaviour and self-reported memory problems are manifestations of subtle changes in the brain symptomatic of cognitive impairment, or indeed there may be other factors that the present cross-sectional self-report study did not capture mediating or moderating the relationship.

Whatever the explanations, this study shows that napping during the day and subjectively poorer memory was significantly associated. It may, therefore, be useful for GPs to consider this factor. If napping is a behaviour not conducive to good subjective memory, since it may, for example, result in diminished alertness for an unknown period after awaking that then contributes to forgetfulness, there may be scope within the Primary Care setting for individualised sleep hygiene interventions with older adults to reduce the frequency of napping behaviour and so improve subjective and potentially objective memory. Alternatively, since napping remained significantly predictive of greater subjective memory problems even after mood state was controlled for, this may potentially indicate a group of individuals at increased risk of cognitive impairment (e.g. Yaffe et al., 2014) and, thus, may flag the need for further investigation of memory and cognition using at least a brief cognitive screening tool.

Although consuming alcohol also remained significantly associated with better subjective memory, after mood was controlled for, there is a strong likelihood that the relationship between perceived memory and alcohol consumption is mediated by other factors. Alcohol consumption was captured in this study with a yes/no answer to the question whether one drinks alcohol or not, and the level of alcohol consumption was not assessed. However, as a screening question to identify any participants with potentially problematic alcohol use in the current sample, participants were required to answer the "eye opener" question from the widely used CAGE questionnaire ("Have you ever had a drink first thing in the morning (an "eye-opener") to steady your nerves or to get rid of a hangover?"). As only 2% answered positively to this question, the sample overall can be considered to contain very few heavy consumers of alcohol. Poorer self-rated PM has been documented in chronic alcohol users (Heffernan, Moss & Ling, 2002), which is not surprising given the well-established negative effect of alcohol on recall (e.g. Grant, 1987), working memory (Ambrose, Bowden & Whelan, 2001) and executive function (Wendt & Risberg, 2001).

The significant positive association of self-reported alcohol consumption to subjective memory in the current sample is likely due to the general absence of self-reported problematic drinking and is likely confounded by other positive psychosocial factors. For example, it may be that older adults who drink have increased opportunity for regular socialising and that this benefits their general subjective well-being and translates to less subjective concern about their memory. The finding, of course, warrants further investigation, taking into account a wider range of mediating and moderating factors. Nevertheless, if increased opportunity for social recreation is one of the underlying reasons for the association, this might suggest that a worthwhile endeavour for Primary Care professionals in contact with older adults who do not drink alcohol and who complain about their memory is to try to ascertain the individual's degree of opportunity for various avenues of social contact and social recreation. An interesting finding with some relevance to this topic emerged from the recently reported Wave 4 Tilda study, which reported that volunteering and social participation significantly increases the subjective well-being of older adults (Ward, Gibney & Mosca, 2018). This is an interesting finding also in the context of the merits of social prescribing in Primary Care (e.g. Brown et al., 2004).

The current study went beyond a description of the association of particular variables to self-reported memory failures to an examination of the relative contribution of these significant covariates to the overall variance in Total PRMQ scores, PM scores and RM scores through stepwise regression. Hence, we are provided with perspective on the relative importance of the covariates identified as significant in the univariate analyses. Depression and anxiety emerged the most significant predictors of worse self-reported memory; depression explained almost 7% of the variance in total PRMQ scores, while anxiety explained an additional 1 - 2% of the variance. Daytime napping was a significant predictor of memory failures, though marginally so, since it accounted for approximately 1% of the variance in memory ability after the influence of depression and anxiety. Consuming alcohol was significantly predictive of lower frequency of memory failures, but the additional variance accounted for by this variable was very small – less than an additional 1%.

This information on the association, and relative contribution, of other significant variables to levels of self-reported memory problems in older community-dwelling adults is valuable for GPs and other primary care professionals. It may guide a more comprehensive and meaningfully clinical assessment of older adults and facilitate a keener insight as to the potential significance and seriousness of their self-reported memory complaints. While a relatively large number of covariates were investigated in the current study, this does not preclude other potential influential associations with self-reported memory failures that might usefully inform future research studies. A sizeable amount of variation in levels of self-reported memory failures remains to be explained as is the strength of the relationships between self-report and objective performance. This, then is the focus of Study 2.

Chapter 5: Study 2 – Self-reported and objective memory performance in older adults

5.1 Study Background

As noted in Chapter 1 and Chapter 2, detection of cognitive impairment needs to occur at a much earlier stage than is currently happening so that supports and interventions believed to help delay or prevent further deterioration so that affected individuals can be supported to live well and so that relevant interventions, where appropriate can be provided to affected individuals and their family. Major dementia care guidelines and national dementia strategies worldwide, including the Irish National

Dementia Strategy, emphasise that Primary Care is the setting in which cognitive impairment and dementia should be detected. However, current screening tools recommended for use in Primary Care by the Irish College of General Practitioners (ICGP) (Foley & Swanwick, 2014) are not sensitive enough to detect the earliest, subtle signs of cognitive decline. The guidelines did not include a recommendation for inclusion of subjective measure(s) of memory failures. This may be due, at least in part, to the fact that, despite evidence supporting the predictive validity of these complaints, the relationship between memory complaints and actual memory performance remains inconclusive. Most likely, this is because both subjective memory complaints and objective test performance is influenced by other variables (for example, depression and anxiety). Heterogenous methodologies have also been cited as reason for the inconsistent findings.

Neither did the ICGP guidelines incorporate a recommendation for the objective assessment of Prospective Memory (PM) (memory for future intentions). PM failures are known to be sensitive indicators of current and future cognitive decline, independent of retrospective memory (RM) failures. Despite this, measures of PM are seldom included in formal assessments of memory in a clinical context.

The present study – Study 2 - aimed to address these issues. Presented below is an overview of the Study Goals, study design and study methodology for Study 2.

5.2 Study Goals

This study used a separate sample of community-dwelling older adults, categorised based on T-scores into two groups (high self-reporters of memory problems versus low self-reporters of memory problems) to achieve the following aims;

1. To clarify the relationships between subjective PM and RM (PRMQ) performance and performance on objective cognitive tests recommended by the ICGP (2014).

2. To determine the relationship between PRMQ scores and scores on an objective test of PM (CAMPROMPT; Wilson et al., 2005).

3. To determine the effectiveness of the respective cognitive tests for predicting membership of the high or low self-reporter groups.

Importantly, the study aimed to clarify relationships between self-report measures of memory and objective test performance while controlling for variables known to impact memory. Furthermore, inclusion of a standardised subjective PM measure and a standardised, ecologically valid, objective measure of PM aimed to increase the theoretical and methodological similarity between subjective and objective test domains and clarify the subjective-objective relationship.

5.3 Study Methods

5.3.1 Study Design

This study used a cross-sectional design. It comprised a single, face-to-face, neuropsychological evaluation of individual participants. Participants were invited to come to DCU to undergo their assessment, which lasted approximately 70-80 minutes and involved completion of the Study 1 questionnaire and a number of objective cognitive tests recommended for use in Primary Care.

5.3.2 Ethical Approval

Ethical approval for Study 2 was obtained simultaneously to ethical approval for Study 1 from DCU Ethics Committee (reference: DCUREC/2015/2016). As for Study 1, following the Call for Volunteers (see Appendix D) only individuals without a known history of dementia or other neurological or psychiatric conditions were permitted to take part in this study. The specific inclusion and exclusion criteria were identical to those adopted for Study 1 and these inclusion and exclusion criteria and their rationale are outlined in Chapter 3. Recruited participants were required to confirm that, to the best of their knowledge, they met the study inclusion criteria and did not suffer from any of the conditions detailed as exclusion criteria. The ethical consideration specific to this study are also described in detail in Chapter 3.

5.3.3 Study Materials

Participants in Study 2 were asked to complete the same survey that was administered to participants in Study 1. The survey included two standardised self-report measures, the PRMQ and the HADS, and questions pertaining to socio-demographics, health, and sleep, all of which are described in full detail in Chapter 3. In addition, participants were requested to complete a number of objective cognitive tests. These tests, the MMSE, Mini-Cog and GPCOG, are described in detail in the Measures section for

Study 2 in Chapter 3. A standardised test of objective PM, the Cambridge Prospective Memory Test (CAMPROMPT; Wilson & Wilson, 2005) was also included in the test battery, and is also described in Chapter 3. In total, this evaluation generally lasted between 70 and 80 minutes.

5.3.4. Participants: Recruitment and Sample Characteristics

A convenience sample of 99 healthy participants aged 50 and over was recruited on a volunteer basis from the community, using the snowball technique as described in Chapter 3.

The face-to-face nature of the evaluation helped to avoid missing data that might have occurred more frequently in the absence of a researcher. Nonetheless, two participants from the final sample did not complete the full set of objective tests. In both these cases, the CAMPROMPT was not completed. One participant did not complete the CAMPROMPT as she became upset about her test performance on the previously administered cognitive tests. Therefore, a joint decision was made with the participant to terminate the evaluation and the participant was debriefed in line with the ethical protocol for the study. The other participant received telephone notice of a personal emergency that necessitated premature termination of the evaluation, leaving the CAMPROMPT uncompleted. These two cases were thus excluded, leaving a total of 97 participants available for subsequent analyses.

Table 5.1 presents summary demographic data for this sample (N=97). The mean age of this sample was 66.3 years, range 51 - 91 years. As can be seen from the table, there were 58 females (59.8%) and 39 males (40.2%) in the final sample.

Overall, 63.9% of the sample were married, 11.3% were single, 15.5% were widowed, 2.1% were separated, almost 2.1% were divorced, 4% were cohabiting and 0.2% were in a civil partnership.

In terms of education, 12.4% had a Third level Degree, 19.6% had completed their Leaving Certificate, 12.4% had a Post-Leaving Certificate qualification, 15.5% had a Higher Diploma, 5.2% had a master's degree, 14.4% were educated to Inter-certificate/Junior Certificate level, 13.4% had completed Primary level education, 5.2% held a vocational training apprenticeship, and 2.1% had a PhD.

In terms of occupation, a high proportion described themselves as professionals (22.1%). In terms of occupational status, the next most common categories were Managers (20%), followed by Clerical Support Workers (18.9%), other occupations (18.9%), Services and Sales Workers (8.4%) and Technician or associated professional (8.4%). A smaller percentage self-identified as Craft and related trades occupations (1.1%) and Elementary occupation (2.1%).

Just over twice as many participants reported they drink alcohol (69.7%) than do not drink (30.3%).

Table 5.1: Basic descriptive demographic data for the Study 2 sample

Variable	N (%)
Gender	97 (100)
Males	39 (40.2)
Females	58 (59.8)
Marital status	97 (100)
Single	11 (12.2)
Married	62 (63.9)
civil partnership	1 (0.2)
Cohabiting	4 (4.1)
Separated	2 (2.1)
Divorced	2 (2.1)
Widowed	15 (15.5)
Education (highest level obtained)	97 (100)
Primary	13 (13.4)
Inter/Junior Certificate	14 (14.4)
Leaving Certificate	19 (19.6)
Post Leaving Certificate	12 (12.4)
Vocational training apprenticeship	5 (5.4)
Third level degree	12 (12.4)
Higher diploma	15 (15.5)
Masters	5 (5.2)
PhD	2 (2.1)
Education (years)	97 (100)
0-6 years	4 (4.0)
7-10 years	20 (20.6)
11-13 years	23 (23.7)
14-17 years	35 (36.1)
18-19 years	7 (7.2)
20+ years	8 (8.2)
Occupation	95 (98)
Manager	19 (20)
Professional	21 (22.1)
Technician	8 (8.4)
Clerical Support	18 (18.9)
Services & Sales	8 (8.4)
Skilled Agriculture, Forestry, Fisheries	0 (0)
Crafts and Trades	1 (1.1)
Plant/Machine Operator/Assembler	0 (0)
Elementary occupation	2 (2.1)
Other occupation	18 (18.9)
Drinks alcohol	69 (69.7)
Non-drinkers	30 (30.3)

Regarding information relating to sleep, the average number of hours of sleep obtained was 6.73 hours. The distribution of the average number of hours of daily sleep reported by participants is depicted in Table 5.2 below. As can be seen from this table, the greatest proportion of participants (18.6%) self-reported obtaining 6 hours of sleep, on average, per night. This was followed by an average of 7.5 hours (17.5%), then 7 hours (14.4%). 13.4% of the sample reported obtaining the often recommended 8 hours of daily sleep. At the other end of the continuum, one participant (1%) reported obtaining as few as 3 hours of sleep, on average, daily, and another individual (1%) reported getting an average of 1.5 hours of sleep. Two participants (2.1%) reported an average of 4 hours daily sleep and six participants (6.2%) get an average of 5 hours daily sleep.

Table 5.2: Average number of hours of sleep per night reported by participants

Average number of hours sleep per night	Frequency	Percent
3.0	1	1.0
3.5	1	1.0
4.0	2	2.1
5.0	6	6.2
5.5	10	10.3
6	18	18.6
6.5	8	8.2
7.0	14	14.4
7.5	17	17.5
8.0	13	13.4
8.5	2	2.1
9.0	3	3.1
9.5	2	2.1

A higher proportion of the sample reported no difficulty with falling asleep (78.4%), compared with those who did report such difficulty (21.6%). However, a higher proportion also self-reported waking up during the night (83.5% -v- 16.5% who did not). Finally, 41 participants (42.3%) self-reported waking earlier than intended, while for 56 (57.7%) participants, this was not a problem.

Regarding physical health of the sample, the prevalence and type of chronic health conditions self-reported in the sociodemographic questionnaire by participants is presented in Table 5.3. As the table highlights, the most commonly endorsed physical health condition was arthritis (23.7%), followed by breathing problems (16.5%) and diabetes (13.4%). The least commonly endorsed health conditions were ulcerative colitis (0%) followed by Crohn's disease (1%) and hormonal problems (2%).

Table 5.3: Prevalence and type of self-reported physical health conditions.

Physical Condition	N (%)
Cardiovascular Disease (CVD)	7 (7.2)
Hormonal Problems	2 (2.1)
Breathing Problems	16 (16.5)
Gastric Problems	9 (9.3)
Diabetes	13 (13.4)
Chronic Pain	5 (5.2)
Arthritis	23 (23.7)
Ulcerative Colitis	0
Thyroiditis	8 (8.2)
Crohn's Disease	1 (1.0)
Other physical condition	15 (15.5)

In total, 15 participants (15.5%) also endorsed the category "other condition". While there was some overlap with conditions already specified and endorsed in the socio-demographic questionnaire, such "other" conditions included (but were not limited to) cancer in remission, auto-immune disease, Fibromyalgia, tinnitus, osteopenia, osteoporosis, renal failure, ADHD, hernia, sciatica and conditions not perceived to warrant full clinical diagnosis, e.g. "a touch of diabetes." High blood pressure was listed in this category by 5 participants, and other heart problems – mainly atrial fibrillation - were reported by 4 participants in the absence of self-reported diagnosed cardiovascular disease. A count of the prevalence of two or more self-reported chronic conditions in the sample was carried out, showing that 20 (20.6%) participants demonstrated multimorbidity. There was a significant difference in age between those with multimorbidity (M = 69.25, SD = 5.66) and those without (M = 65.32, SD = 7.386, unequal variances t(37.651) = 2.581, p (2-tailed) = .014 but the two groups did not differ in terms of education level X^2 (8) = 6.131, p = .693. Notably, there was no significant difference between those with multimorbidity and those without in terms of in the spread of HADS Anxiety scores, U = 693.00, p = .490. Neither was there a significant difference between the groups in terms of HADS Depression scores; U = 641.50, p = .242.

Analyses of whether this subset of older participants with multimorbidity experienced significantly greater subjective and objective cognitive impairment than the participants without multimorbidity were also carried out and findings are reported later in this Chapter.

As for Study 1, to help determine the extent to which the sample in Study 2 is representative of the general older Irish population, an attempt was made to draw comparisons between the sample characteristics in Study 2 and the sample characteristics in TILDA and the 2016 Irish Census.

The TILDA report following analysis of Wave 1 data reported that in the population aged 50 years and above in Ireland, 48% are men and 52% are women. In Study 2, this broad gender distribution was replicated, although there were slightly fewer males and more females in the present sample than is represented in the general Irish population: specifically, 40.2% of the Study 2 sample were males and 59.8% were females. While TILDA reported that the greater proportion of people aged 50 and over in Ireland are in the 50 to 64 years age group (58%), the present sample showed an opposite trend, with the greater proportion of participants in the sample aged above 64 years.

In the TILDA Wave 1 report, which ascertained marriage *history,* almost 10% of people aged 50 years and above have never been married, and men were more likely to never have been married than women (13% men; 7% women). As with Study 1, Study 2 obtained data on *current* marital status and so is not directly comparable. However, for the interested reader, 15.5% of participants were widowed, 12.2% of the sample were single, 2.1% were separated and 2.1% were divorced. Remaining participants were either currently married (63.9%), in a civil partnership (0.2%), or cohabiting (4.1%).

Regarding education, the TILDA study reported that most older adults in Ireland have achieved at least secondary education (62%). This compares to 72.6 % of older adults with at least secondary education in our Study 2 sample. Therefore, the present Study 2 sample, on average, has obtained slightly higher educational status than the general older population of Ireland.

Census 2016 data also highlighted that the more educated a person is the more likely they are to be married. However, amongst individuals aged between 55 and 64 years, those with either lower secondary or third level degree or higher qualification had a similar likelihood of getting married (71.3% -v- 72.6%). The much smaller sample size in Study 2 (n= 97), combined with a very small number of participants with low and very high educational attainment makes meaningful comparison difficult. Across the entire Study 2 sample aged 50 years and above, more females were separated (3.4%) and divorced (3.4%) than were males (0%). In the age group 65 years and over, 2.8% of females were separated while no males were separated, and 2.8% of females were divorced in contrast to no males. The rates of divorce and separation in females were higher in the 50 – 64 age group than in those aged 65 and above. Overall, while Study 2 sample size is a much smaller convenience sample, these patterns corresponds broadly to the census data showing that the peak age for separation or divorce is 53 years and showing a trend of higher rates of separation and divorce in females than in males.

As noted earlier, in terms of self-reported depression, the TILDA study, using the CES-D, found that 10% of the population aged 50 years and above reported clinically significant depressive symptoms, with a further 18% reporting subthreshold levels of depression. Notably, none of the 97 participants in the Study 2 sample could be classified as clinically depressed and just 2 individuals (2.1%) could be classified as having mild or subthreshold depression. By comparison, using the Crawford et al., (2001) cut-off scores, just 1 individual would be classified as clinically depressed. Regarding anxiety, using Zigmond & Snaith's cut-offs, 1 participant could be classified as clinically anxious, while 10 (10.3%) could be regarded as having mild or subthreshold anxiety. Applying the cut-off used in Crawford et al. (2011), 5 (5.2%) of the sample would be classified as anxious.

As previously mentioned, according to the TILDA study, the most prevalent medical conditions among adults aged 50 years and older in Ireland were hypertension (38% at Wave 4), arthritis (39% at Wave 4) and pain (35% at Wave 4). This compares to the most prevalent prespecified physical health conditions self-selected in the Study 2 sample, which were arthritis (23.7%), followed by breathing problems (16.5%) and diabetes (13.4%).

Acknowledging that occupational groupings used in this study and those used in the Census are not identical, the current sample comprises a higher proportion of individuals with professional occupations than the general population, most likely reflecting the relatively high level of education in the sample.

5.3.5 Data Processing and Data Analysis

All data for Study 2 was scored and entered manually into SPSS for statistical analysis. As noted above, two individuals did not complete the CAMPROMPT and these cases were excluded from analyses. All scoring procedures can be found by referring to specific testing manuals. Following this, the software package PASW Statistics 22 (Predictive Analytic Software) (IBM SPSS Inc.) was used to carry out all statistical analyses. Prior to the detailed analyses, some variables were recoded as necessary.

The analysis focused initially on descriptive statistics and, in the case of the self-report and cognitive test data, on measures of centrality and dispersion. Subsequent analyses focused on effects of demographic variables, age, gender and education, as well as health, sleep and mood variables on PRMQ scores using parametric and non-parametric correlational analyses. This was then followed by correlations between the objective test measures with the self-report measures of memory and age and mood. Differences in cognitive test performance between those self-reporting high versus lower levels of everyday memory problems, between those self-reporting high versus low levels of depression and anxiety and between men and women were also examined using t-tests and Mann-Whitney U

tests. Relationships between self-reported memory and the variables in the socio-demographic questionnaire, as well as the relationships between objective test performance and the variables from the socio-demographic questionnaire were examined via correlations, t-tests, ANOVAs and their non-parametric equivalent as appropriate. Inferential analyses controlled for levels of self-reported anxiety and depression where required.

To derive natural groupings of high versus low self-reporters of memory problems based on PM and RM T-scores, cluster analysis was performed. Finally, a series of binary logistic regressions investigating the contribution of a combination of sociodemographic, health and mood variables on reporter status was carried out.

5.4 Results

For the purpose of presenting the results, the three primary goals of the study are addressed separately.

5.4.1 Data Screening: missing data, normality and outliers

As noted above, two cases in the initial sample were missing CAMPRMOMPT data. These two cases were thus removed from the sample, leaving a final sample consisting of 97 participants for all subsequent analyses. Full data sets were available for each of these 97 individuals.

All data were assessed to determine whether they departed significantly from the assumptions of normality and equal variance. Normality was assessed visually using histograms, normal probability Q-Q plots, skewness and kurtosis values and Shapiro-Wilks test statistics. To begin with, skewness and kurtosis indices for the PRMQ Total Scale data, PM subscale data and RM subscale data of. 402, .363, and .439 respectively were converted to z-scores by dividing the skewness and kurtosis values by their respective standard errors. Because the sample size was 97, z-values equal to or less than 1.96 were taken as establishing normality of the data, as recommended by Ghasemi and Zahediasl, (2012). z-scores were all close to, but below, 1.96. Sample skewness statistic for the PM was .363, and .439 for the RM subscale, indicating slight positive skewness that nonetheless fell within the normal range, as indicated by the skewness z-values. Normality of the PRMQ data was further supported by a non-significant Shapiro-Wilk test statistic for the PM subscale (p = .161) and RM subscale (p = .061).

No cases were flagged by Tukey's boxplots as extreme outliers in the PRMQ Total scale data, the PM subscale data or the RM sub scale data.

Inspection of levels of self-reported depression and anxiety as assessed by the HADS revealed the data departed from normality, with a sample skewness value of .951 and a z-value greater than 1.96 on the

Anxiety subscale, and a sample skewness value of 2.03 on and a z-value greater than 1.96 on the Depression subscale. Shapiro Wilk test statistic was significant at the .001 alpha level for the depression subscale (p = 0.00) and anxiety subscale (p = .002). Tukey's boxplots showed one extreme outlier on the HADS Depression subscale.

Examination of the cognitive test data showed that all of the test data departed significantly from normality, with skewness and kurtosis z-values greater than 1.96, and Shapiro Wilk test statistics for the MMSE, Mini-Cog, and GPCOG all significant at the .001 alpha level. Visual inspection of QQ-plots, histograms and Tukey's boxplots further highlighted that all of the cognitive test data were negatively skewed, with the mass of the distribution of total test scores concentrated to the right. This indicated the need for non-parametric analyses of the cognitive test data.

The CAMPROMPT data is pre-categorised into quantitative performance bands, and so is subject to non-parametric analyses due to the categorical nature of the CAMPROMPT data.

5.4.2 PRMQ Scale Reliability

Cronbach's alpha reliability coefficient and confidence intervals were calculated for the overall PRMQ scale, as well as for the PM and RM subscales. Cronbach's alpha coefficient for the PRMQ Total scale was .93, CI (.90, .95). Cronbach's alpha for the PM subscale was .89, CIs (.85, .92). and for the RM subscale it was .84, 95% CIs (.78, .88). Based on these results, the PRMQ can be considered a reliable measure for this sample.

5.4.3 Self-reported PM and RM Failures

The frequency of self-reported difficulty across the test protocol (individual items; PM and RM subscales) were obtained for the Study 2 sample. Table 5.4 summarises the raw score means, standard deviations and ranges for the PRMQ total scale and its subscales (PM and RM). It should be noted, however, that the remaining analyses are completed with PRMQ T-scores, with a mean of 50, and an SD of 10.

Table 5.4: Summary statistics for PRMQ (n=97)

Scale	Mean	SD	Range	SEM	Skewness	Kurtosis
PRMQ Total	37.37	11.19	54	1.12	.394	.177
Prospective Memory (PM)	19.70	6.01	27	.609	.372	-.057
Retrospective Memory (RM)	17.80	5.42	27	.550	.437	.189

SD: standard deviation; SEM: standard error of the mean

5.4.4 Correlates of self-reported memory failures – verification of Study 1 findings

To investigate the extent to which demographic, health status and sleep variables, as measured by the demographic questionnaire items, were related to self-reported memory failures as established in Study 1, correlational and other statistical tests were conducted. Correlations were considered significant at a < 0.05 and were two-sided unless otherwise stated. The main findings of interest are now reported.

5.4.4.1 Influence of age on PRMQ: Age did not significantly influence frequency of PRMQ Total failures, as shown by the non-significant Pearson's product moment correlation between PRMQ Total T-scores and age, $r = -.035$, $p = .736$. Neither did age significantly influence frequency of self-reported PM failures, r = .015, p = .887, or RM failures, r = -.088, p = .363.

5.4.4.2 Influence of gender on PRMQ: Levene's test showed that the variance in test scores for both males and females was relatively equal. A t-test was, therefore, carried out to investigate whether frequency of self-reported memory problems differed significantly according to gender. There were no significant differences in PRMQ Total T-scores between males (M = 50.61, SD = 10.49) and females (M = 49.58, SD = 9.72), $t(73.396) = .48$, $p = .630$ (2-tailed). There was also no evidence of a significant difference in self-reported PM problems between males (M = 50.72, SD = 10.53) and females (M = 49.52, SD = 9.69), $t(76.964) = .571$, p = .560 (2-tailed) or a significant difference in self-reported RM problems between males (M = 50.50, SD = 10.29) and females (M = 49.67, SD = 9.87), $t(79.29) = .395$ $p = .694$ (2-tailed).

5.4.4.3 Influence of education on PRMQ: The potential influence of level of education on self-reported PM failures was investigated with a Kruskal-Wallis test. Results revealed that there were no significant differences in the distribution of total self-reported PRMQ failures according to the highest level of education obtained; $H(8) = .396$, P = .861. Results also revealed no evidence of a significant difference in the distribution of self-reported PM failures based on level of education; $H(8) = 2.99$, p = .935 nor was there evidence of an impact of education level on self-reported RM failures; $H(8) = 6.842$, p = .554.

These findings were further supported by the results of Spearman's rho correlations, where all correlations were non-significant [PRMQ Total*: r* = .116, *p* = .259; PM: *r* = -.057*, p* = .577; RM*: r* = -.143 *p* = .161]. However, the inverse nature of the correlations between memory performance and education level did show a trend of decreasing frequency of self-reported PM and RM failures as level of education increased.

5.4.4.4 Influence of Mood State on PRMQ: Summary statistics for the self-report measure of anxiety and depression, as assessed by means of the HADS are presented in Table 5.5 below. As can be seen, mean levels of self-reported anxiety and depression are low.

Using the HADS cut-offs recommended by HADS authors (Zigmond and Snaith, 1984), of ≥16 for severe cases of anxiety and/or depression, 1 participant obtained a score that fell within the severe range for anxiety symptoms, while no participants obtained a score suggesting severe depression. 3 individuals (3.1%) had HADS anxiety scores in the 11 – 15 range, indicating moderate anxiety, while 1 (1%) individual had a score between 11 and 15 on HADS depression, indicating moderate depression. 10(10.3%) individuals scored between 8 and 10 on HADS anxiety, indicating mild anxiety, while 2 (2.1 %) individuals obtained a scores between 8 and 10 on HADS depression, indicating mild depression.

Using the cut-off scores used by Crawford et al., (2001) of 10/11, 5 individuals (5.2%) of the sample scored greater than 10 and could be classified as potential cases of anxiety (compared to 12.6 % in Crawford et al., 2001), and 1 individual (1%) of the sample could be classified as case of depression (compared to 3.6% in the Crawford et al. 2001 sample). Overall, levels of self-reported anxiety and depression were low in this sample. As seen in Study 1, levels of anxiety were slightly higher than levels of depression.

Table 5.5: Summary statistics for HADS (n=97)

Scale	*Mean*	*SD*	*Range*	*SEM*	*Skewness*	*Kurtosis*
HADS Total	7.21	4.93	0-31	.500	1.40	4.36
HADS Anxiety	4.74	3.51	0-18	.357	.95	1.55
HADS Depression	2.57	2.33	0-15	.237	2.02	7.17

*Higher scores reflect higher self-reported depression and anxiety

Levels of self-reported anxiety were influenced by age, with self-reported anxiety decreasing in line with increasing age, as shown by a significant negative correlation; Spearman's r = -.275, p = .003. The relationship between self-reported depression and age was not significant. In contrast, the relationship between self-reported anxiety and level of education was not significant; Spearman's r = - .117, p = .251. Neither was the relationship between self-reported depression and level of education; Spearman's r = -.081, p = .428.

As with Study 1, there was a significant relationship between self-reported anxiety and depression and self-reported PM and RM failures, such that levels of self-reported memory failures increased in line with increases in self-reported anxiety and depression. Correlational data for the PRMQ and HADS scores is presented in Table 5.6

Table 5.6: Correlations between PRMQ and HADS scales: Spearman's rho

	PRMQ Total	PRMQ PM T-score	PRMQ RM T-score	HADS Total	HADS Anxiety	HADS Depression
PRMQ Total T-score	1					
PRMQ PM T-score	.957**	1				
PRMQ RM T-score	.959**	.852**	1			
HADS Total	-.507**	-.492**	-.459**	1		
HADS Anxiety	-.442**	-.445**	-.384**	.921**	1	
HADS Depression	-.413**	-.393**	-.391**	.781**	.524**	1

**Correlation is significant at the 0.01 level

5.4.4.5 Influence of sleep on PRMQ: Whether difficulty falling asleep exerted an influence on the frequency of self-reported memory failures was investigated with t-tests. Unlike Study 1, results revealed a significant difference in the level of total self-reported PRMQ failures between those who reported difficulty falling asleep (*M* = 45.79, 0, *SD* = 10.26) and those who did not (*M* = 51.16, *SD* = 9.67), *t*(95) = -2.205, *p* = .028. There was also a significant difference in the level of self-reported PM failures between those who reported difficulty falling asleep (*M* = 42.90, *SD* = 11.97) and those who did not (*M* = 49.05, *SD* = 11.47), *t*(95) = -2.154, *p* = .034. However, in line with Study 1, results revealed no significant difference between those who report difficulties falling asleep (M = 41.62, SD = 10.81) and those who do not (M = 52.30, SD = 10.54) on RM; *t*(95) = -1.792, *p* = .076.

In contrast to the results of Study 1, no significant difference in the total number of self-reported PRMQ failures between those who reported that they wake during the night (M = 49.34, SD = 9.90), and those who reported they do not wake during the night (M = 53.31, SD = 10.16) was detected; *t*(95) = -1.161 *p* = 147. Likewise, there was no evidence of a significant difference in self-reported PM failures between those who reported that they wake during the night (M = 46.86, SD = 11.54), and those who do not (M = 52.06, SD = 12.46); *t*(95) = -1.625, *p* = 107. Finally, as was the case in Study 1, no significant difference in self-reported RM failures emerged between those who reported that they wake during the night (*M* = 50.65, *SD* = 10.70), and those who do not (*M* = 54.50, *SD* = 10.60), *t*(95) = -1.316, *p* = .191. Unlike Study 1, no significant difference was detected in the total number of PRMQ failures between those who reported waking earlier than expected (*M* = 47.75 , *SD* = 10.32) and those who did not (M = 51.64, SD = 9.52), *t*(95) = -1.918, *p* = .058. Similarly, no significant difference was detected in self-reported PM failures between those who reported waking earlier than expected (*M* = 45.41 , *SD* = 12.12) and those who did not (M = 49.41, SD = 11.36), *t*(95) = -1.664, *p* = .099. However, the difference in self-reported RM failures between those who reported waking earlier (*M* = 48.73 , *SD* = 11.10) and those who did not (*M* = 53.16 , *SD* = 10.12) was statistically significant, *t*(95) = -2.041, *p* = .044.

Unlike Study 1, there was no evidence of a significant difference in the overall level of total self-reported PRMQ memory failures between people who take naps during the day (*M* = 49.41, *SD* = 10.71) and those who do not nap (*M* = 50.80, *SD* = 9.65), *t*(95) = -.484, *p* = .630. There was also no evidence of significant differences in levels of self-reported PM ability between people who take naps during the day (*M* = 46.68, *SD* = 11.93) and those who do not nap (*M* = 48.46, *SD* = 11.75), *t*(95) = -.695, *p* = .498. Neither was there evidence of a significant differences in levels of RM ability in people who nap (*M* = 30.90, *SD* = 10.72) and non-nappers, *M* = 51.56, *SD* = 10.82), *t*(95) = -.067, *p* = .947.

In contrast to Study 1, the relationship between self-reported total PRMQ failures and average number of hours sleep was not significant; Pearson's r = .098, p = .340. Similarly, the relationships between

average number of hours of sleep and self-reported PM and RM failures were not significant (PM: Pearson's r = .096, p = .349; RM: Pearson's r = .103, p = .315).

5.4.4.6 Influence of physical health (multimorbidity) on PRMQ: An unequal variances t-test was conducted to investigate whether levels of self-report memory failures, as denoted by PRMQ T-scores, varied as a function of multimorbidity. In terms of PRMQ Total T-score, no significant difference was observed between those with multimorbidity (M = 47.75, SD = 10.40) and those without (M = 50.40, SD = 9.92), unequal variances t(28.55) = - 1.096, p = .282. There was also no evidence of a significant differences in PM T-scores between those with multimorbidity (*M* = 48.08, *SD* = 10.33) and those without (*M* = 50.40, *SD* = 9.92), unequal variances *t*(28.77) = -.942, *p* = .354. Neither was there a significant difference in RM T-scores between those with (*M* = 47.49, *SD* = 9.86) and those without (*M* = 50.66, *SD* = 9.99) multimorbidity, unequal variances *t*(29.97) = - 1.275, *p* = .212.

Further analysis revealed a link between multimorbidity and sleep. A chi-square test showed a significant difference in the probability of having difficulty falling asleep according to whether one experienced multimorbidity or not, with those reporting multimorbidity having a significantly greater probability (87.0%) of experiencing difficulty falling asleep than those without multimorbidity (45.0%), X^2 (1) = 16.521, *p* <.001.

5.4.5 Objective Cognitive Test Data

Summary statistics for each of the cognitive tests typically used by GPs, namely the MMSE, Mini-Cog and GPCOG are presented in Table 5.7 below and the spread of scores for each test are presented in Table 5.8. CAMPROMPT data are summarised in Table 5.9.

Table 5.7: Summary statistics for MMSE, Mini-Cog and GPCOG (n=97)

Test	Mean	SD	Range	SEM	Skewness	Kurtosis	Median (range)	IQR
MMSE	29.28	1.10	25-30	.111	-1.93	4.07	30 (29 - 30)	8-9
Mini-Cog	4.40	.985	1-5	.100	-1.62	1.68	5 (1 -5)	29-30
GPCOG	8.60	.73	6-9	.07	-1.98	.485	9 (3-6)	4-5

Table 5.8: Spread of Test Scores (MMSE, Mini-Cog and GPCOG)

MMSE Total Score	N (%)

25	2 (2.1)
26	1 (1.0)
27	4 (4.1)
28	10 (10.3)
29	24 (24.7)
30	56 (57.7)
Mini-Cog Total Score	
1	1 (1,0)
2	7 (7.2)
3	8 (8.2)
4	17 (17.5)
5	64 (66.0)
GPCOG Total Score	
6	3 (3.0)
7	5 (5.2)
8	20 (20.6)
9	69 (71.1)

Table 5.9: Spread of Test Scores (CAMPROMPT)

CAMPROMPT IQ Adjusted Performance Band	N (%)
Impaired	1 (1.0)
Poor	7 (7.2)
Borderline	10 (10.3)
Average	49 (50.5)
Above average	20 (20.6)
Very good	10 (10.3)

As can be seen from the spread of scores on all the cognitive tests, the cognitive performance of most participants can be within the normal range.

5.4.6 Self-reported memory performance: relationships to objective cognitive test scores

K-means cluster analysis, with two groups specified, was conducted to determine group membership of two distinct sub-groups, representing individuals who reported higher levels of forgetfulness and those who reported low levels of forgetfulness. In K-means cluster analysis, the number of desired clusters must be specified in advance of implementing clustering technique. Two groups were prespecified, since it was of interest to obtain a group of individual's self-reporting a high frequency of prospective and retrospective memory problems and a group of individuals self-reporting a low frequency of prospective and retrospective memory problems. Mantyla (2003) previously conducted two experiments, the first with middle-aged participants who self-reported exceptional problems in prospective remembering, while the second experiment involved middle-aged participants divided into self-reporters and non-reporters of retrospective memory problems based on the frequency of self-rated memory failure on the PRMQ, facilitating detection of objective impairment in PM tasks in the high self-reporter group.

In acknowledgement of the utility of all three scales in the PRMQ protocol (as illustrated in the preceding CFA), the PRMQ Total scale, PRMQ PM subscale and PRMQ RM subscale T-scores were subjected to this K-means clustering technique. The two clusters obtained, therefore, consisted of a group of individuals who self-reported a higher frequency of prospective and retrospective memory failures and a group of individuals who self-reported a lower frequency of prospective and retrospective memory failures. Cluster analysis enables the derivation of such natural groupings in the data, as opposed to splitting the data according to a mean or median split on each of the subscales which might present difficulties around categorisation in those cases where individuals score above the mean or median cut-off on RM and below the mean or median cut-off on PM, and vice versa.

This K-means cluster analysis, using PRMQ Total, PRMQ PM and PRMQ RM T-Scores as the potential grouping variables, resulted in 48 individuals in Cluster 1: lower levels of forgetfulness and 49 individuals in Cluster 2: higher levels of forgetfulness (i.e. poor memory). See Table 5.10 for cluster centres.

Table 5.10: PRMQ T-scores for the initial and the final cluster centres

	Cluster	
	1	**2**
	Good Memory	**Poor Memory**
Initial Cluster Centres		
PRMQ Total T-Score	74.00	16.00
PRMQ PM T-Score	74.00	19.00
PRMQ RM T-score	71.00	17.00
Final Cluster Centres	**(n=48)**	**(n=49)**
PRMQ Total T-Score	61.83	42.59
PRMQ PM T-Score	59.96	41.43
PRMQ RM T-score	59.85	43.41

PRMQ: Prospective and Retrospective Memory Questionnaire; PM: Prospective memory; RM: Retrospective Memory

The resulting subgroups differed significantly in terms of anxiety (U = 629.50, p <.001) and depression (U = 740.50, p = .001) as measured by the HADS. Anxiety and Depression were, however, low in both groups [Anxiety: High self-reporter group mean = 5.93, Median = 5.00, SD = 3.58; Low self-reporter group mean = 3.77, Median = 3.00, SD = 3.47; Depression: High self-reporter group mean = 3.20, Median = 2.00, SD = 2.19; Low self-reporter group mean = 2.07, Median = 2.00, SD = 2.37]. Neither group can, therefore, be considered significantly anxious or depressed.

A series of Mann Whitney U tests showed that high (*Median* = 30) and low self-reporters (*Median* = 30) did not differ significantly on MMSE (U = 1091.50 , p = .523), Mini-Cog (high reporters *Median* = 5; low reporters *Median* = 5) (U = 1144.50 , p = .816), GPCOG (high reporters *Median* = 9; low reporters *Median* = 9) (U = 1142.00, p = .810) or CAMPROMPT – either on the original six CAMPROMPT performance bands, Fisher's exact (5)= 2.097, p = .916; or on the collapsed categories of "poor", "average" and "good" CAMPROMPT performance, X^2 = .213, p = .899. For this latter analysis, the original performance bands of the CAMPROMPT were collapsed to form three categories (poor, average and good). The "poor" category contained performers originally classified as impaired, borderline or poor; the "average" category remained unchanged, containing those originally classified as average performers, and the "good" category contained performers originally classified as 'above average' or 'very good'.

The relationship between PRMQ T-scores (subjective memory ratings) and performance on the objective cognitive tests was also explored by means of correlational analyses (Kendall's Tau-b correlations). These nonparametric correlations are presented in Table 5.11 below and no correlations

were significant. Note that for these correlational analyses, the six original CAMPROMPT performance categories (Impaired, Borderline, Poor, Average, Above average and Very good) were utilised.

Table 5.11: Correlations* between the PRMQ T-scores and total scores of cognitive tests (n=97)

	PRMQ		
	PM T-score	**RM T-score**	**Total T-score**
MMSE	.032	.067	.055
Mini-Cog	-.043	.015	-.017
GPCOG	-.009	.046	.018
CAMPROMPT	.044	.063	.054

*Kendall's tau

A direct logistic-regression analysis was also performed with subjective memory status (poorer memory -v- good self-reported memory) as outcome and the predictors MMSE total score, Mini-Cog total score, GPCOG total score and the collapsed "good" (comprising Above Average and Very Good performers) and "poor" (comprising Impaired, Borderline and Poor performers) performance categories of the CAMPROMPT. A test of the full model with all of these predictors against a constant-only model was not statistically significant, X^2 (5, N = 97) = 1.005 , p = .962, indicating that these predictors (objective cognitive test scores) did not significantly distinguish between high self-reporters and low self-reporters of memory lapses. Accordingly, the variance in subjective memory status accounted for was very small, with Nagelkerke's R square = .014. Classification was unimpressive, with just 56% of high self-reporters (Cluster 1: poorer memory) classified correctly, and just 51.1% of low self-reporters (Cluster 2: good memory) classified correctly, with an overall success rate of 58% (compared to a null model of 51.5%).

5.4.7 Objective test performance: influence of demographic and other variables

5.4.7.1 Influence of age: Spearman correlations were carried out to investigate relations between age and scores on three of the cognitive tests (MMSE, Mini-Cog and GPCOG). A significant effect of age was found for the MMSE, Spearman's *rho* = -.176, p = .042 (one-tailed) but not for either the Mini-Cog, Spearman's rho = -.118, p = .126 or the GPCOG, Spearman's *rho* = -.082, p = .213. A significant effect of age was also found across the categories of the CAMPROMPT collapsed into "poor" , "average" and "good" classification categories, as demonstrated by Kruskal-Wallis test; H(2) = 6.370, p = .041, with average performers reporting higher age than the other CAMPOMPT groups.

5.4.7.2 Influence of gender: To explore the potential effect of gender on the objective cognitive test scores, Mann-Whitney U tests were carried out. No significant differences were found in MMSE total scores between males (*Mdn* = 30.00) and females (*Mdn* = 30.00), *U* = -1126.50, *p* = .970. Similarly, no evidence of a significant gender difference was found on the Mini-Cog [males: *Mdn* = 5.00; females: *Mdn* = 5.00, *U* = -1091.00, *p* = .726] or on the GPCOG [males:*Mdn* = 5.00; females: *Mdn* = 5.00, *U* = 1040.50, *p* = .402].

Since the CAMPROMPT performance bands are considered categories, Fisher's exact test was carried out to examine whether the distribution of CAMPROMPT performance classifications differed significantly across males and females. Results showed that, in this sample, there was no significant difference in CAMPROMPT performance between males and females, *p* = .491.

5.4.7.3 Influence of education: The influence of level of education on cognitive test performance was investigated with a series of Kruskal Wallis tests. These analyses revealed no significant effect of level of education for MMSE total scores, *H(8)* = 5.605, *p* = .691, Mini-Cog total scores *H(8)* = 6.581, *p* = .582 or GPCOG total scores *H(8)* = 6.797, *p* = .559.

Due to the small counts in some cells of the CAMPROMPT performance bands and the highest levels of education obtained, CAMPROMPT performance bands were further collapsed into good performance (comprising Very Good, Above Average, and Average performance bands) and poor performance (comprising Impaired, Borderline or Poor performance bands). A Chi-square test revealed no evidence that CAMPROMPT performance was dependent on level of education, X2(16) = 13.484, p = .637.

5.4.7.4 Influence of mood state: The potential influence of self-reported anxiety and depression on performance on each of the objective cognitive tests was assessed via non-parametric correlational analyses. As shown by Table 5.12 below, correlational analyses revealed that levels of anxiety and depression, as measured by HADS, were not significantly related to total scores on each of the objective cognitive tests. Because QQ-plots, normality plots and skewness and kurtosis statistics showed HADS data to be positively skewed and kurtotic and Shapiro-Wilk tests showed the distribution of cognitive test scores departed from normality, Spearman's rho correlations were computed.

Table 5.12: Correlations between Cognitive Test Scores and Mood State: Spearman's rho

	MMSE Total	Mini-Cog Total	GPCOG Total	CAMPROMPT Total	HADS Total	HADS Anxiety	HADS Depression
MMSE Total	1						
Mini-Cog Total	.186*	1					
GPCOG Total	.361**	.310**	1				
CAMPROMPT Total	.124	.240**	.078	1			
HADS Total	.057	.113	.399	.008	1		
HADS Anxiety	0.77	.122	.386	.048	.921**	1	
HADS Depression	0.32	.071	.236	.055	.781**	.524**	1

**Correlation is significant at the 0.01 level

5.4.7.5 Influence of sleep: Differences in performance on the objective cognitive tests between those who reported problems with sleep and those who did not were investigated with Mann-Whitney U tests and Fisher's Exact test.

Difficulty falling asleep: On the MMSE, those who reported difficulty falling asleep (*Mdn* = 30) did not perform more poorly than did those who did not report difficulty falling asleep (*Mdn* = 30); *U* = 689.00, *p* = .283. Similarly, there was no group difference in Mini-Cog performance between those who reported difficulty falling asleep (*Mdn* = 9) and those who did not (*Mdn* = 9), *U* = 699.00, *p* = .302 and CAMPROMPT performance was not dependent on group membership $X^2(2)$ = 3.261, *p* = .196. However, there *was* a significant difference in GPCOG performance between those who reported difficulty falling asleep (*Mdn* = 8) and those who did not (*Mdn* = 9), *U* = 589.00, *p* = .021, with those who had difficulty falling asleep performing more poorly.

Waking during the night: Performance on the MMSE did not differ significantly between those who reported waking during the night (Mdn = 30) and those who did not (Mdn = 30), U = 620.00, p = .760. Similarly, performance on the Mini-Cog did not differ significantly between those who reported waking during the night and those who did not, U = 624.00, p = .781, not did performance on the GPCOG, U = 618.50, p = .718 or CAMPROMPT, $X^2(5)$ = 3.390 p = .640.

Waking earlier than intended: MMSE performance did not differ significantly between those who reported waking earlier than intended and those who did not, U = 1129.50, p = .879. Similarly, Mini-Cog performance did not differ significantly between those who reported waking earlier than intended (Mdn = 5) than did those who did not (Mdn = 5), U = 1116.00, p = .781. Neither did GPCPG performance differ significantly between those who reported waking earlier than intended (Mdn = 9) and those who

did not (Mdn = 9) , U = 1130.00, p = .869. Finally, performance on CAMPROMPT did not depend on group membership, $X^2(2)$, = .198, p = .906.

Takes naps during the day: Mann-Whitney U tests revealed no significant differences between those who nap during the day and those who do not. On the MMSE, performance did not differ between nappers (Mdn = 30) and non-nappers (Mdn = 30), U = 1021.50, p = .329. Similarly, on Mini-Cog, performance did not differ between nappers (Mdn = 5) and non-nappers (Mdn = 5), U = 998.00, p = .329 and a similar finding was observed on GPCOG scores [nappers: Mdn = 9; non-nappers: Mdn = 9, U = 1123.50, p = .879]. Finally, there was no significant difference in the spread of CAMPROMPT performance bands across nappers and non-nappers, $X^2(5)$ = 3.462, p = .629.

Average number of hours of sleep: Interestingly, the average number of hours of sleep reported by participants related significantly to some cognitive tests and not to others. The relationship between the average number of hours of sleep and MMSE performance was significant, Spearman's r = .174, p = .044, such that more hours of sleep was associated with better MMSE performance. Spearman's r correlation between the average number of hours of sleep and Mini-Cog performance was also significant; Spearman's r = .383, p = .000. In contrast, the relationship between the average number of hours sleep and GPCOG performance was not significant; Spearman's r = .099, p = .168 and there was no significant relationship between the average number of hours of sleep and performance on the CAMPROMPT, r = .143, p = .082. Separately, there was no significant difference in the average number of hours of sleep obtained by those who reported they take naps (M = 6.76, SD = 1.49) during the day and those who do not (M = 6.71, SD = 1.1.3), t(95) = .196, p = .845.

5.4.7.6 Influence of physical health (multimorbidity): A series of Mann-Whitney U tests was conducted to investigate whether levels of memory failures, as denoted by scores of the MMSE, Mini-Cog and GPCOG, differed significantly as a function of multimorbidity whilst the impact of multimorbidity on CAMPROMPT performance was examined by means of a chi-square test. No significant difference was found in the distribution of MMSE scores between those with multimorbidity (*Mdn = 30.00*) and those without (*Mdn =30.00*); *U* =769.00, *p* = .992. Likewise, Mini-Cog scores did not differ significantly between those with (*Mdn*= 5) and without multimorbidity (*Mdn*= 5); *U* = 686.00, *p* = .373 nor did GPCOG scores [with multimorbidity: *Mdn*= 9; without multimorbidity: *Mdn*= 9; *U* = 677.50, *p* = .299]. In contrast, CAMPROMPT performance (as denoted by the three collapsed CAMPROMPT categories of "good", "average" and "poor") was dependent upon multimorbidity status; $X^2(2)$ = 8.301, *p* = .016.

5.4.8 Predictors of Subjective Memory Status: Binary Logistic Regression

In order to examine whether self-reporter status could be predicted by cognitive test performance, a series of binary logistic regression analyses were performed with self-reporter status as the outcome variable and the respective cognitive test as the sole predictor in each model. Results showed that none of these models represented a significant improvement above the null model and none of the cognitive tests were significant predictors of self-reporter status. Accordingly, a number of binary logistic regression analyses were performed to investigate whether objective cognitive test performance, in combination with a small number of covariates selected based on the univariate analyses and psychological theory, resulted in improved prediction of self-reported status. In each model, 97 cases were analysed. The findings from these analyses are summarised below in Table 5.13.

In each of the models, classification rates represented an improvement above the null-model classification rate (53.6%) but in no model did the objective cognitive test contribute significantly to the final classification rate. Confirming other results, the key predictor variables were typically anxiety, and the presence of multimorbidity.

5.13: Predictors of self-reported memory status (Poor self-reported memory – high self-reporters – good self-reported memory – low self-reporters)

Predictors	Correct Classification Rate-self-reported	Improvement over Null Model - omnibus chi-square	Proportion of Variance Accounted for	Significance of Predictors	Increase in Classification odds as self-reported poor memory
MMSE, HADS Anxiety, HADS Depression, Difficulty Falling Asleep	Poor: 27/45 (60%) Good: 41/52 (78.8%)	10.74, df = 4, p = .03).	11% - 14%	Anxiety: Wald's $t(1)$ = 4.044, p = .044 Depression: Wald's t(1) = .702, p = .402 Difficulty falling asleep: Wald's t = .056, p = .812 MMSE: Wald's t(1) = .178, p = .673	1.19, 95% CI (1.004 – 1.38)
GPCog, HADS Anxiety HADS Depression Difficulty Falling Asleep	Poor: 26/45 (57.8%) Good: 39/52 (75.0%)	10.65, df = 4, p = .03	10% - 13%	Anxiety: Wald's $t(1)$ = 4.055, p = .044 Depression: Wald's t(1) = .654, p = .411 Difficulty falling asleep: Wald's t = .048, p = .827 GPCOG: Wald's $t(1)$ = .088, p = .766	1.19, 95% CI (1.004 – 1.38)
Mini-Cog, HADS Anxiety HADS Depression Difficulty Falling Asleep	Poor: 26/45 (57.8%) Good: 39/52 (75.0%)	10.65, df = 4, p = .0301.	10% - 14%	Anxiety: Wald's $t(1)$ = 4.043, p = .044 Depression: Wald's t(1) = .689, p = .407 Difficulty falling asleep: Wald's $t(1)$ = .061, p = .805 Mini-Cog: Wald's $t(1)$ = .061, p = .805	1.180, 95% CI (1.004 – 1.386)
CAMPROMPT (good -v poor), HADS Anxiety HADS Depression Difficulty Falling Asleep	Poor: 25/45 (55.6%) Good; 41/52 (78.8%)	10.84 df = 5, p = .05	10% - 14%	Anxiety: Wald's $t(1)$ = 3.867, p = .049 Depression: Wald's t(1) = .742, p = .389 Difficulty falling asleep: Wald's $t(1)$ = .092 p = .761 CAMPROMPT: Wald's $t(1)$ = .107, p = .744	1.17, 95% CI (1.004 – 1.38)
MMSE , HADS Anxiety, HADS Depression, Multimorbidity	Poor: 28/45 (62.2%) Good: 39/52 (75%)	15.73, df = 4, p < 0.05.	15% - 20%	Anxiety: Wald's $t(1)$ = 4.698, p = .030. Multimorbidity Wald's $t(1)$ = 4.698, p = .029 Depression: Wald's t(1) = .975, p = .323. MMSE: Wald's $t(1)$ = .336, p = .562.	1.20 (95% CI 1.02, 1.42). 3.43 (95% CI 1.11 – 10.13).
GPCOG, HADS Anxiety HADS Depression Multimorbidity	Poor: 27/45 (60%) Good: 38/52 (7%)	15.43, df = 4, p < 0.05.	14.7 - 19.6%	Anxiety: Wald's $t(1)$ = 4.715, p = .03 Multimorbidity: Wald's $t(1)$ = 4.554, p = .033 Depression: Wald's t(1) = .916, p = .339. GPCOG:Wald's $t(1)$ = .036, p = .850	1.20 (95%CI 1.11 – 1.42) 3.35 (95% CI 1.11 – 10.14)
Mini-Cog, HADS Anxiety HADS Depression Multimorbidity	Poor: 29/45 (64.4%) Good: 38/52 (73%)	15.42, df = 4, p < 0.05.	14.7 -19.6%	Anxiety Wald's $t(1)$=4.701, p=.030 Multimorbidity: Wald's $t(1)$ = 4.556, p = .033 Depression; Wald's $t(1)$ = .935, p = .333. Mini-Cog: Wald's $t(1)$ = .020, p = .887.	1.20 (95%CI 1.11 – 1.417). 3.35 (95% CI 1.11 – 10.15)
CAMPROMPT (good -v poor), HADS Anxiety HADS Depression Difficulty Falling Asleep	Poor: 27/45 (60.0%) Good: 39/52 (75.0%).	15.45, df = 5, p < 0.05.	14.7 % - 19.7%	Anxiety: Wald's $t(1)$ = 4.72, p = .030 Multimorbidity: Wald's $t(1)$ = 4.49, p = .035 Depression: Wald's $t(1)$ = .848, p = .357 CAMPROMPT: Wald's $t(1)$ = .028, p = .866.	1.20 (95%CI 1.108 – 1.43) 3.44 (95% CI 1.09 – 10.89)

5.5 Interim Summary and Discussion

The current study set out to investigate the relationship between self-reported memory failures as assessed by the PRMQ and objective performance on cognitive tests, namely the MMSE, Mini-Cog, GPCOG and CAMPROMPT. It also set out to determine this relationship by taking into account other variables known, or suspected, to exert an influence on self-reported memory and cognitive test performance. Finally, in recognition of the dearth of assessment of PM, not only in screening for cognitive impairment in Primary Care but in neuropsychological assessments in various settings, a standardised objective test of PM was included in the cognitive test battery. The inclusion of an objective test of PM was also envisaged to show closer correspondence to the PM content of the subjective memory measure, the PRMQ.

No significant association of PRMQ scores to objective test performance was detected in this study. Reid and MacLullich (2006) reviewed the evidence of the relationship between subjective and objective cognitive performance and concluded the self-reported memory problems were inconsistently related to current cognitive impairment. There may be many reasons for this lack of relationship. In general, a lack of concordance between the type of subjective problems assessed on self-reported instruments – often problems relating to subjective RM/episodic memory – and the many and varied types of cognitive processes assessed by cognitive tests may be partly responsible. The PRMQ, however, includes a component of PM as well as a RM.

The lack of significant association between the PRMQ and the cognitive tests MMSE, GPCOG, and Mini-Cog used in this study, and recommended for use by the ICGP and Alzheimer's Association, is, thus, perhaps not surprising, primarily because these tests do not include any elements of objective PM assessment that might map more precisely onto the PM items contained within the PRMQ. To further illustrate this point, case summary analysis of the PRMQ and cognitive test data per participant revealed that CAMPROMPT performers in the combined Impaired, Borderline and Poor performance bands displayed a trend of higher levels of self-reported memory problems than Average, Above Average and Very Good CAMPROMPT performers. At the same time, the majority of poor CAMPROMPT performers obtained perfect, or near perfect, total scores on the MMSE, Mini-Cog and GPCOG. This would suggest that the MMSE, Mini-Cog, and GPCOG, which do not contain items assessing PM (similar to all of the currently recognised and recommended screening tools for cognitive impairment in Primary Care) are not successfully detecting subtle PM impairment to the extent that the CAMPROMPT, as an objective test of PM, appears to.

However, in agreement with many other cross-sectional and longitudinal studies, univariate analyses showed that self-reported memory failures in the current study were significantly related to a number

of other variables, specifically, anxiety, depression, and sleep problems. While a relationship between having multiple chronic conditions and PM scores was detected in Study 1, after controlling for depression, a similar significant relationship was not found in Study 2. This finding contrasts with the finding of a significant relationship of multimorbidity to subjective cognition by Caracciolo et al. (2013). The findings regarding anxiety and depression are in line with our findings in Study 1 and much of the literature (e.g. Minette et al., 2008; Balash et al., 2012). Depression has, in and of itself, been established as a risk factor for current and future cognitive impairment and for the future development of dementia (Diniz, Butters, Albert, Dew & Reynolds, 2013), although the direction and temporality of this relationship is debated (Kohler & Thomas, 2018). Similarly, although the literature on anxiety is less extensive than that on depression, anxiety has been established as a risk factor for cognitive impairment in cross-sectional (De Bruin et al., 2014) as well as retrospective cohort studies (Gulpers et al., 2016), although it was noted that this risk did not increase for those with existing mild cognitive impairment (Gulpers et al., 2016). Regarding the direction and temporality of the relationship of anxiety to dementia, Gulpers et al. concluded based on meta-analytic findings that a stronger association of anxiety to dementia increases with age, that anxiety might be a prodromal symptom of dementia, rather than a causal risk factor.

Evidence continues to emerge regarding the positive predictive value of sleep problems with regards to cognitive impairment and dementia (e.g. Johar, Kawan, Thwing & Karl-Heinz, 2016; de Almondes, Costa, Malloy-Diniz & Diniz, 2016; Yaffe et al., 2011). However, differential associations of the various sleep variables to PRMQ scores were found in the current study compared to Study 1, and differential associations between sleep and mood were also observed in the current study compared to Study 1. Specifically, the current study found a significant difference in PRMQ scores across all of the PRMQ scales in those who reported difficulty falling asleep versus no difficulty. This contrasts to Study 1, which found a difference between groups on RM scores only. Moreover, unlike Study 1, difficulty falling asleep was not found to be significantly associated with depression or anxiety in the current sample. Difficulty falling asleep therefore does not appear to be mediated by levels of depression and anxiety in the current sample as it was in the larger sample of Study 1. Difficulty falling asleep also related significantly to multimorbidity status but there were no significant differences as a function of multimorbidity status in PRMQ scores. Therefore, it appears that the influence of difficulty falling asleep on self-reported memory was not significantly mediated by either mood state or poor physical health in the current sample.

A relationship between waking earlier than intended and PM scores was no longer significant after anxiety was accounted for in the current sample, in contrast to Study 1. Unlike Study 1, however, which found a significant difference in PRMQ scores between those who wake during the night and those

who don't (which lost significance after controlling for mood) the current study did not find this relationship.

In terms of objective performance, while self-reported memory difficulties did not significantly associate with performance on the cognitive tests, age was found to correlate significantly with MMSE scores, such that MMSE total scores decreased as ages increased. This finding supports the literature on age effects of the MMSE (e.g. Tombaugh & McIntyre, 1992). There was also a significant difference in years of age across collapsed poor, average and good performance categories of the CAMPROMPT, with average performers reporting significantly higher age than poor and good performers. Depression and anxiety were not significantly associated to objective performance in this study. This contrasts with many findings in the literature (e.g. Steinberg et al., 2013, Thomas & O'Brien, 2008). Performance on the GPCOG was significantly poorer in individuals who reported difficulty falling asleep as compared with those who did not, but this relationship was only observed for the GPCOG. While studies relating specifically to the GPCOG were not found, other studies have demonstrated a similar relationship between difficulty falling asleep and performance on other objective tests (Haimov, Hanuka & Horowitz, 2008).

Thus, while PRMQ scores were not significantly associated with the cognitive tests, PRMQ scores were significantly associated with the variables difficulty falling asleep, depression and anxiety, and of these variables, difficulty falling asleep was found to be the sole predictor of objective cognitive test performance (and only on the GPCOG).

Nonetheless, the significant association of variables like depression, anxiety and difficulty falling asleep with self-reported memory failures should flag the potential presence of these conditions, all of which increase the vulnerability of older adults to cognitive impairment. The timely assessment, detection and appropriate treatment of these conditions in older adults can help protect these individuals from future cognitive impairment or further cognitive decline. Even in cases where the depression or anxiety has already been recognised by a practitioner, the potential presence of self-reported problems of memory should be assessed, since the medications often used to treat these mood disorders (benzodiazepines for anxiety in particular) are known to increase subjective cognitive difficulties (Stewart, 2005). Admittedly, further research is needed to fully elucidate the mechanisms underlying the relationship between cognitive impairment and difficulty falling asleep, as well as regarding the efficacy of interventions to address sleep issues. However, Primary Care practitioners are well-placed to enquire after and address sleep problems with potential interventions such as exercise and sleep hygiene (Reid et al., 2010) melatonin and bright light therapy (Leng &Yaffe, 2018), or review of current medications that may impact sleep. In so doing they may help to decrease the vulnerability of older

adults not only to cognitive impairment but also to potential mood disorders, which negatively impact well-being, and which are also, in turn, risk factors for cognitive impairment.

In summary, self-reported memory failures may not predict objective cognition as measured by some of the currently recommended standardised cognitive tests. However, identification of variables that are significantly associated with self-reported memory problems is an extremely valuable endeavour from a case-finding perspective. The reasons for memory complaints and poor or less than optimal performance on cognitive tests are myriad and range from factors such as mood state (Alexopoulos, 2005), physical health (Loprinzi, 2016), medication side-effects (e.g. Stewart, 2005; Ortinski & Meador, 2004) sensory impairment (Plassman et al., 2008) tiredness and fatigues, test anxiety (Sarason, 1984), to actual cognitive impairment (Mattos et al., 2003).. As discussed in Chapters 1 and 2, not every older adult with subtle or mild cognitive dysfunction will go on to develop dementia. Many individuals may experience a reversal of their cognitive symptoms if the underlying reason(s) for their cognitive difficulty are detected and treated appropriately in a timely manner. Since many of these underlying conditions are also believed to be risk factors for cognitive impairment, information on associations to subjective cognitive difficulty is valuable for assisting the identification of older adults who may be particularly vulnerable to further cognitive decline.

Separately, it is interesting to consider the difference in findings that emerged from the univariate compared to the logistic regression analyses. The binary logistic regressions with an outcome variable based on cluster analysis of PM and RM T-scores that derived two natural groupings of high forgetfulness and low forgetfulness, found that neither depression nor difficulty falling asleep emerged as significant predictors of whether an individual reports high or low levels of forgetfulness. Anxiety remained the sole significant predictor of levels of forgetfulness in these analyses. When multimorbidity was entered as a predictor instead of difficulty falling asleep in a subsequent series of logistic regression models, both multimorbidity and anxiety emerged as significant predictors of levels of forgetfulness. These findings contrast with the outcomes of the univariate analyses, which showed a significant association between difficulty falling asleep and PRMQ scores, and which showed a non-significant association of multimorbidity to PRMQ scores. Notwithstanding that the relationship between these and other variables and subjective memory is likely to be nuanced and complex, the difference in findings between the univariate and logistic regression analyses may reflect the different computational approach adopted in each. Logistic regression goes beyond univariate analyses to provide a valuable account of the magnitude of any relationship between a predictor and the outcome as well as its relative contribution to a predictive model after controlling for other predictors. Furthermore, it could be argued that subjecting PM and RM T-scores to cluster analysis allows a more realistic account of an individual's subjective memory and its relationship with other variables, since it

takes into account the naturally occurring association between PM and RM ability. This is an important consideration given that successful PM contains both a PM component (i.e. remembering that one has to do something in the future) and an RM component (i.e. remembering the actual content of what one was supposed to do in the future). Hence, these components are dissociable, but are also overlapping (Simons, Scholvnick, Gilbert, Frith & Burgess, 2006).

Chapter 6: Study 3: Construction of a short-form PRMQ

6.1 Study Background

For a number of reasons, there is a need for brief, reliable instruments for the assessment of subjective memory concern in Primary Care. As noted in Chapter 2, self-reported difficulties form part of the criteria for concern regarding MCI and dementia (Alzheimer's Association) and, although still somewhat controversial, there is longitudinal evidence of the predictive utility of such self-reports. At present, however, there are no clinical recommendations for the use of a standardised, reliable self-report instrument for evaluating self-reported difficulties in primary care and for benchmarking the extent of reported difficulties against normative data.

At an applied clinical level, the inconclusive nature of the literature pertaining to the relationship between self-reported memory problems and objective performance on cognitive tests may be part of the reason for the lack of attention often paid to self-report. Indeed, as reported in Chapter 5, investigation of the relationship between the PRMQ and the selected cognitive tests used in Study 2 were not statistically significant, confirming previous studies that used similar test measures. There are, of course, a few reasons why subjective reports and objective test performance might not map neatly onto each other. Among these reasons are the facts that our subjective measures may tap difficulties not captured in our objective tests; the fact that currently employed brief objective tests are not sufficiently sensitive to identify cognitive difficulties and the fact that not all items in our subjective tests are of direct relevance in identifying 'atypical' memory failures.

The use of total scores, or subscale scores, in the analysis of the relationship between self-reports and cognitive test performance may be obscuring concurrent and predictive relationships at the item level. Hence, the goal of this study is to conduct an analysis of the PRMQ at the level of individual items to investigate the degree to which particular items, denoting particular everyday memory failures, are endorsed by those who also demonstrate subtle difficulty with performance on selected cognitive tests.

The psychometric properties of these items are also examined. Item analysis involves a group of statistics that can be computed for each item on a test or an assessment measure in order to assess the quality of each item and, thus, the test. An item analysis can show why a test is reliable or unreliable and it can suggest ways of improving the measurement characteristics of the instrument, by indicating items for inclusion or omission from the instrument. Those items that demonstrate the ability to discriminate between respondents who perform perfectly on the objective cognitive tests versus those whose final test score is less than perfect (thus indicating subtle difficulty with objective memory or cognitive function) and which also display good psychometric properties are retained for inclusion in a

shorter version PRMQ, while ensuring adequate coverage of the original PRMQ domains of Prospective Memory (PM) and Retrospective Memory (RM).

6.2 Study Goals

The present study aimed to achieve the following goals:

1. To investigate the psychometric properties of PRMQ items.
2. To investigate the ability of individual PRMQ items to discriminate between those with differential performance on the objective cognitive tests (perfect total scores versus less than perfect total scores).
3. To develop a reliable, shortened form of the PRMQ from a selection of those items shown to discriminate between different levels of objective cognitive ability and that demonstrate sound psychometric properties and maintain adequate coverage of the PM and RM domains.

6.3 Study Methods

6.3.1 Study Design

This study employed a cross-sectional design, using the techniques of Classical Item Analysis under the Classical Test Theory framework.

Item analysis techniques for self-report measures with Likert-style response options typically involves investigating item means, corrected item-total correlations, and Cronbach's alpha, although the exact choice and interpretation of the statistics that make up an item analysis are determined by the purpose and nature of the test and the test developer's objectives These item analysis techniques are a part of the theoretical framework of psychological measurement and test development called Classical Test Theory (CTT).

To provide an understanding of the theoretical framework guiding item analysis in the present study, an overview of CTT is provided next.

6.3.1.1 Classical Test Theory

Classical test theory (CTT) is a traditional quantitative approach to testing the reliability and validity of a scale based on its items. As a body of theory and research, it can provide insight into ways to improve a test. It does so by providing information on item characteristics, the probability of item endorsement, the overall ability of the test taker, and the extent to which an item conforms with the rest of the items in a test.

Mathematically, CTT assumes that each observed score (X) on an instrument is a combination of an underlying true score (T) on the concept of interest and unsystematic (i.e., random) error (E). Also known as True Score Theory, it assumes that each person has a true score (T) that would be obtained if there were no errors in measurement. A person's true score is defined as the expected score over an infinite number of independent administrations of the scale. Scale users never observe a person's true score, only an observed score, X. It is assumed that the observed score (X) = true score (T) plus some error (E).

True scores represent in individual's true value on the underlying trait to be measured. It follows that as values of T increase, responses to items representing the same concept should also increase, i.e., there should be a monotonically increasing relationship between Ts and item scores (and assuming, in this example, that item responses are coded so that higher responses reflect more of the concept).

The difference between a true score and an observed score is considered to be random error. CTT assumes that random errors found in observed scores are normally distributed and, therefore, that the expected value of such random fluctuations (i.e., mean of the distribution of errors over a hypothetical infinite number of administrations on the same subject) is zero. In addition, random errors are assumed to be uncorrelated with a true score, with no systematic relationship between a person's true score and whether that person has positive or negative errors.

Techniques of item analysis from the CTT framework were employed in this study to select items with the appropriate psychometric properties for a short version of the PRMQ. Assessment of the loadings of the PRMQ items on their respective PM and RM domains, obtained through CFA of the PRMQ in Study 1, was also carried out to further compliment the classical item analysis.

An outline of the rationale and use of CTT-based item statistics and descriptive statistics was provided in Chapter 3. Briefly, however, item means, standard deviations, spread of endorsed response categories (item skew), item reliability indices, alpha if item deleted, p-values (difficulty indices), corrected item-total correlations (as one type of discrimination index) and item discrimination indices based on the ability of PRMQ items to discriminate between levels of performance on each of the cognitive tests administered in Study 2 were computed. The methods by which these techniques were implemented to construct a briefer, yet reliable version of the PRMQ are described below.

6.3.2 Ethics Approval

As noted in Chapter 3, this study represented, primarily, an extension of the Study 2 data analysis and involved no additional direct contact with participants. Similarly, confirmatory factor analysis of the short-form PRMQ derived from these analyses was undertaken using the larger Study 1 anonymous dataset and, similarly, did not require further direct contact with participants.

6.3.3 Study Materials

As detailed in Study 2, participants underwent an individual face-to-face cognitive evaluation consisting of the PRMQ, socio-demographic status, mood state and health questions, the Mini-Mental State Exam (MMSE), Mini-Cog, GPCOG, CAMPROMPT and NART.

6.3.4 Sample

The demographic and other characteristics of the primary study sample are described in Chapter 5. Briefly, this convenience sample consisted of an initial 99 healthy older community dwelling adults, aged 50 years and above. There were 59 females and 40 males. Two participants were later dropped from analyses because they did not compete the entire evaluation protocol for different reasons. The mean age of the sample was 66.3 years (range; 51 – 91 years). There was a relatively high level of education across the sample; 15.2% completed a Higher Diploma, and 12.1% completed a Third Level degree.

Regarding requirements of sample size based on CTT approaches, while the sample should be large enough for the descriptive and exploratory pursuit of meaningful estimates from the data, Cappelleri, Lundy & Hays (2014) suggest that starting with a sample size of 30 to 50 participants may be reasonable in many circumstances. Thus, the sample of 97 employed here appears adequate.

6.3.5 Data Processing and Data Analysis

First, the descriptive and statistical properties of each of the 16 PRMQ items was examined and showed all items to display sound psychometric properties. Following this, those items with the highest ability to discriminate on the cognitive tests, with priority afforded to the cognitive tests recommended for use in Primary Care settings (i.e. Mini-Cog and GPCOG) were investigated.

To select items for a preliminary short-form PRMQ, the extent to which PRMQ items positively discriminate between upper and lower performance categories on each of the objective cognitive tests was assessed. The ability of each PRMQ item to distinguish between groups of high and lower test performers was reflected by its discrimination index (DI), obtained by subtracting the difficulty index

(p value) of the perfect performing group from the difficulty index of the lower performing group. These items were identified as potential candidates for a short form PRMQ.

An item displayed positive discriminative ability regarding objective cognitive ability (or dysfunction) if the item was endorsed at a greater frequency in the lower performance groups than in the group who obtained a perfect score on the cognitive test, indicating a positive relationship between the self-reported memory difficulty and one's performance on the cognitive test. On the other hand, if an item is said to display negative discriminative ability, it means this item was actually endorsed at a higher frequency by those who obtained a perfect score on the cognitive test(s). Accordingly, data analysis included descriptive statistics regarding item endorsement, as well as analyses grounded in CTT (e.g. scale distribution, item-total correlations, coefficient alpha) and factor loadings obtained from the CFA of the PRMQ in Study 1.

Based on the classical item analysis and factor loadings derived from the CFA in Study 1, a number of items stood apart as having the strongest psychometric properties and best ability to discriminate performance on the objective cognitive tests. These items were identified as potential candidates for a short form of the PRMQ.

Assessment of the psychometric properties of this short-form PRMQ involved revisiting the data from Study 1. CFA was performed to establish the factor structure of the new test measure.

6.4 Results

6.4.1 Item assessment and selection

6.4.1.1 Data dispersion and homogeneity

First, the characteristics of PRMQ data dispersion and homogeneity were explored for each scale (PM and RM) and for the PRMQ total score; mean (M), standard deviation (SD), and reliability was assessed using Cronbach's alpha coefficient of internal consistency and item reliability indices. The main scale summary statistics for the PRMQ scales are illustrated in Table 6.1. As this table highlights, the mean total PRMQ scale score was 37.37 (SD = 11.09). The mean PM subscale score was 19.69 (SD = 6.02) and for RM it was 17.68 (SD = 5.45). Cronbach's alpha reliability coefficients for the PRMQ scales were all good. These reliability coefficients indicate the feasibility of constructing a shorter form PRMQ from the full form.

Table 6.1: Summary statistics and reliability coefficients for the 16-item PRMQ

	Mean (Raw Score)	SD (Raw Score)	Cronbach's alpha
PRMQ Total Scale	37.37	11.09	.927
PM subscale	19.69	6.02	.896
RM subscale	17.68	5,45	.838

A range of item statistics and properties, namely mean, median, SD, item skew, corrected item-total correlations corrected item-total correlations, item reliability indices and alpha if item is deleted are presented for all 16 PRMQ items in Table 6.2.

Table 6.2: Item statistics for PRMQ

PRMQ Item	Mean	Median	SD	Skew	Corrected Item-Total Correlations	Item Reliability Index	Alpha if item deleted
1	3.02	3	0.95	-0.04	.72	.68	.92
2	1.72	2	0.81	1.39	.62	.50	.92
3	2.38	2	1.12	0.60	.69	.77	.92
4	2.68	3	1.10	0.33	.72	.79	.92
5	2.27	2	1.15	0.64	.60	.67	.92
6	1.84	2	0.96	0.82	.41	.39	.93
7	2.32	2	0.96	0.53	.65	.63	.92
8	2.25	2	1.05	0.37	.73	.76	.92
9	2.47	2	1.16	0.37	.58	.67	.93
10	2.89	3	1.08	0.23	.70	.75	.92
11	2.90	3	1.04	0.04	.96	.99	.92
12	2.17	2	0.89	0.55	.76	.67	.92
13	1.67	1	0.81	1.27	.54	.44	.93
14	2.02	2	0.83	0.41	.66	.54	.92
15	2.14	2	0.98	0.32	.60	.58	.92
16	2.36	3	0.98	-0.01	.68	.67	.92

While priority of attention in item selection for a short PRMQ was given to item p-values and item discrimination indices (DIs), the item information contained in Table 6.2 was also examined when deciding between which PRMQ items to retain when two items covered the same domain, cue type and/or temporal type. As can be observed in this table, item means ranged from 1.67 to 3.02 and the average mean was 2.34. The item with the highest mean was Item 1 (How often: *Do you decide to do something in a few minutes time and then forget to do it?; M* = 3.02), followed by Item 11 (How often: *Do you mislay something that you have just put down, like a magazine or glasses?*; *M* = 2.90) and Item 10 (How often: *Do you intend to take something with you, before leaving a room or going out, but minutes later leave it behind, even though it's there in front of you*?; *M* = 2.89).

The lowest mean scores were observed for Item 13 (How often: *Do you look at something without realising you have seen it moments before?*; M = 1.67), Item 2 (How often: *Do you fail to recognise a place you have visited before?*; M = 1.72) and Item 6 (How often: *Do you fail to recognise a character in a radio or television show from scene to scene?; M = 1.84*).

Some of the items had symmetric distributions, but Pearson's skewness coefficients showed that other items displayed notable positive or negative skewness, indicating a high frequency and low frequency of occurrence respectively. RM Item 13 (How often: *Do you look at something without realising you have seen it moments before?)* had a positive Pearson skewness coefficient of 2.47. RM Item 9 (How often: *Do you repeat the same story to the same person on different occasions?)* had a skewness coefficient of 1.22, followed by PM Item 3 (How often: *Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?*). By contrast, PM Item 16 (How often: *Do you forget to tell someone something you had meant to mention a few minutes ago?)* had the skewness coefficient of -1.19. The next largest negative skew was displayed by RM Item 2 (How often: *Do you fail to recognise a place you have visited before?*) at -1.03, followed by RM Item 4 (How often: *Do you forget something that you were told a few minutes earlier?*) with a skew of -0.87.

6.4.1.2 Determining Item Difficulty

Other than reporting means and standard deviations of category endorsement, there are various ways of representing the frequency with which individuals experience memory failure (i.e. item difficulty). One way is to report the percentage of respondents who endorsed each of the response categories; "Never", "Rarely", "Sometimes", "Often", and "Very often." Item difficulty might then be determined by examination of these frequency data. Table 6.3 below presents the spread of responses in each category of the PRMQ in the study sample. Another method of assessing an item's difficulty in a Likert-style scale with multiple response categories is, as outlined in Chapter 3, by comparing the score for the item amongst respondent, and the resulting value is labelled a p-value (otherwise known as a difficulty index).

Table 6.3: Reported frequency of occurrence per PRMQ item (n=97)

Item	Category	How often	Frequency of Occurrence: N (%)				
			Very often	Often	Sometimes	Rarely	Never
1	PM	Do you decide to do something in a few minutes time and then forget to do it?	7 (7.1)	16 (17.3)	53 (54.1)	14 (14.3)	7 (7.1)
2	RM	Do you fail to recognise a place you have visited before?	1 (1.0)	3 (3.1)	7 (7.2)	43 (44.3)	43 (43.3)
3	PM	Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off a kettle?	6 (6.2)	7 (7.2)	29 (29.9)	32 (32.8)	24 (24.7)
4	RM	Do you forget something that you were told a few minutes before?	7 (7.2)	12 (12.4)	29 (29.9)	32 (32.8)	24 (24.7)
5	PM	Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?	4 (4.1)	13 (13.4)	18 (18.6)	34 (34.0)	29 (29.9)
6	RM	Do you fail to recognise a character in a radio or television show from scene to scene?	0 (0)	7 (7.2)	17 (7.5)	27 (27.8)	47 (47.4)
7	PM	Do you forget something you had planned to buy, like a birthday card, even when you see the shop?	4 (4.4)	5 (5.2)	34 (34.0)	30 (30.0)	24 (24.7)
8	RM	Do you fail to recall things that have happened to you in the last few days?	1 (1.0)	12 (12.4)	26 (26.8)	29 (29.9)	29 (29.9)
9	RM	Do you repeat the same story to the same person on different occasions?	5 (5.2)	14 (14.4)	27 (27.8)	27 (27.8)	24 (24.7)
10	PM	Do you intend to take something with you, before leaving a room or going out, but minutes later, leave it behind, even though it's there in front of you?	9 (9.3)	15 (15.5)	39 (39.2)	26 (26.8)	9 (9.3)
11	RM	Do you mislay something that you have just put down, like a magazine or glasses?	6 (6.2)	20 (20.6)	39 (39.2)	24 (24.7)	9 (9.3)
12	PM	Do you fail to mention or give something to a visitor that you were asked to pass on?	1 (1.0)	6 (6.2)	24 (24.7)	45 (45.4)	22 (22.7)
13	RM	Do you look at something without realising you have seen it moments before?	1 (1.0)	1 (1.0)	12 (12.4)	35 (35.1)	49 (50.0)
14	PM	If you tried to contact a friend or relative who was out, would you forget to try again later?	0 (0.0)	4 (4.1)	22 (22.7)	44 (44.3)	28 (28.9)
15	RM	Do you forget what you watched on television the previous day?	0 (0.0)	9 (9.3)	27 (27.8)	30 (30.9)	32 (32.0)
16	PM	Do you forget to tell someone something you had meant to mention a few minutes ago?	2 (2.1)	14 (14.4)	41 (41.2)	26 (26.8)	15 (15.5)

In the case of the PRMQ, it serves as a proxy for the difficulty (or lack thereof) of particular everyday memory tasks or events by virtue of the relative average frequency with which these tasks or events are forgotten in the sample. As Table 6.4 demonstrates, the difficulty of PRMQ items varies, with P-values ranging from .33 (Item 13: How often: *Do you look at something without realising you have seen it moments before?* to .61 (Item 1: How often: *Do you decide to do something in a few minutes time and then forget to do it?).* These values are considered to fall within the medium range of difficulty by many authors (Essen & Akpan, 2014)

Table 6.4: Item difficulty of PRMQ items: rank ordered by p-values

PRMQ Item	Category	How often:	p-values (Item Difficulty)
1	PM	Do you decide to do something in a few minutes time and then forget to do it?	.61
10	PM	Do you intend to take something with you, before leaving a room or going out, but minutes later, leave it behind, even though it's there in front of you?	.58
11	RM	Do you mislay something that you have just put down, like a magazine or glasses?	.58
4	RM	Do you forget something that you were told a few minutes before?	.55
15	RM	Do you forget what you watched on television the previous day?	.54
16	PM	Do you forget to tell someone something you had meant to mention a few minutes ago?	.52
14	PM	If you tried to contact a friend or relative who was out, would you forget to try again later?	.51
9	RM	Do you repeat the same story to the same person on different occasions?	.49
3	PM	Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off a kettle?	.48
6	RM	Do you fail to recognise a character in a radio or television show from scene to scene?	.46
7	PM	Do you forget something you had planned to buy, like a birthday card, even when you see the shop?	.46
5	PM	Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?	.45
8	RM	Do you fail to recall things that have happened to you in the last few days?	.45
12	PM	Do you fail to mention or give something to a visitor that you were asked to pass on?	.43
2	RM	Do you fail to recognise a place you have visited before?	.34
13	RM	Do you look at something without realising you have seen it moments before?	.33

6.4.1.3 Difficulty Indices (p-values) and Item Discrimination Indices (DIs)

For the purpose of obtaining the discriminative ability of PRMQ items with regards to participant performance on each of the objective cognitive tests of interest, a discrimination index (DI) was calculated for each item by subtracting the item p-value in the high performing group (perfect total test scores) from the lower performing group (less than perfect total score).

To maximise the potential validity of a short form PRMQ suitable for use in a primary care context, analysis focused on the discrimination power of items relating to three specific cognitive tests. Two of these (Mini-Cog, GPCOG) have been recommended for use in primary care (ICGP: Foley & Swanwick, 2014; Cordell et al., 2013). Despite its limited sensitivity to mild cognitive deficits, the MMSE was also used as it remains the most widely used brief screening tool. Accordingly, a hierarchical approach to item retention was adopted. Specifically, priority of attention was given to those items that positively discriminated objective performance across *both* the Mini-Cog *and* GPCOG, followed by different items that positively discriminated performance on *either one or the other* of the Mini-Cog or GPCOG, followed, finally, by those items that positively discriminated performance on the MMSE. Those items that discriminated performance on the MMSE (if they did not also discriminate performance on the Mini-Cog and GPCOG) were included in the selection parameters in acknowledgement of the fact that the MMSE is still commonly used by GPs (Foley & Swanwick, 2014) but such items were positioned lower in the selection hierarchy since the MMSE is most useful as a screen for ruling out dementia as opposed to detecting mild cognitive impairment (Mitchell, 2009). For interest, the ability of individual items to discriminate between CAMPROMPT performance groups was also examined, but these data were not used in the process of selecting items for the short-form PRMQ. Discrimination indices for the CAMPROMPT denote item ability to discriminate performance in the collapsed "poor" from the collapsed "good" performance groups.

Based on the difference between p-values in cognitive test performance groups, the following PRMQ items were selected for construction of a short-form PRMQ:

- Items 11 and 15, which displayed discriminative value across all of the cognitive tests (Mini-Cog, GPCOG, MMSE and CAMPROMPT).
- Items 5, which positively discriminated performance on both the Mini-Cog and GPCOG, as well as MMSE.
- Items 1, 3, 9, which exhibited positive discriminative ability on the GPCOG (though not the Mini-Cog).
- Item 13, which exhibited positive discriminative ability on the Mini-Cog (though not the GPCOG).

As can be seen from Table 6.5, items 11 and 15 discriminated positively, to various degrees, across each of the cognitive tests. Item 5 discriminated performance on Mini-Cog, GPCOG and MMSE, but not CAMPROMPT. These items were, therefore, relatively easy to select for inclusion in a short-form PRMQ. The selection of the remaining items is slightly less clear-cut. The degree of discrimination power (indicated by a positive DI) varied amongst items and differed for each item according to the cognitive test at hand. Indeed, while some items discriminated positively on

certain tests, in a few cases, these same items discriminated either negatively or not at all on one or more of the other tests. Nonetheless, items 1, 3, 9 and 13 were selected for inclusion.

Table 6.5: Ability of selected PRMQ items to discriminate performance on objective cognitive tests.

			Difference in p-values between perfect total test score and lower test scores			
PRMQ Item	**How often**	**Subscale**	**Mini-Cog**	**GPCOG**	**MMSE**	**CAMPROMPT**
11	Do you mislay something that you have just put down, like a magazine or glasses?	RM	.03	.11	.09	.20
15	Do you forget what you watched on television the previous day?	RM	.04	.08	.04	.08
5	Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?	PM	.07	.05	.04	-.10
1	Do you decide to do something in a few minutes time and then forget to do it?	PM	-.02	.06	.03	.00
3	Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off a kettle?	PM	-.01	.06	.05	.07
9	Do you repeat the same story to the same person on different occasions?	RM	-.01	.06	.01	.09
13	Do you look at something without realising you have seen it moments before?	RM	.05	-.04	.07	-.4

Regarding those items that discriminated between the upper and lower performance groups on those cognitive tests designed specifically for use in Primary Care, the Mini-Cog and GPCOG, items 5, 11, and 15 positively discriminated between performance groups on both the Mini-Cog and GPCOG (and indeed items 11 and 15 discriminated performance on all the cognitive tests). Additional items in the PRMQ discriminated on either one or the other of the tests. Specifically, items 1, 3 and 9 discriminated perfect from lesser performance on the GPCOG (though not on the Mini-Cog) and item 13 discriminated performance groups on the Mini-Cog GPCOG (though not on the exhibited positive discriminative ability on the GPCOG (though not the Mini-Cog).

A small number of other items also displayed positive discriminative ability on either one or other of the Mini-Cog *or* GPCOG tests. For example, Item 2 discriminated between the Mini-Cog performance groups (DI = .09), while items 8 (DI = .12) and 10 (DI = .09) discriminated between GPCOG performance groups. The potential utility of these items over and above those items already selected was examined. This involved assessment of the type of memory (RM/PM), time-frame (long-term/short-term), and cue-type (self-cued/environmentally-cued) involved in the everyday memory tasks described by the items, as well as examination of item statistics. Those items that were already represented conceptually by previously selected items were discarded in the interests of brevity and parsimony, unless additional item properties of the latter were markedly better than the already selected items. The assessment of items 2, 8 and 10 is outlined next.

Item 2 discriminated positively between performance groups on the Mini-Cog (DI = .09), but it discriminated negatively on the GPCOG (DI = -.13). It's counterpart, item 9, which is the other RM, long-term, environmentally-cued item in the PRMQ, displayed positive discriminative ability on the GPCOG (DI = .06) but only slight negative validity on the Mini-Cog (-.01). Item 9 has a bigger standard deviation (1.16) than did item 2 (.81), indicating greater variability and, hence, potentially better discriminative ability amongst self-reporters of memory failures. Item 2 also displays larger skew (1.39) than item 9 (.37), indicating that item 2 has a less uniform distribution of responses than item 9. Item 2 has a good corrected item-total correlation (.621) and item 9 has a comparable corrected item-total correlation (.578). Alpha coefficients if either item was deleted is also comparable (r = .923 if item 2 is deleted and r = .925 if item 9 is deleted). Thus, both items can be seen to have comparable item statistics and properties, although there is greater variability in responses, and more uniform distribution of responses to item 9. Considering also that the primary purpose in this instance is of constructing a short PRMQ that prioritises discriminative power vis-à-vis objective cognitive performance, the lesser negative discriminate ability shown by item 9 (DI = -.01 on the Mini-Cog) compared to item 2 (DI = -.13 on the GPCOG) points to the retention of item 9 for a short version PRMQ.

While item 8 displayed a positive ability to discriminate between upper and lower performance groups on the GPCOG, it discriminated negatively between performance groups on the Mini-Cog (DI = -.11), (as well as on the MMSE and CAMPROMPT). By contrast, Item 15, the counterpart RM, long-term, self-cued item, positively discriminated between upper and lower performance groups on all of the cognitive tests. Comparison of item reliability indices showed that item 8 had a higher item reliability index (.76) than item 15 (.58). Item 8 had a higher corrected item-total correlation (.73) than item 15 (.60). Item 8 had a slightly higher standard deviation (1.05) than item 15 (.98). Coefficient alpha for the full form PRMQ if item 8 was deleted was only very slightly lower (.92) than that if item 15 was deleted (.93), which would suggest that discarding item 15 instead of item 8 would lead to very slightly improved reliability in comparative terms, though since both values are above .9, this would not be expected to make any significant overall difference to the reliability of the PRMQ. Despite the slightly better psychometric properties of item 8, the psychometric properties of item 15 can still be considered good enough to include in a short form PRMQ and given its better power to discriminate objective ability on both the Mini-Cog and GPCOG, is argued here to be preferred in place of its counterpart item, 8.

Item 3 and Item 10 are both environmentally-cued, short-term PM items. Therefore, for the purpose of a short-form of the PRMQ it is sufficient to retain only one of these items, and preferably the item with better discriminative power.

Both items, 3 and 10, discriminated positively between upper and lower performance groups on the GPCOG, although item 10 displayed slightly higher discriminative power on this test, as denoted by a difference between performance group p-values of .09, compared to a difference in p-values of .06, displayed by item 3. Neither item discriminated positively on the Mini-Cog. However, item 3 positively discriminated performance groups on the MMSE (DI = .05), while item 10 negatively discriminated performance on the MMSE (-.03). Examination of other item descriptive information and item statistics revealed that items 3 and 10 were quite similar. Both item 3 and item 10 had comparably good corrected item-total correlations amongst the self-reporters (.69 and .70, respectively). The deletion of either item would result in equal coefficient alphas of .921. Both items had comparably strong item reliability indices; item 3 had a reliability index of .774 and item 10 had a reliability index of .75. Both items also had similar standard deviations; item 3 had a standard deviation of 1.12 and item 10 had a standard deviation of 1.08. Since item 3 positively discriminated between performance groups on the MMSE (a test which, although most useful as a screen for dementia, is still commonly used for screening of mild cognitive impairment in Primary Care) this item was retained in place of item 10 for short form PRMQ version B.

6.4.2 Preliminary investigation of a short-form PRMQ

Based on the findings of item analyses pertaining to item ability to discriminate objective performance on cognitive tests, PRMQ items 1, 3, 5, 9, 11, 13, and 15 were used to construct an alternative short-form PRMQ. A previous CFA of the original full-form PRMQ in Study 1 (see Chapter 4) obtained factor loadings for all of the PRMQ items and showed that the loadings for each of the 7 selected items on their respective PM/RM domain were good, ranging from .487 to .634.

6.4.2.1 Scale and Item Descriptive Information

Scale descriptive information for the short-form PRMQ is contained in the Table 6.6 below. The item means range from 1.85 to 3.02 and the average inter-item correlation is .42, which is considered within the desirable range. Cronbach's alpha for short-form PRMQ is .82, which is an acceptable value for this reliability coefficient.

Table 6.6: Descriptive information for short-form PRMQ

Scale mean	Minimum mean	Maximum mean	SD
16.45	1.67	2.90	5.15

Item statistics and descriptive information for the short-form PRMQ is presented below in Table 6.7 and the inter-item correlations of the short-form PRMQ are presented in Table 6.8.

Table 6.7: Item properties for short-form PRMQ

Item	Mean	SD	Corrected Item-Total Correlation	Item Reliability Index	Squared Multiple Correlation	Alpha if Item Deleted
PRMQ1	3.02	0.95	.717	.678	.512	.921
PRMQ3	2.38	0.81	.621	.504	.555	.923
PRMQ5	2.47	1.15	.597	.687	.312	.924
PRMQ9	2.47	1.16	.578	.672	.319	.925
PRMQ11	2.90	1.04	.957	.990	.396	.922
PRMQ13	1.67	0.81	.542	.440	.401	.925
PRMQ15	2.14	0.98	.597	.583	.267	.924

Table 6.8: Inter-Item Correlation Matrix for Short-Form PRMQ

	PRMQ1	PRMQ3	PRMQ5	PRMQ9	PRMQ11	PRMQ13	PRMQ15
PRMQ1	1.00						
PRMQ3	.557	1.00					
PRMQ5	.406	.367	1.00				
PRMQ9	.324	.369	.346	1.00			
PRMQ11	.433	.458	.354	.317	1.00		
PRMQ13	.362	.422	.337	.379	.346	1.00	
PRMQ15	.264	.281	.249	.322	.325	.406	1.00

6.4.2.2 Reliability and factor structure of the short-form PRMQ through CFA

The reliability and factor structure of the short-form PRMQ was further explored in a confirmatory factor analysis (CFA) using R-software, version 3.5.1. for Windows, and the *lavaan* programme (Rosseel, 2012) for CFA. Robust Maximum Likelihood (MLR) was used to estimate model parameters. Informed by findings from other studies that conducted CFAs of the original (full-length) PRMQ, a series of models were investigated, beginning with a one-factor model, proceeding to a correlated two-factor model, and finally a (uncorrelated) tripartite model consisting of one general factor (on which all items load) and specific factors of prospective and retrospective memory.

Table 6.9 below contains the results from the Chi-squared test statistic and other fit statistics for the CFA models for the short-form PRMQ.

The one-factor model, in which all of the selected items were specified to load on one general memory factor, converged after 22 iterations, and contained 14 free parameters. Factor loadings ranged from .475 (item 15) to .719 (item 3). Residual correlations were all below the recommended cut-off for problematic residuals of 1.96. The second model tested, in which items were specified to load on one or other of two correlated factors of PM and RM, converged after 28 iterations, and contained 15 free parameters. Factor loadings ranged from 0.517 (item 15) to 0.745 (item 3). All residual correlations were below 1.96. The tripartite model converged after 26 iterations and contained 16 free parameters. Factor loadings for each of the items on the Tripartite model ranged from .517 (item 15) to .745 (item 3). Inspection of the residual correlations showed that none of the residual correlations were problematic.

As can be observed from Table 6.9, the one-factor model, the correlated factors model and the tripartite model were all very similar in terms of fit. However, in the interest of parsimony, and in keeping with the literature relating to the factor structure of the full-form PRMQ, which posits distinct

but overlapping constructs of PM and RM, the present short-form PRMQ can be said to align with the established tripartite structure of the original full-length PRMQ.

Table 6.9: Fit indices for CFA models of the short-form PRMQ

Model	Chi-square	df	p	Normed Chi-Square	Robust CFI	Robust TLI	Robust RMSEA	SRMR
One factor model	42.09	14	.000	3.00	.959	.939	.07 (.05 - .09), p = .150	.040
Correlated factors model	31.69	13	.003	2.44	.937	.956	.06 (.00-.09), p =.390 .	.035
Tripartite model	29.26	16	.004	2.43	.973	.952	.06 (.03-0.09), p = .390	.035

As can be seen from Table 6.9, the short-form PRMQ demonstrated good model fit to the tripartite model. The tripartite model had a significant Chi-square value of 29.26 (*16*), *p*= 0.004. However, because the Chi-square test is sensitive to sample size, it is nearly always significant when the sample size is large (Bentler & Bonnet, 1980; Joreskog & Sorbom, 1993). Relative or normed Chi-Square (X^2/df) was 2.43. While no consensus exists as to an acceptable ratio for the normed Chi-square statistic, this value is above commended ratio cut-off of 2 (Tabachnick & Fidell, 2007) and below the ratio of 5 suggested by Wheaton, Muthen, Alwin and Summers (1977). Robust CFI was 0.973 and robust TLI was 0.952; both are above the value of 0.95, considered to constitute good fit (Hu & Bentler, 1999). Robust RMSEA was 0.062 (95% CI: 0.03 – 0.09), *p* = .390, which can be considered close fit since it is below the generally accepted upper limit of .08 (Hu & Bentler, 1999). The SRMR value was 0.035, which can be considered very good, since it is well below the recommended cut-off of .08 indicting good fit (Hu & Bentler, 1999).

6.5 Interim Summary and Discussion

This study involved a classical item analysis of the PRMQ to obtain the item descriptive and statistical properties, as well as an assessment of the ability of PRMQ items to discriminate between perfect and less than perfect levels of objective cognitive performance, for the construction of a shorter PRMQ. Since the CAMPROMPT is not in use as a standard screening tool for cognitive impairment in Primary Care settings, priority was given instead to those items displaying sound psychometric properties and positive discriminative ability on the tests recommended for, and widely used, in Primary Care – the Mini-Cog, GPCOG and MMSE.

All of the PRMQ items were found to display sound psychometric properties. Similarly, all of the items discriminated to some degree on at least one of the four cognitive tests administered in Study 2,

although it was noted that the extent to which the same items discriminated across the different tests varied. Some items, were, however, superior to others at differentiating between subgroups. It should be noted that the use of a Discrimination Index (DI) in the current study differs slightly from the traditional or classical DI as described and outlined by Kelley (1939). The standard method relies on the extreme group method wherein those with the overall highest and lowest test scores are grouped into upper and lower groups usually consisting of the upper and lower 25-33% respectively. In the context of this study, perfect and less than perfect performance characterised the two subgroups compared. However, Metsamuuronen (2018) points out that:

> *"In a general sense, the item discriminating power (IDP) is a loose term for the characteristic of an item that reflects how accurately or efficiently an item can discriminate between the individuals with the higher item response from those with the lower item response."*

In line with the purpose of this study, participants were grouped into those who obtained a perfect total score on the objective cognitive tests and those who obtained a less than perfect total score for each of the separate objective cognitive tests. Since the differences in PRMQ item p-values between the groups, on which the DIs were based, can be considered quite small according to classical DI guidelines (see Tejinder, Piyush and Daljit, 2009 and Ananthkrishnan, 2000) the value of the DI was judged relative to the DIs displayed by all the other remaining PRMQ items. Items with the higher positive DIs were denoted as better discriminators of objective cognitive test performance. Higher frequency endorsement of these PRMQ items with a higher positive DI should, therefore, more closely reflect objective memory and cognitive performance than endorsement of the PRMQ items with smaller positive, or indeed, negative DIs.

This exercise resulted in the selection of a subset of 7 PRMQ items; 3 items assessing the domains of PM, and 4 items assessing the domain of RM. This short-form PRMQ was subsequently subjected to a CFA, which, keeping in mind the limitations of the Chi-square test statistic, confirmed its reliability and the tripartite factor structure of the original full-form PRMQ.

As always, the advice of Kline (2005) should be kept in mind; a well-fitting model is not always a sign of a useful and valid instrument and an ill-fitting model is not automatically a sign of a poor measure. Ultimately, the utility of a short-form PRMQ will depend on the purpose for which the questionnaire is intended, it's reliability in the sample for which it is intended, its usability and its predictive utility.

Notwithstanding the need for further study of the psychometric properties and clinical utility of the short-form PRMQ proposed here, this short-form PRMQ carries the original advantage of the full-form PRMQ of containing items that assess both PM and RM. However, it possesses the additional advantage

of greater brevity, allowing quick administration and scoring in Primary Care. Previous authors have illustrated that these screening tools need to be brief enough for use within a typical 10-15-minute consultation, and they must display good psychometric properties. They should also be easy to administer, to score and to interpret and they should be relatively unaffected by sociodemographic factors (Iatraki et al., 2017). The short-form PRMQ described here is quick and easy to administer. Responses can be summed to obtain both a PM and RM subscale total. Moreover, Chapter 7 (Study 4) outlines the development of normative data and T-scores (with a mean of 50 and a SD of 10) for both the full-form and this short-form PRMQ to facilitate the easy and rapid interpretation of an individual's PRMQ scores. These normative data and T-scores were obtained for an older Irish population aged 50 years and above from the sample in Study 1, using the sample means and standard deviations. Thus, these data are appropriate for the age cohort most likely to present with cognitive complaints.

Chapter 7: Study 4 - Establishing PRMQ normative data for older Irish Adults

7.1 Background:

Normative data are data from a reference population on a measurement that provides a baseline distribution against which an individual's scores on that measurement can be compared. The appropriateness of normative data for judging an individual's scores on a measure will depend on the degree of similarity between an individual's characteristics and the characteristics of the sample from which the normative data were drawn.

As noted in Study 1, Chapter 4, subtle, but potentially important, differences were found between self-reported memory failures of the Irish sample and the UK normative sample. These differences equated to a low to moderate effect size, indicating that the establishment of PRMQ normative data specific to the older Irish population might be needed. Separately, no normative data currently exist for the short-form PRMQ recommended as a result of the data analyses presented in Chapter 6.

The need for population specific normative data for the PRMQ was previously demonstrated in a Swedish sample (Ronnlund et al., 2008). In that study, just like the present Irish sample, the Swedish sample self-reported significantly *better* memory than did the UK based normative sample.

The findings of Study 1 showing that this older adult sample reported better memory that did the UK normative sample are in line with the literature detailing cross-national comparisons of self-perceived memory and self-perceived general health. For example, a comparison of findings from three longitudinal studies, The Irish Longitudinal Study of Aging (TILDA) (Barrett et al., 2011), English Longitudinal Study of Aging (ELSA) and the US-based Health and Retirement Study (HRS) showed that Irish people, asked to self-rate their memory as *'excellent'*, *'very good'*, *'good'*, *'fair'* or *'poor'*, self-reported significantly better memory than their English counterparts, even though the English sample displayed better performance on objective cognitive tests of verbal fluency than the Irish sample (Savva et al., 2013).

These differences could not be explained by the physical health profile of either sample. Physical health in the TILDA and ELSA samples were similar in terms of chronic diseases (evidenced in the literature to affect cognitive function in many circumstances). Although there was a lower level of hypertension in the ELSA sample than in the TILDA sample, this did not explain the findings. Interestingly, however, even though Irish people are known to be amongst the heaviest users of alcohol in the European Union (European Commission, 2010), the proportion of people reporting themselves as heavy drinkers was substantially lower in TILDA than in the ELSA (and HRS) sample. Studies examining the association between alcohol use and the *subjective* experience of memory problems are scant in comparison to studies documenting *objective* evidence that heavy alcohol use impairs memory and cognition. However, given the link between objective cognitive impairment and high levels of

alcohol consumption (White, 2003), it is plausible that this difference in alcohol use may – at least, partly, - explain the differences between the Irish and English samples in self-rated memory.

It is likely, however, that a combination of biopsychosocial, societal and cultural differences between countries influence self-perceptions of cognitive and physical health. Savva and colleagues (2013) point out that future analyses of combined microdata from longitudinal cross-national studies will enable more detailed comparisons and will better elucidate the underlying reasons for the differences identified and described

7.2 Study Goals:

The primary goal of this study is to generate normative data for older Irish adults for the short-form PRMQ proposed as a result of the data analyses presented in Chapter 6. A secondary goal is to provide normative data for the original long-form PRMQ. Finally, a third goal is to determine the relationship between the short-form PRMQ and the objective test data.

7.3 Study Methods:

7.3.1 Sample: For the purpose of generating normative data for older Irish adults, data were examined from those who participated in Study 1. Full details of this sample are presented in Chapter 4.

7.3.2 Data Analysis:

7.3.2.1 Generation of T-scores for the Irish sample

In generating normative data for the PRMQ, both short- and long-form, it was considered best to express PRMQ total and subscale scores as T-scores, in keeping with normative data previously established by Crawford and colleagues. T-scores are easy to understand (Crawford et al., 1998b), having a mean of 50 and a standard deviation is 10.

For both short- and long-form PRMQ, Irish sample T-scores were obtained in a two-step process. First, participant standard z-scores were computed using means and standard deviations for each of the PRMQ subscales. A z-score has a mean of 0 and a standard deviation of 1. From these z scores, T-scores, with a mean of 50 and a standard deviation of 10, were computed.

Presented data are also expressed in terms of "true scores", which are scores corrected for reliability of the scales (i.e. such that with deviance from perfect reliability the more regression towards the mean is observed on the "true" as compared with observed scores). Corresponding true scores and confidence intervals, symmetrical around these true scores, were obtained using the relevant Classical Test Theory (CTT) formulae, as used by Crawford et al. (2003). Specifically, confidence limits on scores for each of the three PRMQ scales (Total, PM and

RM) were derived by obtaining the standard error of measurement for true scores (Glutting, McDermott and Stanley, 1987; Stanley, 1971) using the following formula:

$$SEM_{xt} = r_{xx}\left(S_x\sqrt{1 - r_{xx}}\right)$$

Where S_x is the standard deviation of the scale (10 in the present case as raw scores are converted to T-scores) and r_{xx} is the reliability of the scale (normally estimated using Cronbach's alpha).

Confidence limits are then formed by multiplying SEM_{xt} by a value of z (a standard normal deviate) corresponding to the desired confidence limits (most commonly used: the SEM is multiplied by 1.96). These confidence limits are not symmetrical around individual's obtained scores but are symmetrical around their estimated true scores (Nunally and Bernstein, 1994; Silverstein, 1989; Stanley, 1971). The estimated true score is obtained by multiplying the obtained score, in deviation form, by the reliability of the test. True scores are regressed towards the mean, with the extent of this regression varying inversely with the reliability of the scale. The formula is as follows:

$$\text{True score} = r_{xx}(X - \overline{X}) + \overline{X},$$

where X is the obtained score and $\overline{X}$ is the mean for the scale.

7.3.2.2 Reliability of the difference between PRMQ PM and RM T-scores

As noted in Chapter 4, Crawford and colleagues suggest that, in addition to standard normative data, it would also be useful to have a means of evaluating discrepancies between an individual's PM and RM scores. Based on the formula they propose, critical values for the Irish dataset, both for the short-form and long-form PRMQ were calculated.

7.3.2.3 Abnormality of the difference between PM and RM scores

The distinction between the reliability of a difference between PM and RM scores and the abnormality of such difference is an important one (Crawford et al., 2003). Many individuals may rate their PM as better than their RM and vice versa. Therefore, Crawford et al (2003) emphasise that a reliable difference need not be unusual or rare and that, in clinical settings, a reliable difference need not necessarily be a cause for concern. To this end, information on the actual abnormality of the difference should accompany information on the reliability of differences between scores. Crawford and colleagues made available a simple computer programme for PCs to automate scoring and the analysis of an individual's PRMQ data. This uses the following formula to obtain a quantity that is distributed as *t:*

$$t = \frac{|T_x - T_y|}{\sqrt{[S_x + S_y - S_x S_y r_{xy}]\left(\frac{N+1}{N}\right)}},$$

Where T_x and T_y are the individual's T-scores on the two scales being compared, S_x and S_y are the standard deviations (10 in the present case as T-scores are used), r_{xy} is the correlation between the scales and N is the size of the normative sample. The percentile point corresponding to the *t* obtained from this formula is then found and multiplied by 100 to provide an estimate of the percentage of the population equalling or exceeding the observed discrepancy.

To obtain the percentage equalling or exceeding the observed discrepancy, regardless of the sign of the discrepancy, the percentile point is multiplied by two before being multiplied by 100.

In the absence of scoring software (as is available for use with the UK normative database: Crawford et al., 2003), the extent to which discrepancy levels might be considered *'abnormal'* or *"statistically unusual",* were determined, both for the long-form and the short-form PRMQ by reference to the distribution of discrepancy scores in the normative (Study 1 sample).

7.4 Results

7.4.1 Short-Form PRMQ

7.4.1.1 Raw Scores, True Scores, T-scores and Confidence Intervals for the short-form PRMQ

Table 7.1 and Table 7.2 below present the normative data for the short-form PRMQ developed in Study 3. For the purpose of these normative data, Study 1 PRMQ data, computed to reflect the shortened PRMQ were used. The short-form Total, PM and RM subscales for the Irish Study 1 sample are presented below in terms of the raw scores and their corresponding True Scores, T-scores and Confidence Intervals. Of note, based on the findings reported in Chapter 4, which demonstrated no discernible effects of age, gender or education on self-reported memory scores, data were not stratified by demographic variables of age, gender or education. In each table, the red line represents the point at which individual scores can be considered *'impaired'.* This cut-off was set to represent scores that fall below the 5th percentile for the normative sample (i.e. > 1.64 standard deviations (SD) above the mean in the case of raw scores – and > 1.64 SD below the mean in the case of T-scores.

Table 7.1: Table for converting raw scores on the **Short-Form PRMQ Total Scale** to *T*-scores and for obtaining 95% confidence limits on true scores. Red line represents cut-off for impairment.

			95% CL	
Raw Score	**T-score**	**True Score**	**Lower**	**Upper**
7	70	67	64	70
8	68	65	62	68
9	65	63	60	66
10	63	61	58	64
11	61	59	56	62
12	58	57	54	60
13	56	55	52	58
14	54	53	50	56
15	51	51	48	54
16	49	50	47	53
17	47	47	44	50
18	44	45	42	48
19	42	43	40	46
20	39	41	38	44
21	37	39	36	42
22	35	37	34	40
23	32	35	32	38
24	30	33	30	36
25	28	32	29	35
26	25	29	26	32
27	23	27	24	30
28	21	26	23	29
29	18	23	24	30
30	<18 (17)	<23	<23	<29
31	<18 (17)	<23	<23	<29
32	<18 (17)	<23	<23	<29
33	<18 (17)	<23	<23	<29
34	<18 (17)	<23	<23	<29
35	<18 (17)	<23	<23	<29

*Raw scores are scored such that *higher* scores represent *greater* self-reported memory difficulty. (i.e. poorer self-reported memory);
**T-scores (mean = 50, SD = 10) were derived from reflected raw scores such that *higher* T-scores represent *better* self-reported memory performance; 95% CL: 95% Confidence Limits

Table 7.2: Table for converting raw scores on the **Short Form PRMQ PM and RM Scale** to *T*-scores and for obtaining 95% confidence limits on true scores.

PRMQ PM Scale					PRMQ RM Scale				
			95% CL					95% CL	
Raw	T-score	True	Lower	Upper	Raw	T-score	True	Lower	Upper
3	69	64	60	68	4	68	62	58	66
4	64	60	56	64	5	64	60	56	64
5	60	57	53	61	6	60	57	53	61
6	55	54	50	58	7	56	54	50	58
7	51	51	47	55	8	52	51	47	55
8	46	47	43	51	9	48	49	45	53
9	42	44	40	48	10	44	46	42	50
10	37	40	36	44	11	40	43	39	47
11	33	37	33	41	12	35	40	36	44
12	28	34	30	38	13	31	37	33	41
13	24	31	27	35	14	27	34	30	38
14	19	27	23	31	15	23	32	28	36
15	<19 (18)	<27	<23	<31	16	19	29	25	33
					17	15	26	22	30
					18	<15	<26	<22	<30
					19	<15	<26	<22	<30
					20	<15	<26	<22	<30

*Raw scores are scored such that *higher* scores represent *greater* self-reported memory difficulty. (i.e. poorer self-reported memory);
**T-scores (mean = 50, SD = 10) were derived from reflected raw scores such that *higher* T-scores represent *better* self-reported memory performance; 95% CL: 95% Confidence Limits

For ease of comparison, Table 7.3 provides a summary of the raw score to T-Score conversions, together with an indication of the cut-off score for impairment on each of the three scales. Alternative cut-off scores are presented in Table 7.4.

Table 7.3: Raw scores and equivalent T-scores for the short-form PRMQ

Short-Form PRMQ Total Raw* Score	Short-Form PRMQ Total T-score**	Short-Form PRMQ PM Raw* score	Short-Form PRMQ PM T-score**	Short-Form PRMQ RM Raw score*	Short-Form PRMQ RM T-score**
7	70	3	69	4	68
8	68	4	64	5	64
9	65	5	60	6	60
10	63	6	55	7	56
11	61	7	51	8	52
12	58	8	46	9	48
13	56	9	42	10	44
14	54	10	37	11	40
15	51	11	33	12	35
16	49	12	28	13	31
17	47	13	24	14	27
18	44	14	19	15	23
19	42	15	<19 (18)	16	19
20	39			17	15
21	37			18	<15
22	35			19	<15
23	32			20	<15
24	30				
25	28				
26	25				
27	23				
28	21				
29	18				
30	<18 (17)				
31	<18 (17)				
32	<18 (17)				
33	<18 (17)				
34	<18 (17)				
35	<18 (17)				

*Raw scores are scored such that *higher* scores represent *greater* self-reported memory difficulty. (i.e. poorer self-reported memory); **T-scores (mean = 50, SD = 10) were derived from reflected raw scores such that *higher* T-scores represent *better* self-reported memory performance

Table 7.4: Percentiles data for short-form PRMQ scales

PRMQ Version and Scale		Percentiles						
		5	10	25	50	75	90	95
Short	T-scores Total	33.56	38.08	44.85	51.62	58.39	62.91	62.91
Form	T-scores PM	32.92	37.57	46.46	50.90	55.34	59.79	64.23
	T-scores RM	32.67	36.49	44.14	51.78	55.61	63.25	63.25

Weighted averages.

7.4.1.2 Reliability of the difference between short-form PRMQ PM and PRMQ RM T-scores

As noted above, Crawford and colleagues (2003) suggest that, in addition to standard normative data, a means of evaluating discrepancies between PM and RM scores would be useful. Based on the formula proposed in Crawford et al, critical values for the Irish dataset for the short-form PRMQ are presented in Table 7.5.

Table 7.5: Critical values for significant (i.e. reliable) differences between estimated true scores on the Short-Form PRMQ PM and RM Scales for the Irish sample.

	Significance level			
	.15	.10	.05	.01
Two-tailed critical value	8	9	11	14
One-tailed critical value	6	7	9	13

Estimated true scores for the PM and RM scales should be obtained from columns 3 of relevant sections of Tables 7.2.

7.4.1.3 Abnormality of the difference between short-form PM and RM T-scores

Both the absolute difference scores (where direction is discounted) and the actual difference scores (preserving information on the direction of difference) between the short-form PM and RM T-scores were calculated using the **Irish Normative Data** for the overall Study 1 sample.

Initial exploration of the data showed that for the **absolute difference scores**: mean = 6.70, SD = 5.24, medial = 6, min difference =0, max difference = 29 . For **actual difference scores:** the mean difference = -0.03, SD = 8.50, median = 1.00, min = -28, max = 29.

Figure 7.1 presents the frequency distribution of absolute differences between **short-form** PM and RM (T-scores), and Figure 7.2 presents the frequency distribution of differences (directional) between **short-form** PM and RM (T-scores) - using the same dataset. Table 7.6 presents the percentile equivalent of difference scores.

Table 7.6: Percentile equivalent of difference scores.

		Percentiles						
		5	**10**	**25**	**50**	**75**	**90**	**95**
Absolute Value	PM/RM Difference	1	1	3	6	9.25	13	17
Actual Value	PM - RM Difference	-16.00	-11.10	-5.25	1.00	6.00	11.00	12.00
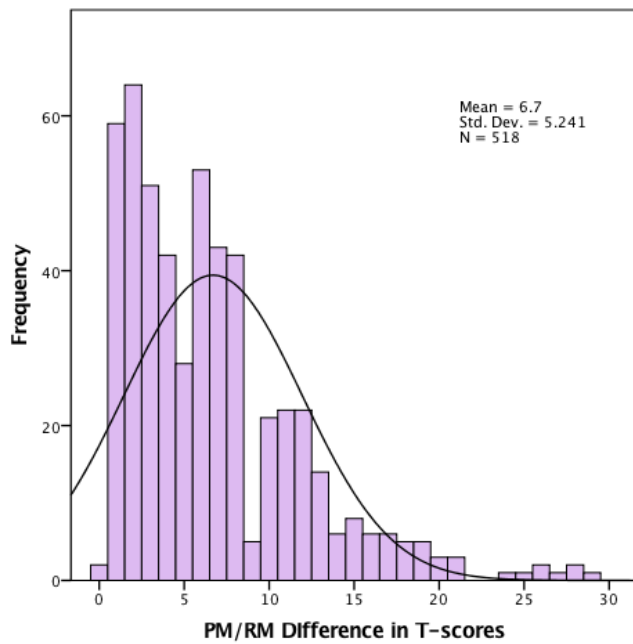
Figure 7.1: Distribution of **absolute** differences in PM/RM T-scores – short-form PRMQ
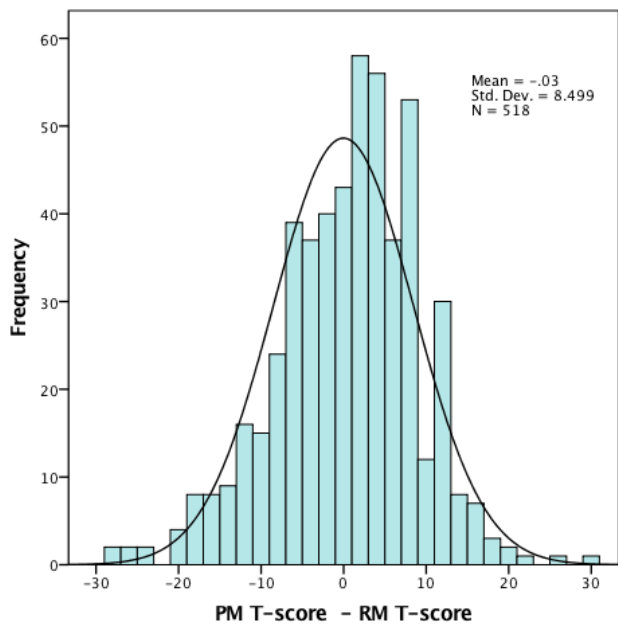
Figure 7.2: Distribution of actual differences between PM and RM T-scores* – short-form

*-ve scores reflect better PM than RM; +ve scores reflect better RM than PM.

Inspection of these figures demonstrates a wide range of discrepancy scores – and a relatively high frequency of what can be considered large discrepancies, confirming the need to examine not just the statistical 'abnormality' of the difference but also its likelihood within the general population. To assist in this task,

frequency distribution tables, for both absolute and actual differences are presented below (Table 7.7 & Table 7.8). From these, it is possible to determine how common a particular size discrepancy is in the general population.

Table 7.7: Frequency distribution of **absolute differences** between short-form PRMQ PM and RM T-scores. T-Score -PRMQ RM T-Scores.

PRMQ PM T-Score – PRMQ RM T-Score Difference				
Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	2	.4	.4	0.4
1	59	11.4	11.4	11.8
2	64	12.4	12.4	24.1
3	51	9.8	9.8	34.0
4	42	8.1	8.1	42.1
5	28	5.4	5.4	47.5
6	53	10.2	10.2	57.7
7	43	8.3	8.3	66.0
8	42	8.1	8.1	74.1
9	5	1.0	1.0	75.1
10	21	4.1	4.1	79.2
11	22	4.2	4.2	83.4
12	22	4.2	4.2	87.6
13	14	2.7	2.7	90.3
14	6	1.2	1.2	91.5
15	8	1.5	1.5	93.1
16	6	1.2	1.2	94.2
17	6	1.2	1.2	95.4
18	5	1.0	1.0	96.3
19	5	1.0	1.0	97.3
20	3	.6	.6	97.9
21	3	.6	.6	98.5
24	1	.2	.2	98.6
25	1	.2	.2	98.8
26	2	.4	.4	99.2
27	1	.2	.2	99.4
28	2	.4	.4	99.8
29	1	.2	.2	100.0
Total	518	100.0	100.0	

Red line represents the point at which a larger difference would be expected in <5% of the population.

Table 7.8: Frequency distribution of **actual differences** between PRMQ PM and RM T-scores .

PRMQ PM T-Score – PRMQ RM T-Score Difference				
Score	Frequency	Percent	Valid Percent	Cumulative Percent
-28	2	.4	.4	.4
-27	1	.2	.2	.6
-26	1	.2	.2	.8
-25	1	.2	.2	1.0
-24	1	.2	.2	1.2
-21	2	.4	.4	1.5
-20	2	.4	.4	1.9
-19	4	.8	.8	2.7
-18	4	.8	.8	3.5
-17	4	.8	.8	4.2
-16	4	.8	.8	5.0
-15	3	.6	.6	5.6
-14	6	1.2	1.2	6.8
-13	6	1.2	1.2	7.9
-12	10	1.9	1.9	9.8
-11	3	.6	.6	10.4
-10	12	2.3	2.3	12.7
-9	2	.4	.4	13.1
-8	22	4.2	4.2	17.4
-7	11	2.1	2.1	19.5
-6	28	5.4	5.4	24.9
-5	15	2.9	2.9	27.8
-4	22	4.2	4.2	32.0
-3	15	2.9	2.9	34.9
-2	25	4.8	4.8	39.8
-1	41	7.9	7.9	47.7
0	2	.4	.4	48.1
1	19	3.7	3.7	51.7
2	39	7.5	7.5	59.3
3	36	6.9	6.9	66.2
4	20	3.9	3.9	70.1
5	13	2.5	2.5	72.6
6	24	4.6	4.6	77.2
7	32	6.2	6.2	83.4
8	21	4.1	4.1	87.5
9	3	.6	.6	88.0
10	9	1.7	1.7	89.8
11	18	3.5	3.5	93.2
12	12	2.3	2.3	95.6
13	8	1.5	1.5	97.1
15	5	1.0	1.0	98.1
16	2	.4	.4	98.5
17	2	.4	.4	98.8
18	1	.2	.2	99.0
19	1	.2	.2	99.2
20	1	.2	.2	99.4
21	1	.2	.2	99.6
26	1	.2	.2	99.8
29	1	.2	.2	100.0
Total	518	100.0	100.0	

Red line represents the point at which a larger difference would be expected in <5% of the population.

7.4.2 Long-Form PRMQ

7.4.2.1 Raw Scores, True Scores, T-scores and Confidence Intervals for long-form PRMQ.

Table 7.9, Table 7.10 and Table 7.11 below present the normative data for the long-form PRMQ Total, PM and RM subscales for the Irish sample derived from sample means and standard deviations. Data are presented in terms of the raw scores and their corresponding True Scores, T-scores and Confidence Intervals. Of note, based on the findings reported in Chapter 4, which demonstrated no discernible effects of age, gender or education on self-reported memory scores, there was no obvious need to stratify the sample by demographic variables of age, gender or education. As with the short-form PRMQ, the cut-off score was set to represent scores that fall below the 5th percentile for the normative sample (i.e. > 1.64 standard deviations (SD) above the mean in the case of raw scores – and > 1.64 SD below the mean in the case of T-scores. Alternative cut-off scores can be obtained from Table 7.12 sample descriptive statistics and percentile scorers are presented.

Table 7.9: Table for converting raw scores on the **Long-form PRMQ Total Scale** to *T*-scores and for obtaining 95% confidence limits on true scores.

			95% CL					95% CL	
Raw	T-score	True	Lower	Upper	Raw	T-score	True	Lower	Upper
16	71	69	64	74	49	34	36	31	41
17	69	67	62	72	50	33	35	30	40
18	68	66	61	71	51	32	34	29	39
19	67	65	60	70	52	31	33	28	38
20	66	64	59	69	53	30	32	27	37
21	65	64	59	69	54	29	31	26	36
22	64	63	58	68	55	27	29	24	34
23	63	62	57	67	56	26	28	23	33
24	62	61	56	66	57	26	28	23	33
25	61	60	55	65	58	24	26	21	31
26	59	58	53	63	59	23	26	21	31
27	58	57	52	62	60	22	25	20	30
28	57	56	51	61	61	21	24	19	29
29	56	55	50	60	62	20	23	18	28
30	55	55	50	60	63	19	22	17	27
31	54	54	49	59	64	18	21	16	26
32	53	53	48	58	65	17	20	15	25
33	52	52	47	57	66	16	19	14	24
34	51	51	46	56	67	15	18	13	23
35	50	51	46	56	68	14	17	12	22
36	48	48	43	53	69	13	16	11	21
37	47	47	42	52	70	12	16	11	21
38	46	46	41	51	71	11	15	10	20
39	45	45	40	50	72	10	14	9	19
40	44	45	40	50	73	9	13	8	18
41	43	44	39	49	74	8	12	7	17
42	42	43	38	48	75	7	11	6	16
43	41	42	37	47	76	6	10	5	15
44	40	41	36	46	77	5	9	4	14
45	38	39	34	44	78	4	8	3	13
46	37	38	33	43	79	3	7	2	12
47	36	37	32	42	80	2	7	2	12
48	35	36	31	41					

*Raw scores are scored such that *higher* scores represent *greater* self-reported memory difficulty. (i.e. poorer self-reported memory);
**T-scores (mean = 50, SD = 10) were derived from reflected raw scores such that *higher* T-scores represent *better* self-reported memory performance; 95% CL: 95% Confidence Limits

Table 7.10: Table for converting raw scores on the **Long-form PRMQ PM scale** to *T*-scores and for obtaining 95% confidence limits on true scores.

PM Raw Score	T-score	True Score	95% Confidence Limits	
			Lower	Upper
8	71	68	62	74
9	69	66	60	72
10	67	65	59	71
11	65	63	57	69
12	63	61	55	67
13	61	60	54	66
14	59	58	52	64
15	57	56	50	62
16	55	54	48	60
17	53	53	47	59
18	51	51	45	57
19	49	49	43	55
20	47	47	41	53
21	45	46	40	52
22	43	44	38	50
23	41	41	35	47
24	39	40	34	46
25	37	39	33	45
26	35	37	31	43
27	34	36	30	42
28	32	34	28	40
29	30	33	27	39
30	28	31	25	37
31	26	29	23	35
32	24	27	21	33
33	22	26	20	32
34	20	24	18	30
35	18	21	15	27
36	16	20	14	26
37	14	19	13	25
38	12	17	11	23
39	10	15	9	21
40	9	13	7	19

*Raw scores are scored such that *higher* scores represent *greater* self-reported memory difficulty. (i.e. poorer self-reported memory);
**T-scores (mean = 50, SD = 10) were derived from reflected raw scores such that *higher* T-scores represent *better* self-reported memory performance; 95% CL: 95% Confidence Limits

Table 7.11: Table for converting raw scores on the **Long-form PRMQ RM subscale** to *T* scores and for obtaining 95% confidence limits on true scores.

RM Raw score	T-score	True score	95% Confidence Limits Upper	95% Confidence Limits Lower
8	68	64	57	71
9	65	62	55	69
10	63	61	54	68
11	61	59	52	67
12	59	57	50	64
13	57	56	49	63
14	54	53	46	60
15	52	52	45	59
16	50	51	44	58
17	48	48	41	55
18	46	47	40	54
19	43	44	37	51
20	41	42	35	49
21	39	40	33	47
22	37	39	32	46
23	35	37	30	44
24	32	34	27	41
25	30	33	26	40
26	28	32	25	39
27	26	31	24	38
28	24	29	22	36
29	22	27	20	34
30	19	25	18	32
31	17	23	16	30
32	15	22	15	29
33	13	20	13	27
34	11	18	11	25
35	9	17	10	24
36	7	15	8	22
37	5	14	7	21
38	3	12	5	19
39	1	10	3	17
40	1	9	2	16

*Raw scores are scored such that *higher* scores represent *greater* self-reported memory difficulty. (i.e. poorer self-reported memory);
**T-scores (mean = 50, SD = 10) were derived from reflected raw scores such that *higher* T-scores represent *better* self-reported memory performance; 95% CL: 95% Confidence Limits

Table 7.12: Percentiles data for long-form PRMQ scales

PRMQ Version and Scale		Percentiles						
		5	10	25	50	75	90	95
Full Form	T-scores Total	31.63	37.32	43.63	52.05	57.31	62.37	64.68
	T-scores PM	31.68	36.63	43.85	51.46	57.16	62.87	64.77
	T-scores RM	31.81	38.00	44.19	50.38	56.57	62.75	62.75

Weighted averages.

7.4.2.2 Reliability of the difference between PRMQ PM and PRMQ RM T-scores

As noted above, critical values for discrepancy scores were also computed and these are presented below in Table 7, Crawford and colleagues suggest that, in addition to standard normative data, it would also be useful to have a means of evaluating discrepancies between an individual's PM and RM scores. Based on the formula they propose, critical values for the Irish dataset are presented in Table 7.12.

Table 7.12a: Critical values for significant (i.e. reliable) differences between estimated true scores on the PM and RM scales for the Irish sample.

	Significance level			
	.15	.10	.05	.01
Two-tailed critical value	7	8	9	12
One-tailed critical value	5	6	8	11

Estimated true scores for the Prospective and Retrospective scales should be obtained from columns 3 of and 4 of Tables 7.9 and 7.10 respectively.

Table 7.13 presents the critical values for significant (i.e. reliable) differences between estimated true PM and RM scores in both the Irish and the UK normative samples.

A comparison of the critical values for determining reliable difference as obtained in the current study and in the normative study by Crawford and colleagues shows that they differ by a value of 1 at the 0.05 level of significance. This means that the use of the critical values in Crawford et al's (2003) paper in the Irish population would result in the underestimation of the reliability of the difference in an individual's scores if the difference was to the value of 9 points. This further underlines the need for Irish age appropriate normative data.

Table 7.13: Comparison of critical values for significant (i.e. reliable) differences between estimated true scores on the PM and RM scales in Irish and UK normative samples.

Irish sample					UK sample				
	Significance level				*level*		*Significance*		
	.15	.10	.05	.01		.15	.10	.05	.01
Two-tailed critical value	7	8	9	12	Two-tailed critical value	7	8	10	13
One-tailed critical value	5	6	8	11	One-tailed critical value	5	6	8	11

Estimated true scores for the Irish population aged 50 and above on the PM and RM scales should be obtained from Columns 3 of and 4 of Tables 7.2 and 7.3 respectively.

7.4.2.3 Abnormality of the difference between PM and RM scores

As with the PRMQ short-form, both the absolute difference scores (where direction is discounted) and the actual difference scores (preserving information on the direction of difference) between the long-form PM and RM T-scores were calculated using the **Irish Normative Data** for the overall Study 1 sample. Initial exploration of the data showed that for the **absolute difference scores**: mean = 5.20, SD = 4.16 median = 4, min difference =0, max difference = 23. For **actual difference scores:** the mean difference = -.10, SD = 6.67, median = .28 min = -20, max = 23. Figure 7.3 presents the frequency distribution of absolute differences between **long-form** PM and RM (T-scores), and Figure 7.4 presents the frequency distribution of differences (directional) between **short-form** PM and RM (T-scores) - using the same dataset. Table 7.5 presents the percentile equivalent of difference scores.
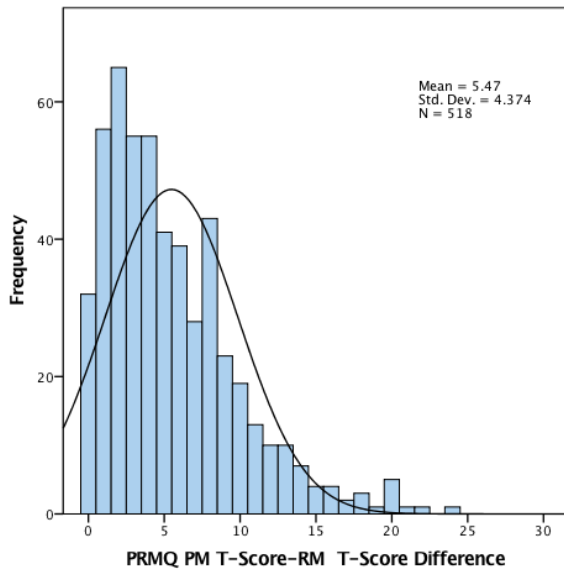
Figure 7.3: Distribution of **absolute** differences in PM/RM T-scores – long-form PRMQ
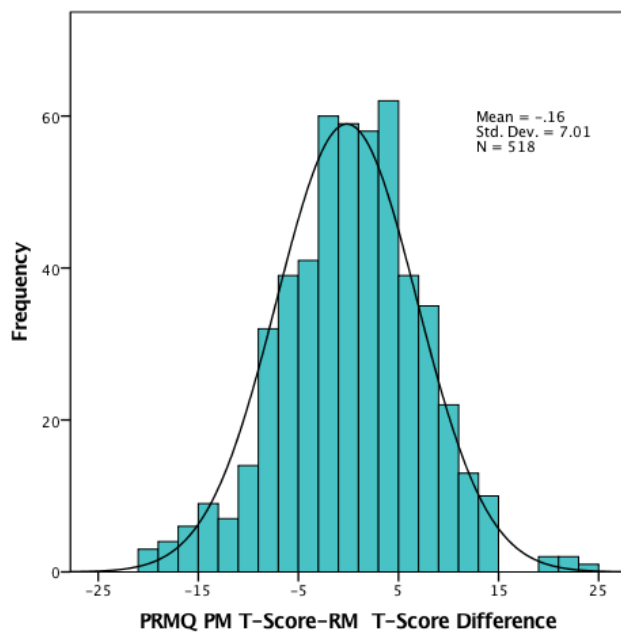
Figure 7.4: Distribution of **actual** differences in PM/RM T-scores – long-form PRMQ

Table 7.14: Absolute PRMQ PM T-Score -PRMQ RM T-Score Difference Irish Normative Data

	PRMQ PM T-Score – PRMQ RM T-Score Difference			
Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	32	6.0	6.2	6.2
1	56	10.5	10.8	17.0
2	65	12.2	12.5	29.5
3	55	10.3	10.6	40.2
4	55	10.3	10.6	50.8
5	41	7.7	7.9	58.7
6	39	7.3	7.5	66.2
7	28	5.3	5.4	71.6
8	43	8.1	8.3	79.9
9	23	4.3	4.4	84.4
10	19	3.6	3.7	88.0
11	13	2.4	2.5	90.5
12	10	1.9	1.9	92.5
13	10	1.9	1.9	94.4
14	7	1.3	1.4	95.8
15	4	0.8	0.8	96.5
16	4	0.8	0.8	97.3
17	2	0.4	0.4	97.7
18	3	0.6	0.6	98.3
19	1	0.2	0.2	98.5
20	5	0.9	1.0	99.4
21	1	0.2	0.2	99.6
22	1	0.2	0.2	99.8
24	1	0.2	0.2	100.0

Red line represents the point at which a larger difference would be expected in <5% of the population.

Table 7.15: PRMQ PM T-Score -PRMQ RM T-Score Difference Irish Normative Data (directional)

PRMQ PM T-Score – PRMQ RM T-Score Difference

Score	Frequency	Percent	Valid Percent	Cumulative Percent
-20	3	.6	.6	.6
-19	1	.2	.2	.8
-18	3	.6	.6	1.4
-17	2	.4	.4	1.7
-16	4	.8	.8	2.5
-15	4	.8	.8	3.3
-14	5	.9	1.0	4.2
-13	2	.4	.4	4.6
-12	5	.9	1.0	5.6
-11	5	.9	1.0	6.6
-10	9	1.7	1.7	8.3
-9	11	2.1	2.1	10.4
-8	21	3.9	4.1	14.5
-7	15	2.8	2.9	17.4
-6	24	4.5	4.6	22.0
-5	17	3.2	3.3	25.3
-4	24	4.5	4.6	29.9
-3	24	4.5	4.6	34.6
-2	36	6.8	6.9	41.5
-1	27	5.1	5.2	46.7
0	32	6.0	6.2	52.9
1	29	5.4	5.6	58.5
2	29	5.4	5.6	64.1
3	31	5.8	6.0	70.1
4	31	5.8	6.0	76.1
5	24	4.5	4.6	80.7
6	15	2.8	2.9	83.6
7	13	2.4	2.5	86.1
8	22	4.1	4.2	90.3
9	12	2.3	2.3	92.7
10	10	1.9	1.9	94.6
11	8	1.5	1.5	96.1
12	5	.9	1.0	97.1
13	8	1.5	1.5	98.6
14	2	.4	.4	99.0
20	2	.4	.4	99.4
21	1	.2	.2	99.6
22	1	.2	.2	99.8
24	1	.2	.2	100.0

Red line represents the point at which a larger difference would be expected in <5% of the population.

As before, inspection of the data shows the high frequency of large discrepancies, confirming the need to examine not just the statistical 'abnormality' but frequency of occurrence. likelihood within the general population. To assist in this task, frequency distribution tables, for both absolute and actual differences are presented below. From these, it is possible to determine how common a particular size discrepancy is in the general population.

7.4.3 Relating Short-form Normative data to objective test performance

In order to determine whether this short-form PRMQ might be a useful adjunct to brief assessment tools used in clinical practice, individual case profiling was undertaken to identify different patterns of performance on PRMQ and objective cognitive tests. In essence, this individual case profiling was designed to determine how many and which participants fell into each of the following categories (see Figure 7.5). Ultimately, the goal was to seek to determine whether it might be possible to contribute to our current understanding of discordance between subjective and objective test performance.

Objective Tests

	Not Impaired	**Impaired**
Subjective — Not Impaired	(A) Concordant – not impaired	(B) Discordant
Subjective — Impaired	(C) Discordant	(D) Concordant – impaired

Figure 7.5: Correspondence between self-reported memory and objective test performance.

In terms of absolute numbers, these 4 categories of responding are summarised in Table 7.16. As can be seen from this table, a total of 58 individuals obtained T-scores on the PRMQ that were considered to be above the cut-off for impairment (i.e. they were not impaired on self-report) and, at the same time, were not significantly impaired on any of the objective measures. Thus, 58 fell into **Category A: concordant: not impaired**. For the purpose of this calculation, all 3 scale scores were considered (PRMQ Total, PRMQ PM and PRMQ RM) as was the discrepancy between PM and RM. With just 1 exception, all of these 58 individuals were above the cut-off on all three PRMQ scales and did not display a significant discrepancy between PM and RM. The remaining participant fell below the cut-off on RM T-scores, and the difference between this score and the score obtained on PM was significant (p<.01).

Seven individuals reported poor memory with at least some reason to suspect cognitive difficulty **(Category D: concordant impaired).** Whilst none of the 7 fell below the cut-off on MMSE, all 7 obtained a below-perfect score on GPCOG (i.e. obtained a GPCOG score that warrants informant information: i.e. score range 7 – 8). Of note, 4 obtained scores of 3 or below on Mini-Cog and 1 was impaired on CAMPTOMPT.

Table 7.16: Subjective and objective concordance / discordance in the Irish sample

		Objective	
		Not Impaired	**Impaired**
Subjective	**Not Impaired**	(A) n = 58	(B) n = 6
	Impaired	(C) n = 10	(D) n = 7

Note: numbers do not add to 97 as a number of individuals (n = 16) did not fall readily into any of these categories.

Case summary data for those with discordant subjective and objective performance is presented in Table 7.17. Also presented are case summary data for those who did not report significant difficulty by self-report, did not present with difficulty on MMSE or Mini-Cog but who obtained a score of <9 on GPCOG.

As can be seen from these data, and from Table 7.16 above, six individuals did not report significant memory problems, but they were below the cut-off score on one or more of the objective cognitive tests **(Category B - discordant).** Of note, all 6 obtained low scores on Mini-Cog (with 5/6 obtaining a score of 0 on the CDT component of the test). The same 5 individuals obtained a score of <9 on GPCOG, suggesting that a collateral history is required. These data also suggest possible executive dysfunction – poor CDT - which might, at least in part, contribute to under-reporting of everyday memory problems.

Ten individuals reported poor memory – but there was no evidence of impairment on the objective tests administered **(Category C – discordant).** Of interest, all 10 performed at ceiling on GPCOG, were well above the cut-off on MMSE and Mini-Cog, and all obtained full marks on CDT. All 10 also performed within the Average or above average categories on CAMPROMPT. While these scores suggest that cognitive function is largely intact, as assessed by these tests, the significant association between self-reported memory problems and other variables such as anxiety, depression and multi-morbidity, suggest that the potential presence of these underlying reasons for self-reported memory problems should be explored and considered.
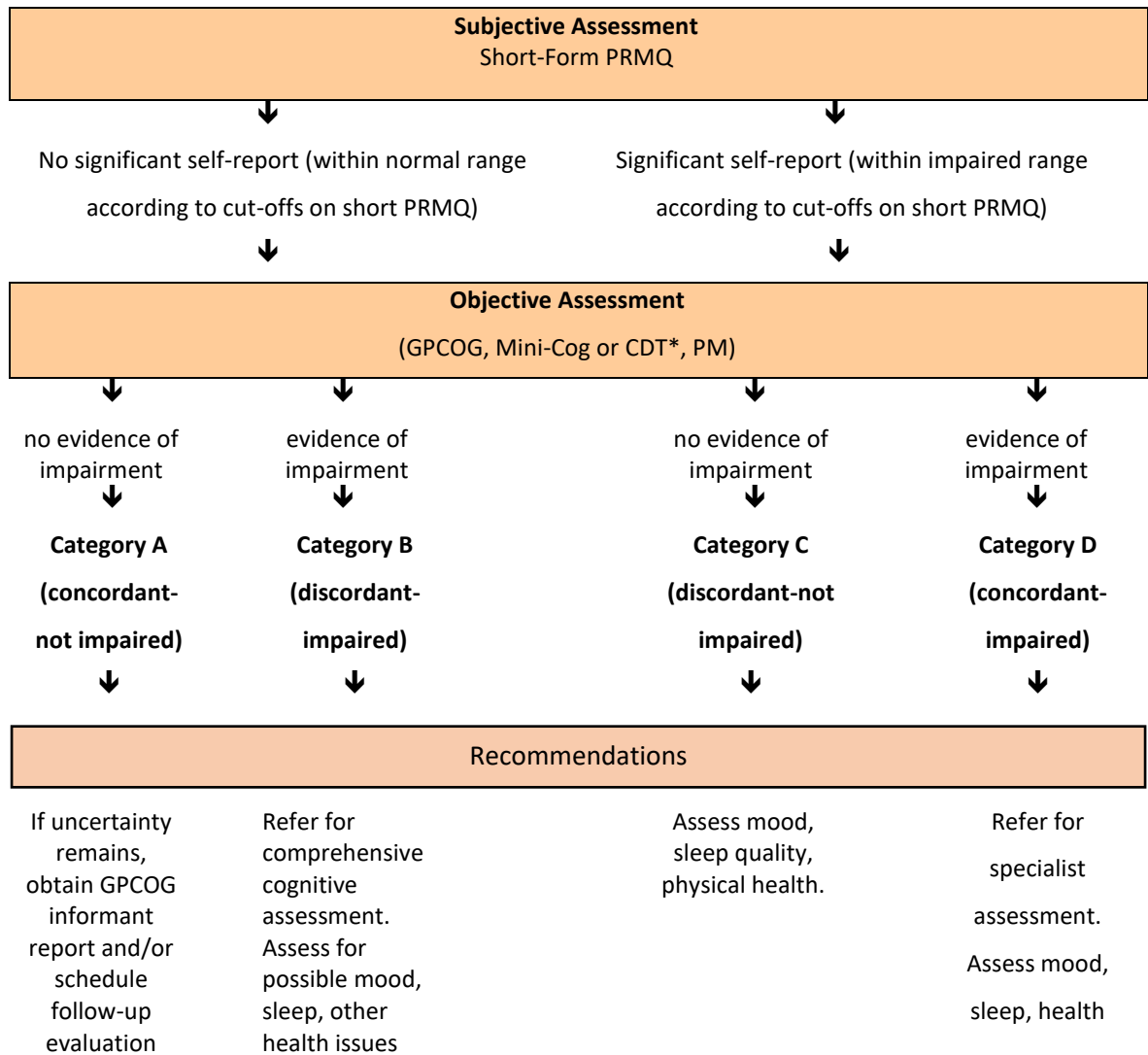
Table 7.17: Case summary data for those with discordant subjective and objective performance.

	Total	PM	RM	PM/RM Discrepancy	MMSE	Mini-Cog	Mini-cog CDT	GPCOG	CAMPROMPT	NART IQ	HADS-A	HADS - D
1	68	64	68	ns	30	2	0	8	Above average	115	2	1
2	65	64	64	ns	28	2	0	8	Average	106	4	0
3	63	60	64	ns	29	2	0	8	Poor	112	3	1
4	51	51	52	ns	29	2	2	9	Borderline	111	1	1
5	47	46	48	ns	28	1	0	7	Average	94	7	2
6	39	46	35	ns	29	2	0	7	Borderline	119	3	8
Total	**6**	**6**	**6**		**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
1	39	28	52	<.05	30	4	2	9	Average	108	7	2
2	35	33	40	<.05	30	5	2	9	Very good	108	10	3
3	42	33	52	<.05	27	5	2	9	Average	117	8	7
4	37	51	27	<.05	30	3	2	9	Average	118	3	2
5	35	46	27	<.05	29	4	2	9	Average	120	2	5
6	30	24	40	<.05	29	4	2	9	Above average	97	9	2
7	32	37	31	ns	30	5	2	9	Above average	110	8	4
8	21	28	19	<.05	30	5	2	9	Above average	118	8	6
9	30	33	31	ns	30	4	2	9	Average	111	12	5
10	23	24	27	ns	30	5	2	9	Average	118	5	2
Total	**10**	**10**	**10**		**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
1	63	64	60	ns	30	5	2	8	Above average	117	0	0
2	44	46	44	ns	30	5	2	8	Average	113	6	2
3	47	55	40	<.05	30	5	2	8	Average	114	7	1
4	63	60	64	ns	30	5	2	8	Average	118	2	3
5	58	55	60	ns	29	5	2	8	Very good	109	1	1
6	56	60	52	ns	29	4	2	7	Average	117	3	1
7	51	46	56	ns	29	5	2	8	Average	91	5	1
8	54	51	56	ns	27	5	2	8	Above average	107	3	2
9	54	60	48	ns	30	5	2	8	Above average	94	16	15
10	47	46	48	ns	30	5	2	8	Average	113	5	3
11	47	42	52	ns	28	5	2	8	Average	115	4	3
12	42	37	48	ns	30	3	2	8	Average	96	0	1
13	39	37	44	ns	28	4	2	7	Average	118	3	3
14	42	51	35	.01	25	3	0	6	Average	118	0	1
15	42	46	40	ns	29	5	2	8	Average	111	5	0
16	35	37	35	ns	28	5	2	8	Average	116	9	4
Total	**16**	**16**	**16**		**16**	**16**	**16**	**16**	**16**	**16**	**16**	**16**

The remaining 16 participants reported no obvious impairment in memory, performed above the cut-off for impairment on MMSE and Mini-Cog, but obtained a less than perfect score on GPCOG (scores of 6: n = 1; 7: n = 2; or 8: n = 13). Notably, all of these individuals performed well on MMSE, performed in the Average or Above Average range on the CAMPROMPT and all but 1 produced a full-marks copy of the clock on Mini-Cog. Thus, although the GPCOG score indicates that a collateral history is required, there is little to suggest objective cognitive impairments, at least as assessed here.

7.4.4 Proposed algorithm for case ascertainment

Subjective Assessment
Short-Form PRMQ

No significant self-report (within normal range according to cut-offs on short PRMQ)   Significant self-report (within impaired range according to cut-offs on short PRMQ)

Objective Assessment
(GPCOG, Mini-Cog or CDT*, PM)

no evidence of impairment	evidence of impairment	no evidence of impairment	evidence of impairment
Category A (concordant-not impaired)	**Category B (discordant-impaired)**	**Category C (discordant-not impaired)**	**Category D (concordant-impaired)**

Recommendations

If uncertainty remains, obtain GPCOG informant report and/or schedule follow-up evaluation	Refer for comprehensive cognitive assessment. Assess for possible mood, sleep, other health issues	Assess mood, sleep quality, physical health.	Refer for specialist assessment. Assess mood, sleep, health

* clock drawing scored according to Mini-Cog criteria; Category A: concordant - no subjective or objective impairment; Category B: discordant – objective but not subjective impairment; Category C: discordant – subjective but not objective impairment; Category D: concordant - subjective and objective impairment.

Figure 7.6: Algorithm for case ascertainment

Based on case summary data of the participants with concordant or discordant subjective and objective performance, an algorithm (see Figure 7.6) for the ascertainment of cases of subtle or mild cognitive impairment in Primary Care is proposed.

As can be seen in Figure 7. 6, this algorithm uses the short-form PRMQ as the self-report assessment of PM and RM ability, with accompanying normative data and cut-offs, and the GPCOG, Mini-Cog (or the CDT scoring

criteria from Mini-Cog) and a brief test of PM (e.g. a subtask from CAMPROMPT) as the objective assessment component of cognition. Importantly, it also facilitates the taking into account of other variables known to significantly associate to poor subjective and objective cognition, such as mood and poor physical health. Using the algorithm, participants can be categorised as falling into one of four categories based on their subjective and objective assessment scores.

The first of these categories, Category A: Concordant- Not Impaired, indicates that an individual did not self-report memory failures in the impaired range according to short-form PRMQ normative data and cut-offs and that their performance on the GPCOG, MiniCog and test of PM was within the normal range. If perfect scores on all of the cognitive tests are obtained, there is no immediate need for the GP or practitioner to follow-up with a similar evaluation in the near future. Unless specific concerns regarding mood and/or specific physical health ailments are the primary purpose of the consultation (or are explicitly expressed by the individual during the course of the consultation), no imperative to assess for mood state or physical health, or to review current medications, is indicated. Note, however, that even if performance on the Mini-Cog is normal and the PM subtask is performed correctly, a GPCOG score of 5-8 warrants a collateral history from an informant. Thus, while not presenting a clear case of cognitive impairment, some question regarding the potential presence of subtle cognitive dysfunction may remain. Any uncertainty, however slight, concerning the individual's cognitive status can be resolved by obtaining the GPCOG informant report and/or scheduling a follow-up subjective and objective evaluation in the future to determine if any further decline has occurred.

The second category B: Discordant – no subjective but objective impairment, denotes that an individual's self-reported memory ability was above the cut-offs for subjective impairment relative to the normative sample, but their performance on one or more of the cognitive tests is classifiable as impaired. Placement in this category suggests that the individual lacks accurate insight to their cognitive difficulties, and indicates the clear need for further, more comprehensive cognitive assessment. If the individual obtains a score on the GPCOG indicative of the need for a collateral history with the associated GPCOG informant report, the practitioner can obtain this. However, if such a collateral history is not readily available, abnormal performance on the clock drawing component of either/both the GPCOG or Mini-Cog can be interpreted as confirming the need for onward referral for further comprehensive cognitive assessment. As discussed in Chapters 4 and 5, the potential presence of depression, anxiety, poor physical health, and perhaps sleep problems, should also be briefly assessed for, due to the negative impact of these conditions on current cognitive function, as well as the risk they confer for the development of future cognitive impairment. Where any of these conditions are present and currently treated with medication, a review of the individual's medication regimen might be considered.

The third category C: Discordant-subjective but not objective impairment, comprises those individuals that self-reported subjective impairment according to cut-offs on the short-form PRMQ, yet perform within the normal

range on the cognitive tests. A perfect score on the GPCOG, correct performance of the PM subtask and a score in the non-impaired range of the Mini-Cog indicate the absence of ostensible cognitive impairment. However, as is the case for participants in Category B, since conditions such as anxiety, depression and difficulties sleeping are closely associated with self-reported memory problems, the presence of subjective memory impairment, regardless of cognitive tests scores, should trigger a brief assessment of self-reported anxiety and depression, as well as an exploration of sleep quality. Physical health and current medications might also be explored, since poor physical health often coexists with subjective memory complaints and certain medications can adversely affect cognition.

The fourth and final category, D: Concordant-Impaired, consists of those individuals classifiable as subjectively impaired on the short PRMQ and also objectively impaired one or more of the specified cognitive tests. These individuals appear to have accurate awareness of their cognitive difficulties. This outcome of the proposed brief subjective and objective evaluation should trigger further in-depth assessment or, more typically, onward referral for specialist comprehensive assessment of cognitive impairment. A brief self-report assessment of anxiety, depression and physical health conditions could also be ascertained, since this information will be crucial for the continued maintenance of the individual's subjective well-being and for the delay of additional cognitive decline.

Finally, for the cohort of individuals who report significant problems on the PRMQ, who produce a perfect CDT, but whose score on the GPCOG falls below 9 (albeit above the cut-off for impairment), there should be no cause for concern about cognitive function. A GPCOG informant report should, however, be obtained, in line with the test instructions. Depending on the conclusions drawn from this informant report, the practitioner may or may not decide to schedule a follow-up evaluation of cognition in the near future to assess if further decline in test scores has occurred. Mood state and other variables known to impact on subjective reports should also be explored.

7.5 Interim Summary and Discussion

This study generated normative data for older Irish adults for the short-form PRMQ constructed in Study 3, using the larger sample data from Study 1. The normative data, in the form of T-scores, can serve as the baseline distribution, against which an older Irish individual's scores on the short-form PRMQ can be compared. This will, it is contended, assist GPs and other primary care professionals in judging the likely relevance of an individual's complaints, especially important since the base rate of cognitive complaints is relatively high in the typical older adult population (Cooper et al., 2011; Jonker et al., 2000; Slavin et al, 2010) making it potentially difficult to differentiate atypical memory complaints from normal aging. To further assist the meaningful interpretation of scores, normative data tables for the conversion of raw scores to T-scores also contain cut-offs to represent scores that fall below the 5th percentile for the normative sample (i.e. > 1.64 standard deviations (SD) above the mean in the case of raw scores and > 1.64 SD below the mean in the case of T-scores). Alternative cut-off scores from sample descriptive statistics and percentile scores were also presented.

Crawford et al., (2003) suggested that the discrepancy between an individual's PM and RM ability might also be of clinical interest. Thus, following the Classical Test formulae presented in their paper, critical values for judging the reliability of an individuals' PM-RM discrepancy was also presented. In the absence of computer scoring software such as was provided for calculating the abnormality of discrepancies in a UK sample, frequency classification tables for assessing the abnormality of an individual's PM-RM discrepancy in relation to the frequency of abnormal discrepancies in the older Irish population are provided. These frequency tables are useful for highlighting the fact that reliable discrepancies in the older Irish population are quite common, therefore clinicians should not only consider the statistical abnormality of a discrepancy, but also its likelihood of occurrence in other Irish adults of similar age and background.

In recognition of the subtle differences in T-scores observed between the Irish sample and the UK sample in Study 1, this study also obtained Irish normative data, based on Study 1 sample data for the long-form PRMQ. Similar to the short-form PRMQ, cut-offs representing scores that fall below the 5th percentile for the normative sample, alternative cut-off scores from sample descriptive statistics and percentile scores were also presented. As for the short-form PRMQ, critical values for obtaining the reliability of a discrepancy in PM and RM subjective ability and frequency tables for assessing the relative abnormality of discrepancies were also provided.

Individual case profiling carried out to identify patterns of performance on the short-form PRMQ using these normative data and objective cognitive tests revealed that participants could be classified into one of four categories reflecting either concordance or discordance between their subjective and objective cognitive performance, and the presence or absence of impairment. Hence the short-form PRMQ was shown to be a potentially valuable and useful addition to a brief cognitive assessment.

Accordingly, an algorithm was proposed for case ascertainment of cognitive impairment in Primary Care, which comprises a subjective component consisting of the short-form PRMQ, and an objective component consisting of the GPCOG and a brief PM task (such as a subtask of the CAMPROMPT), as well as the Mini-Cog – or the CDT scoring component of Mini-Cog.

The MMSE, athough still in popular use in primary care settings, is not recommended for inclusion in the current assessment algorithm. A meta-analysis by Mitchell (2009), which assessed the accuracy of the MMSE in identifying dementia versus healthy people, the accuracy of MMSE in identifying MCI versus healthy people and the accuracy of MMSE in identifying dementia versus MCI, concluded that the MMSE offered only modest accuracy and was best used for ruling out a diagnosis of dementia in community and primary care, rather than for detecting MCI. Furthermore, the author recommended that, for all other uses, it should be combined with or replaced by other methods.

As a brief test of PM, a GP could include an adapted version of the event-based *objects* subtask of the CAMPROMPT. The original form of this subtask in the CAMPROMPT involves the tester hiding five objects in different locations around the testing room and requiring the examinee to remember to remind the tester at the end of the session that the tester must now retrieve those objects. The examinee must also tell the tester or GP what each of the objects are and the location in which they are hidden. In the administration of the CAMPROMPT, examinees are advised at the beginning of the session that they are free to use whatever strategies they like to aid them in remembering, including note taking. However, various researchers have pointed out that such use of external aids in PM tasks such as in this manner may help obscure the effects of ageing on PM ability (Kvavilashvili, 1992; McDaniel & Einstein, 1992) and potentially obscure the effects of impairment (e.g. Foley, 2007). Arguably, however, the difficulty of remembering the type and location of five objects necessitates the use of note-taking by most older individuals. It is proposed, therefore, in the interests of brevity and convenience and in the interests of maximising the potential to detect PM impairment, that an adapted version of this PM task be adopted. Specifically, as adapted from CAMPROMPT manual instructions, the GP might say to the examinee at the beginning of the brief cognitive assessment, "What I am going to do first, is to hide this object in a location in the room. When I tell you that the test is over, I would like you to remind me that I have hidden this object and tell me what it is and where it is hidden." If the examinee is not watching or paying attention, the GP should ask them to watch what the GP is doing. At the end of the brief cognitive assessment (which goes on to include administration of the Mini-Cog and GPCOG), the GP should tell the examinee that they have finished the tests, at which point the examinee should now remember to tell the GP about the object and its location. In the CAMPROMPT proper, each of the PM subtasks are given a score according to the pattern of responding and whether a prompt is needed, and these scores are summed to give

a raw total score on the CAMPROMPT. However, in the case of a sole PM subtask such as the *object* task, a dichotomous correct/incorrect score can be awarded.

The total time required for all of these tests is estimated to fall within the 10-15 minutes duration of a typical Primary Care consultation. However, if time is an issue, we recommend that at least the short-form PRMQ, GPCOG and PM task are administered. This is because the GPCOG contains a clock drawing component (similar to the MiniCog, although scored differently), items measuring recall ability (also measured by the Mini-Cog) but additionally an item assessing the report of a recent event and an item assessing time orientation. Moreover, a helpful feature of the GPCOG is the explicit instruction that a score within the range of 5-8 indicates to the Primary Care professional that a collateral history via the accompanying GPCOG informant report is required. Based on the results of the case profiling exercise in the current study, and in line with current best practice principles (e.g., DSM-5 American Psychiatric Association, 2013; Foley & Swanwick, 2014, 2019; Cordell et al., 2013), the proposed algorithm provides guidelines for GPs and other Primary Care professionals regarding care and referral decisions of individuals based on the outcome of their brief cognitive assessment.

As outlined in Chapter 2, the Alzheimer's Association Medicare Annual Wellness Visit Algorithm for Assessment of Cognition (Cordell et al., 2013) provided guidance on the objective cognitive tests that might be used with the patient as part of the decision-making process, and the GPCOG, Mini-Cog and MIS were recommended as frontline tools. However, other key components of the algorithm are a review of the patient Health Risk Assessment (HRA) information, patient observation, unstructured questioning during the Annual Wellness Visit, and, where deemed necessary, informant information about cognitive function. Their algorithm adopts a stepwise, iterative approach, beginning with a review of the HRA (especially a report of functional deficits). This information is expected to be combined with clinician observations, information regarding self-reported concerns, queries of the patient, and – if available – an informant. If it emerges from this initial step in the assessment that signs or symptoms of cognitive impairment are present, then the algorithm proposes that the practitioner conducts a brief structured assessment using the GPCOG, Mini-Cog or MIS.

The potential exists however, as the wider help-seeking literature conveys (Hurt et al., 2011) and as our case summary data from Study 4 shows, that not all individuals will self-report memory failures, either voluntarily, or when asked explicitly about the state of their memory, even if objective cognitive impairment is present. This may be because they lack insight into their condition, perhaps reflecting their position at the more advanced end of the pre-dementia continuum as proposed by Jessen and colleagues (2014a, 2014b). Alternatively, the use of a single global question about the general state of an older individual's memory may not elicit as accurate a self-appraisal of memory as a multi-item measure assessing more specific aspects of everyday memory (Stone & Schiffman, 1994).

Regardless of cause, an advantage of briefly assessing both subjective and objective cognition together in combination is that any such discordance between subjective and objective cognitive status can be clearly highlighted. This discordance can provide the practitioner with useful information about an individual's metamemory or insight, for at least where unfounded worry about memory is present, the practitioner can then attempt to assuage this, and if the individual lacks awareness of deficits, the practitioner may sensitively counsel them regarding strategies for maintaining personal safety. Although our sample was not recruited purposively from a Primary Care setting, the sample can generally be considered representative of older Irish adults who attend Primary Care. The case profiling outcomes of the current study indicate that a brief objective assessment of cognition in Primary Care will sometimes uncover cognitive impairment that has gone undetected because the individual has not self-reported problems. The question then is, how should a practitioner know to assess for cognitive impairment at all if the individual does not self-present with memory complaints, no informant is forthcoming, and if, when deliberately asked about their satisfaction or otherwise with the state of their memory, the individual still does not report difficulty?

Purposive screening for mild cognitive impairment is not currently recommended in Primary Care, due to the potential negative psychological impact of false positives, coupled with the apparent lack of disease altering treatments (Rabin et al., 2017). However, there is ample argument for the adoption of a case-finding approach to subtle cognitive impairment. Available information regarding specific variables and conditions associated with both subjective memory complaints and objective cognitive dysfunction can alert a GP or other primary care practitioner to the possible co-morbid presence of subjective or objective cognitive difficulty. At the early stage of cognitive impairment, targeted interventions addressing associated conditions or variables can have important preventive effects for further cognitive deterioration (Rabin et al., 2017). Study 2 findings revealed that those who reported difficulty falling asleep obtained significantly lower GPCOG scores than those who did not report difficulty falling asleep. It is acknowledged that further research is needed to explore the additional predictive value of including sleep problems as a marker of future dementia (Leng & Yafffe, 2018). In this study, 1 out of the 6 participants displaying objective cognitive impairment who self-reported little everyday memory difficulty also reported difficulty falling asleep, and 4 out of 10 of those who reported impaired subjective memory but who displayed normal objective performance also reported difficulty falling asleep. Despite inconclusiveness regarding the risk conferred for future dementia, such sleep problems may exacerbate existing cognitive difficulties, for example through interfering with the consolidation of memory (Stickgold, 2005) and this information is of value in the continued care of the individual.

As considered in the Medicare Annual Wellness Visit Assessment of Cognition algorithm, clinician observation is an important initial component of the decision to assess, alongside self- and informant reports. One could argue that, where self-and informant reports are not forthcoming, the onus on clinician observation is further

emphasised. It is suggested on the basis of the current thesis findings, and with reference to the literature regarding the covariates of cognitive impairment, that signs of possible anxiety, depression, sleep problems, and/or the known presence of multimorbidity should signal Irish Primary Care practitioners to conduct the brief cognitive assessment proposed in the current study.

Brief cognitive assessment of individuals with suspected or confirmed anxiety, depression, sleep issues or multiple chronic health conditions would help avoid any oversight of individuals with diminished insight, individuals who have simply forgotten their memory failures, or who fail to relate a general question about the overall state of their memory to personal specific everyday experiences of forgetting. Cognitive assessment results can form a baseline, to which the clinician can compare a later cognitive re-evaluation. Successful treatment of the coexisting depression, anxiety, physical health or sleep issues in the interim may have improved subjective/objective cognition, in which case no further cognitive evaluation should be required. Alternatively, if cognition has remained poor, or indeed, worsened despite successful treatment of the coexisting conditions, this would indicate the need for onward referral for specialist cognitive assessment.

Underlining this argument, amongst a number of covariates demonstrated in the literature, anxiety (Steinberg et al., 2013; Balash et al., 2013; Eyesenck et al., 2007), depression (Montejo et al., 2011; Martinez-Aran et al., 2004) and poor physical health (Montejo et al., 2011; Aarts et al., 2011) have been shown to be significantly associated with both subjective and objective cognitive function.

In conclusion, the algorithm proposed on the basis of the current thesis findings and wider literature comprises a biopsychosocial approach to brief cognitive assessment (such as espoused by Rabin et al., 2017), incorporating, where appropriate, recommendations for the self-assessment of depression, anxiety, and, where applicable, poor physical health and sleep. Awareness of the presence of these oft-associated conditions can orient the clinician to the potential presence of subjective or objective cognitive impairment, even if no self- or informant reports of subjective impairment are forth-coming, and this should trigger a brief cognitive assessment. Successful treatment of associated conditions may confer positive benefits to the individual's current and future cognitive health. Importantly, the proposed algorithm provides explicit guidance regarding the inclusion of an assessment of self-reported memory – a similar recommendation regarding a subjective component of memory assessment was not included in the most recent ICGP guidelines to dementia detection and diagnosis in primary Care (Foley & Swanwick, 2014).

By recommending the use of a specific, brief and reliable self-report measure (the short-form PRMQ), the current proposed algorithm further assists Primary Care practitioners faced with a vast array of subjective assessment approaches to choose from. The short-form PRMQ also has the valuable advantage of providing clinicians with normative data and cut-offs for judging the level of subjective impairment implied by self-reports. Potential discordance between subjective and objective memory and cognition, as shown by this

algorithm, can itself provide useful information regarding older individuals' insight and metamemory to Primary Care clinicians with a proviso to maintain and promote overall wellbeing. Importantly, this algorithm also addresses the heretofore neglect of formal clinical assessment of both subjective and objective PM – demonstrated to be a sensitive marker of cognitive decline (e.g. Blanco-Campal et al., 2009) by including as its subjective assessment measure the short-form PRMQ and a brief PM subtask from the CAMPROMPT as a component of the objective assessment.

Chapter 8: General Discussion and Moving beyond the Current Studies

This chapter presents a general overview and discussion of the PhD. The findings from Studies 1, 2, 3, and 4 are summarised and a critical interpretation of the implication of these findings is provided. Strengths and limitations of the research project are discussed and future directions for research are suggested.

8.1 PhD Rationale and Objectives

There is a consensus regarding the need to detect and diagnose cognitive decline at a much earlier stage than is currently happening. There is also consensus that Primary Care is the setting in which this should take place. The recognition that earlier detection and diagnosis is important is because it is recognised that even subtle forms of cognitive decline can have far reaching consequences beyond daily forgetfulness, and can negatively impact safety (Woods et al., 2008), quality of life (Fortin et al., 2002) and the ability to live independently (Cockburn & Smith, 1988).

As outlined in Chapter 2, there are limitations to the currently used approaches to the assessment of cognitive impairment in Primary Care, and many currently recommended cognitive screening tools do not appear to be sensitive enough to detect early cognitive decline. Moreover, despite the demonstrated sensitivity of prospective memory to cognitive decline (e.g., Delprado et al., 2012; Blanco-Campal et al., 2009; Duchek, Balota & Cortese, 2006) tests of prospective memory are rarely included in a formal assessment of cognition. Despite a mass of longitudinal evidence supporting the predictive validity of self-reported memory failures for the prediction of future cognitive impairment and dementia, even when baseline performance on cognitive tests is normal (e.g. Wang et al., 2004; Dufouil et al., 2005), recent guidelines for the detection and diagnosis of dementia and cognitive impairment in Primary Care from the Irish College of General Practitioners (ICGP) (Foley & Swanwick, 2014), did not include a recommendation for a self-report measure of memory.

Sociodemographic variables and other variables such as mood, health, and sleep are also imperative to take into account when looking at the potential relationship between self-reported cognitive difficulties and objective performance. More extensive knowledge of factors and conditions associated with cognitive and memory complaints may assist Primary Care professionals in the identification of individuals potentially at risk of cognitive impairment and enable them to provide better-tailored person-centred interventions to build cognitive resilience.

This thesis, therefore, set out to address the issues outlined above in four inter-related studies, with specific objectives.

Study 1 aimed to profile the nature and type of memory complaints, as assessed by the PRMQ, in a sample of healthy older Irish adults. In so doing, it aimed to establish the reliability and suitability of the PRMQ for use

with older Irish adults. It also investigated the association between these failures and demographic, mood, alcohol, health and sleep variables.

Study 2 aimed to determine the relationship between subjective prospective and retrospective memory failures and performance on standard objective cognitive tests deemed suitable for use in Primary Care, (the MMSE, Mini-Cog, GPCOG) and also, importantly, included a standardised objective test of prospective memory. As per Study 1, demographic, mood, health and sleep variables with potential associations to memory and cognition were taken into statistical account to further clarify the complex relationships between subjective and objective cognition.

Study 3 involved the construction of a short-form PRMQ, for even briefer administration within Primary Care, on the basis of a Classical Test Theory item analysis of the full-form PRMQ using Study 2 sample data.

Study 4 provided Irish normative data for both the short-form and long-form PRMQ, with associated cut-offs for indicating subjective memory impairment relative to other older Irish adults. To assist with the evaluation of the reliability and abnormality of PRMQ, T-scores, critical values and frequency tables of abnormal discrepancies were also provided. This study also investigated the utility of the short-form PRMQ as an adjunct to brief cognitive assessment through case profiling of the patterns of performance on the short PRMQ and cognitive tests using sample 2 data.

8.2 Summary of Key Findings

Overall, this PhD project achieved its overarching aim of investigating and clarifying the relationship between subjective and objective cognition and memory in an Irish primary care context. This involved drawing together the interlinked objectives and findings of the four studies in the PhD research project. A summary of key findings from each of the four studies is now presented. These findings are interpreted critically with reference to the relevant literature, followed by a discussion of implications for the assessment of cognitive problems in Primary Care.

In Study 1, self-reported memory failures, as assessed by the PRMQ, were found to be common in this sample of older Irish community-dwelling adults. The range of responses to each of the PRMQ items indicated the wide variability in experienced forgetfulness. This variability suggests that reporting of a memory failure, in and of itself, may well reflect "normal" variation in memory performance rather than a clinical problem. This finding is valuable for clinicians to be aware of, since it signals the value of seeking additional information about an older individual's cognitive state when they present with memory complaints. As will be further discussed later, it also highlights the value of accompanying normative data for self-reported memory failures, against which the frequency of complaints can be benchmarked.

While difficulty was reported with both PM and RM items, overall, PM items were identified as more difficult (as reflected by higher rates of reported frequency of occurrence) than RM items. This appears to support the argument that when people complain about their memory, they are usually complaining about their PM, as opposed to RM (Mantyla, 2003; Smith et al., 2000). Considering the relevance of PM ability to safety (Woods et al., 2008), everyday functioning and the ability to live independently (Rabin et al., 2014), as well as the link between PM and executive function processes (Burgess & Shallice, 1997; McDaniel et al., 1999; Kesner, 1989; Burgess et al., 2003), it is imperative that more attention is paid within the Primary Care consultation to the structured assessment of self-reported failures of both PM and RM, through the use of a reliable questionnaire such as the PRMQ.

It has generally been believed that PM tasks present more difficulty than RM tasks largely because of the effortful processing involved in the successful execution of such tasks (Einstein & McDaniel, 1996). The findings from Study 1 call for a more nuanced understanding of PM. When items were ranked in terms of greatest difficulty (most frequently occurring memory lapse - i.e. occurring "very often" or "often"), the RM item How often *"Do you mislay something you have just put down, like a magazine or glasses? "*was found to have a high rate of frequency of occurrence. Close to 20% of respondents reported that this occurred 'often' or 'very often'. The frequency of this memory failure is broadly in line with findings from another survey study of community dwelling older adults above the age of 64 years in Madrid. In that study, almost 25% of the sample reported that they frequently forget where they put things (Montejo et al., 2011).

Regardless of whether an item pertained to PM or RM ability, Study 1 found that, in general, the greatest difficulty with remembering was reported to occur for those items that were self-cued and that appear to require self-initiated recollection, whilst examination of those items that participants reported the least difficulty with suggests that the particular memory tasks they describe are possibly more likely to be facilitated by a cue or environmental event.

These findings corroborate the literature (e.g. Smith, 2000; Craik, 1986) that has demonstrated that the greatest difficulty in remembering occurs for RM and PM items that require self-generated recollection, in contrast to remembering that is facilitated by a cue or environmental event. Smith et al., (2000) found PM errors were rated significantly more frequent than RM errors in healthy older and younger controls, and self-cued errors were rated as significantly more frequent than environmentally-cued errors. As noted in Chapter 2, in Craik's hierarchy of memory tasks, designed to be of use when understanding the different effects of normal aging across studies of PM and RM, PM tasks were placed at the top as they are typically low in environmental support and require a high degree of self-initiated activity. Below the PM tasks in the hierarchy come RM tasks of free recall, cued recall, recognition, and priming, in descending order of age-related deficits.

However, in contradiction to the assumption of Craik's hierarchy of difficulty that PM tasks are inherently more difficult because they rely on self-initiated processes to a greater extent than RM, the table of frequencies of item endorsements in the current sample showed that subjective RM tasks that are self-cued, i.e. that require self-initiated processing in the form of free recall with low environmental support, may be equally or sometimes more demanding than PM tasks. This is likely also because it is not always the case that all PM tasks are low in environmental support and high in self-initiated activity. Study 1 results revealed that subjective event-based PM failures generally occurred as frequently as time-based PM failures in older people. This finding lends support to arguments in the PM literature that a range of contextual factors such as cue focality, salience and discrepancy, attentional allocation, motivation etc., (e.g. Lee & McDaniel, 2013) may vary between event-based PM tasks, thus influencing the level of task difficulty. Indeed, Scullin, McDaniel and Shelton (2013) outline in the Dynamic Multi-process Framework of PM how monitoring and spontaneous retrieval are dynamically interconnected processes and that this is highlighted by the contextual variability of such PM tasks. The framework describes how individuals engage in monitoring when PM cues are expected, disengage when cues are not expected, and when monitoring is disengaged, a probabilistic spontaneous retrieval mechanism can support PM.

The variability in the frequency with which PRMQ items were endorsed by healthy older adults attests to the difficulty faced by GPs and other primary care practitioners when judging the potential seriousness of an individual's memory complaints. For this reason, appropriate normative data provides a useful benchmark against which an individual's self-reported memory failures can be compared. For normative data to be reliable, they should be derived from a sample as similar as possible in demographic characteristics to the population of interest. Normative data based on a UK sample of wider age range was previously established by Crawford and colleagues (2003), in the form of T-scores with a mean of 50 and a standard deviation of 10. Comparison of Study 1 sample T-scores and the published T-scores obtained by Crawford and colleagues showed subtle differences between the two samples, with the Irish sample reporting less overall difficulty with their memory. These differences are not unique to Ireland, since a previous study involving the PRMQ in a Swedish sample reported better subjective memory in the older Swedish sample compared to the UK sample (Ronnlund et al., 2008). Indeed, a study outlining cross-national comparisons of longitudinal ageing studies showed that Irish people reported better self-perceived cognitive and physical health than their English and American counterparts and the authors concluded that various bio-psychosocial factors were likely to be responsible (Savva, Maty & Feeney, 2013).

The differences in T-scores between the UK normative data and the data obtained from the Irish sample were quite small, and, for the purpose of Study 2, where self-reported and objective test performance was to be compared, the original normative data as obtained by Crawford and colleagues were judged reliable and

appropriate for use with the older Irish population. By using these published data, direct comparisons of the findings from this study with other studies in the literature was also possible.

The CFA showed that the previously established tripartite structure of the PRMQ (Crawford et al., 2003; Ronnlund et al., 2008; Piauilino et al., 2010), consisting of a general memory factor on which orthogonal PM and RM factors load – was supported in an older Irish sample. These CFA findings also point to the usefulness of all three scales of the PRMQ; the PRMQ Total Scale, PM subscale and RM subscale for the assessment of memory failures and their relationships to cognitive test scores and other variables.

Study 1 also investigated the potential associations of a wide range of demographic variables (gender, age, education, occupation, marital status), physical health, alcohol and sleep variables with self-reported memory problems. By means of logistic regression, it also investigated the relative contribution of these variables, alone and in combination, to levels of self-reported forgetfulness. Identification of significant associations between some of these variables and subjective memory failures can be considered a worthwhile endeavour from a case-finding perspective. Rabin et al., (2017) argue that a comprehensive biopsychosocial approach to characterising individuals is needed to understand the contribute unique and shared variance to self-reported memory and cognitive decline and go on to say,

> Such approach could illuminate unique profiles or subtypes of [subjective cognitive decline] that are associated with the highest risk for incipient Alzheimer's disease, as well as identify individuals that may respond to different interventions (e.g. for depression, or chronic pain).

It is important to note here that Rabin et al discuss the identification of individuals who may be at increased risk of development of dementia of the Alzheimer's type, but many other types of dementia exist, with aetiologies presumed to be different or overlapping. It is possible that different associations of variables to different types of self-reported cognitive difficulties may indicate the incipient presence of alternative underlying pathologies, where such pathology exists. Of course, the association between certain variables and self-reported memory problems can, importantly, also point to reversible causes of an individual's self-perceived poor memory, which is discussed later in this chapter.

The univariate analyses revealed that depression and anxiety were significantly positively related to increased self-reported PM and RM failures, such that higher levels of self-reported depression and anxiety were correlated with a higher frequency of self-reported memory failures. This result mirrors the majority of studies in the literature investigating the relationship between mood and subjective memory, using a variety of different self-report measures of memory and mood. For example, a study of community dwelling older adults by Steinberg and colleagues (2013), also using the PRMQ, found that levels of self-reported depression and

anxiety, as measured by the GDS and DASS subscales, increased significantly in line with increasing self-reported PRMQ failures. TILDA data also revealed a significant positive relationship between self-reported depression as assessed by the CES-D and self-rated memory using a single global memory question (Barret et al., 2011).

The significant associations found between self-reported memory and multimorbidity and the specific sleep problems of difficulty falling asleep and waking during the night were no longer significant after depression and anxiety were controlled for in the context of retrospective memory and after depression and a significant interaction between multimorbidity and anxiety were controlled for in the context of prospective memory. However, waking earlier than intended continued to have a significant effect on self-reported prospective memory after depression and anxiety were controlled for. Waking earlier also continued to exert a significant effect on retrospective memory after anxiety was controlled for – although the assumption of homogeneity of variances was violated and so this statistical result should be interpreted with a degree of caution. By contrast, the effect of waking earlier than intended on retrospective memory was no longer significant after taking depression into statistical account. Of note, also, was the fact that the significant association between daytime napping and self-reported memory remained even after statistically controlling for the effect of self-reported mood. Although consuming alcohol also remained significantly associated with better subjective memory, after mood was controlled for, this relationship is likely to have been mediated by other factors not assessed in this study.

When the relative importance of the covariates identified as significant in the univariate analyses were investigated in a multiple linear regression, depression and anxiety emerged as the most significant predictors of poorer self-reported memory; depression explained almost 7% of the variance in total PRMQ scores, while anxiety explained almost an additional 2% of the variance. Daytime napping was also a significant predictor of memory failures, although marginally so, since it accounted for only a small percentage of the variance (almost 1%) in memory ability after the influence of depression and anxiety were accounted for. Consuming alcohol was significantly predictive of lower frequency of memory failures, but the additional variance accounted for by this variable was very small (~1%).

These findings pertaining to the significant associations, and relative statistical contribution, of depression, anxiety and daytime napping to poorer subjective memory and cognition in non-cognitively impaired, older community-dwelling adults are valuable for Primary Care professionals interested in adopting a case finding approach to subtle cognitive impairment. This is because each of these variables, depression, anxiety and daytime napping, are interesting as covariates sign-posting the concurrent presence of subjective cognitive complaints, but also as potential predictors of current and future cognitive impairment and possible dementia.

Taking depression as the first variable of interest, the presentation of depression in older adults can include symptoms of perceived or actual cognitive impairment (Steffans & Potter, 2008). According to the cognitive

model of depression (Peckham, McHugh & Otto, 2010), individuals with depression often display an attentional bias towards negative information that may at least partly explain higher levels of reported dissatisfaction with one's memory and cognition. Therefore, addressing underlying symptoms of depression in older individuals by pharmacological or psychotherapeutic means may result in an improvement in self-perceived memory and a reduction in memory complaints (Smart et al., 2017). However, other studies have indicated that the onset of late-life depression may be a prodrome of dementia (Kohler & Thomas, 2018) and longitudinal evidence has also established depression as a risk factor for the later development of cognitive impairment and dementia, perhaps through vascular mechanisms (Krishnan et al., 1997; Alexopoulos et al., 1997), and/or increasing pro-inflammatory cytokines (Howren, Lamkin & Suls, 2009; Dinan, 2009) and other means (Kohler & Thomas, 2018). The timely assessment and detection of depression in Primary Care, therefore, is imperative from the standpoint of improving current quality of life, as well as potential prevention of further cognitive deterioration.

Similarly, anxiety has a long history of association with subjective memory complaints, leading to the widespread use in earlier literature of the term, the "worried well" (Smart et al., 2017). However, longitudinal studies have sufficiently demonstrated the predictive value of memory complaints in the development of cognitive impairment and dementia regardless of comorbid anxiety, so the presence of anxiety should never be considered as reason for disregarding the validity of an individual's memory complaints. Even though the link between anxiety and dementia is, as yet, somewhat debated, an increasing amount of longitudinal evidence is amassing to attest to the predictive validity of clinical anxiety in the development of cognitive impairment (Gatz et al., 2005) probably through disruption of the hypothalamic-pituitary-adrenal axis which is implicated in the regulation of stress in the body (Kohler & Thomas, 2018). The timely detection and appropriate treatment of anxiety should improve current subjective well-being but may also have an important preventive effect regarding future cognitive impairment.

To provide a sense of perspective on the levels of depression and anxiety in the Study 1 sample, sample means for anxiety and depression were within the ranges found by Spinhoven et al. (1997) for three large samples of the general adult population in the Netherlands. Inspection of the data in this Irish study, in light of the literature, shows that the Irish sample cannot be considered either significantly anxious or significantly depressed. Moreover, the higher self-reported levels of anxiety amongst older adults in our sample relative to depression is not surprising since a number of studies have reported that anxiety among older adults is more common than late-life depression (Regier, Rae, Narrow, Kaelber & Schatzberg, 1998; Singleton, Bumpstead, O'Brien, Lee & Meltzer, 2003).

Data from the TILDA study reveals that, at present, depression and anxiety in the older Irish population is largely under-diagnosed, and both clinical and sub-threshold levels of depression and anxiety are common in the Irish general population aged 50 years and above (Barret et al., 2011). This further underlines the need for Primary

Care practitioners in Ireland to place greater urgency on the assessment of depression and anxiety. The findings of this thesis also suggest that the presence of significant subjective memory complaints in older individuals, regardless of objective cognitive function, should trigger an assessment for co-existing mood disorder or at least elevated levels of depression and/or anxiety. Detection and appropriate treatment of mood issues can, in many cases, ameliorate current memory complaints and can also help reduce the risk for future cognitive impairment and dementia.

While a growing literature details a significant association between sleep issues and subjective cognitive impairment and continues to evidence sleep problems as a significant predictor of future cognitive impairment and dementia (Leng & Yaffe, 2018), further research is required to reach firm conclusions about the significance of daytime napping to subjective and objective cognitive impairment. Nevertheless, excessive day-time napping is common in people with dementia (Deschenes & McCurry, 2009), believed to be caused partially be degeneration of key brain areas, such as the suprachiasmatic nucleus (SCN), critical in the homeostatic maintenance of circadian rhythms (Swaab, Fliers & Partiman, 1985). Furthermore, a number of prospective studies now show self-reported napping to be an independent predictor of future dementia risk (Tsapanou et al., 2015; Foley et al., 2001; Jaussent et al., 2012; Elwood et al., 2011). For example, results from the Honolulu Asia Aging Study illustrated that older Japanese-American men who reported excessive daytime sleepiness at baseline were twice as likely to be diagnosed with incident dementia after three years (Foley et al., 2001). However, Leng and Yafffe (2018) point out that no study has yet used objective measures of napping to determine the risk conferred for the development of future dementia.

Of note, although day-time napping may be a symptom of other health problems in the elderly (Leng & Yaffe, 2018), napping in this sample was independent of poor physical health, mood state and other reported sleep difficulties, indicating that napping in this sample is not an apparent consequence of reduced sleep quantity or poor sleep quality, poor reported physical health or mood state. Directionality of relationship between napping and self-reported memory failures cannot be determined in the current cross-sectional study, and one can only speculate as to the possibility that daytime napping and poorer subjective memory are both symptoms of an underlying pathological process (for example of a hypothesis involving a bi-directional relationship between sleep problems and amyloid beta accumulation, see Ju et al., 2014). Sleep disturbances, more generally, are increasingly recognised as a risk factor for Alzheimer's dementia (Leng & Yaffe, 2018). Proposed mechanisms include, as mentioned, the bi-directional relationship with accumulation of the AD-related protein, Amyloid-beta (Ju et al., 2014; Brown, Rainey-Smith, Bucks, Weinborn & Martins, 2016), and interference with memory consolidation and normal brain function for which sleep is essential (Diekelmann & Born, 2010; Stickgold, 2005). Furthermore, inefficient sleep is thought to interfere with neuronal transmission and impair synaptic plasticity (Havekes, Vescey & Abel, 2012), and to lead to neuronal inflammation and disrupted neurogenesis in

hippocampal regions so integral to memory (Zhu et al., 2012). When an older individual presents with memory complaints, therefore, Primary Care practitioners might be advised to enquire about sleep in general, and about whether the individual also takes naps during the day. Implementation of a simple sleep hygiene intervention in which daytime napping is refrained from, may potentially improve self-perceived memory. If no improvement is observed, consideration of the predictive significance of self-reported napping for future cognitive impairment demonstrated by a growing number of studies might indicate a recommendation of regular repeated clinical follow-up of this individual's subjective and objective memory and cognition.

As mentioned, a number of other covariates that displayed an association with self-reported memory failures were no longer significant after their relationship with self-reported depression and anxiety was taken into account. For example, lower education was associated with poorer RM compared to individuals who reported higher education, but this association was no longer significant after self-reported depression was taken into account. Although subjective sleep problems have been operationalised in various ways in the literature, significant correlations of the sleep problems such as difficulty falling asleep and disturbed sleep throughout the night to mood is similar to findings from other studies in the literature (Rodin et al., 1988; Spira, Friedman, Aulakh, Lee, Sheikh, & Yesavage, 2008).

Although inadequate or poor-quality sleep is believed to influence memory directly by interfering with memory consolidation (Stickgold, 2005), the relationship between difficulty falling asleep, waking during the night and waking earlier than expected and PRMQ scores did not retain significance in this sample after accounting for the relationship between sleep problems and mood. This suggests that sleep problems in this sample may well be arising as a symptom of mild-moderate levels of anxiety and depression that can still be considered subclinical according to traditional HADS cut-offs and thus are exerting their effects more indirectly through mood. Having two or more chronic physical health condition (multimorbidity) was also significantly positively correlated with depression and anxiety in Study 1, similar to other studies (Gunn et al., 2010; Pedro et al., 2016; Aarts et al., 2011) but multimorbidity was no longer associated with self-reported memory after self-reported depression and anxiety was taken into account. It is possible in this case that higher levels of depression and anxiety experienced by individuals living with multiple chronic health conditions also leads these individuals to perceive their memory ability more negatively due to the negative attention bias previously described (Peckham et al., 2010). However, the wider literature shows that memory complaints may reflect genuine objective difficulties caused, or exacerbated, by certain physical conditions. For example, chronic pain has been shown to interfere with cognitive function (Hart, Martelli & Zasler, 2000). Furthermore, while medications were not assessed in the current study, it is incumbent on clinicians to bear in mind that older adults with multimorbidity may also experience increased forgetfulness as a side effect of medications to treat their

physical conditions, and so subjective reports of memory problems in older adults with poor physical health should trigger an assessment of both the individual's mood state and general medication regimen.

In summary, Study 1 provided previously lacking information regarding the frequency of PM and RM failures in older Irish adults and illustrated that reported memory failures are common and may not indicate a serious memory disorder. To this end, an important advantage of the PRMQ is that it is accompanied by published normative data to provide a benchmark against which an individual's scores can be compared, and critical values for judging the reliability and abnormality of individual discrepancies in PM and RM ability are also available for the interested clinician. The reliability of the PRMQ for use in the older Irish population was supported by CFA results that confirmed the tripartite factor structure established by previous studies. Depression, anxiety and daytime napping were significant predictors of self-reported prospective and retrospective failures; the coexistence of these conditions or behaviours with memory complaints indicates that if an individual presents in Primary Care with significant subjective memory complaints, an assessment for mood and napping or general sleep issues should be conducted. On the other hand, if an older individual is expressing concerns about mood, or reporting increased napping behaviour, their opinion regarding the state of their memory and current cognitive ability should be elicited. Since significantly associated variables such as depression and anxiety are also established risk factors for future cognitive impairment, the assessment, intervention and treatment where appropriate of coexisting conditions can serve the dual purpose of improving current subjective wellbeing and preventing or delaying cognitive deterioration.

Study 2 aimed to determine the relationship between subjective prospective and retrospective memory failures and performance on standard objective cognitive tests, the MMSE, Mini-Cog, GPCOG or CAMPROMPT. These brief cognitive screening tests were recommended for use in Primary care by recent clinical guidelines (Foley & Swanwick, 2014; Cordell et al., 2013) and reviews of cognitive screening tools (Lorentz et al., 2002; Brodaty et al., 2006; Milne et al., 2008; Ismail et al., 2010). To address the lack of current formal assessment of PM in clinical practice, and to increase the potential concordance with the self-reported prospective memory ability as measured by the PRMQ, a standardised objective test of memory, the CAMPROMPT, was also included in the cognitive test battery. As for Study 1, demographic, mood, health and sleep variables with potential associations to memory and cognition were taken into statistical account to further clarify the complex relationships between subjective and objective cognition.

Results of Study 2 found that self-reported memory failures as measured by the PRMQ were not significantly associated with objective performance on any of the cognitive tests. This finding aligns with many other cross-sectional studies that have failed to detect a significant linear relationship between self-reported memory and objective performance (e.g., Steinberg et al., 2013; Jungwirth et al., 2004; Reid & MacLullich, 2006; Hanninen et al., 1994). However, the limitations of cross-sectional studies in detecting a relationship between self-

reported memory concerns have been discussed by authors such as Jonker, Geerlings & Schmand (2000) and, generally, a variety of reasons have been proposed for the lack of significant correlation between subjective and objective memory and cognition (e.g. Gilewski & Zelinski, 1986; Herrman, 1982; Moritz, et al., 2004). The potential confounding effect of demographic, mood and other variables was addressed in the current thesis by the statistical account of the relationships between these variables and both subjective memory and objective performance on the MMSE, Mini-Cog, GPCOG and CAMPROMPT.

The limitations of currently available cognitive tests used for the objective assessment of cognitive performance are also increasingly recognised, particularly at early stages of cognitive decline, when cognitive changes are too subtle for the majority of current cognitive tests to detect (Rabin et al., 2017; Jessen et al., 2014). While multiple screening test reviews (e.g. Lorentz et al., 2002; Brodaty et al., 2006; Milne et al., 2008; Ismail et al., 2010), and guidelines from the ICGP (Foley & Swanwick, 2014) and the Medicare Detection of Cognitive Impairment Workgroup (Cordell et al., 2013), recommend the GPCOG and Mini-Cog tests as reliable and suitable for the detection of cognitive impairment in primary care settings, Table 2.2 in Chapter 2, (adapted from Cordell et al., 2013) outlines the key advantages but also the limitations of these, and many other, brief cognitive assessment tools evaluated in multiple reviews. Separately, the neglect to include an objective test of PM in any formal clinical assessment of cognitive ability is noteworthy (Rabin et al.,2014) despite is ability to discriminate cognitive impairment (Delprado et al., 2012, Foley et al., 2011, Duchek et al., 2006), even above and beyond RM (Blanco-Campal et al., 2009). Another possible reason for the absence of a significant cross-sectional subjective-objective relationship is the lack of concordance between the content of traditionally used self-report measures, that typically measure everyday episodic retrospective memory ability, and objective assessments of cognition, which measure a host of cognitive processes beyond memory alone (Cullen et al., 2007), and which, additionally, may suffer a lack of ecological validity (Maylor, 2003). As mentioned, Study 2 attempted to increase concordance between subjective and objective assessment methods by using the PRMQ that obtains a self-assessment of PM in addition to RM, and by also including a standardised objective measure of PM, the CAMPROMPT.

Although criticisms have long been directed at the reliability and predictive validity of self-reports (Rabbitt, Maylor, McInees, Bent & Moore, 1995; Dixon, 1989; Schwarz, Park, Knauper & Sudman, 1999), the predictive validity of self-reports regarding future cognitive impairment and dementia is now well-established by longitudinal population-based and clinical studies that found that memory complaints predicted cognitive performance (e.g., Jonker et al., 2000; Dik et al., 2001; Dufouil et al., 2005; Wang et al., 2004).

To this end, important findings from the Betula Prospective Cohort Study in Sweden support the reliability and validity of the PRMQ for predicting future dementia, over a long time-course of 10-12 years. The sample consisted of older adults aged 60 years and above with no cognitive impairment at baseline. Results at the end

of the follow-up revealed that PRMQ z-scores did predict dementia [Hazard ration (HR) = 1.21 for all-cause dementia, p < .01; HR = 1.25 for AD, p < .01].

Few other studies have looked at the correspondence between self-reported PM and a standardised objective test of PM in older adults. Our findings, however, are in agreement with studies by Foley (2007) and Rabin et al., (2014). Foley (2007) investigated the subjective and objective memory of healthy older adults and older adults with cognitive impairment and mild dementia using the PRMQ as the self-report measure, and the Rivermead Memory Behaviour Test (RMBT) and the CAMPROMPT as objective tests of retrospective and prospective memory, respectively (Foley, 2007). Similar to our findings regarding a lack of relationship between the PRMQ and CAMPROMPT performance, Foley found that subjective memory as self-rated by the PRMQ was not related to objective CAMPROMPT or RMBT performance in cognitively healthy older adults, but was negatively associated with PM performance in cognitively impaired older adults, attesting to the decline of PM in cognitive impairment demonstrated in the literature (e.g., Delprado et al., 2012; Blanco-Campal et al., 2009; Duchek et al., 2006).

Foley claimed a potential reason for the lack of relationship between CAMPROMPT and the PRMQ may be the test's naturalistic design which allows the test taker to use any strategies they like to assist them with remembering the tasks. Indeed, strategy use has been demonstrated to aid objective memory performance; Hutchins et al., (2012) reported that observed use of strategies was significantly associated with RM performance on the California Verbal Learning Test for both healthy older adults and older adults with amnestic MCI, and with prospective memory performance for the amnestic MCI group.

Findings from Rabin et al., (2014) revealed no significant relationship between scores of everyday subjective PM on the Comprehensive Assessment of Prospective Memory, Section B (CAPMB; Chau, Lee, Fleming, Roche & Shum, 2007) (containing 39 items relating to PM failures within the broad categories of instrumental activities of daily living) and total scores on a test of objective PM, the Royal Prince Alfred Prospective Memory test (RPA-ProMem; Radford, Lah, Say, & Miller, 2011). The RPA-ProMem consists of two event-based and two time-based tasks, further categorised as long-term versus short-term. Half of these tasks are completed within the 10-minute duration of the laboratory testing session (i.e. these tasks were regarded as short-term tasks) and half of the tasks are designed to be more naturalistic and to be completed at a later stage outside the laboratory (i.e. long-term tasks). The sample consisted of 257 older, non-demented community-dwelling older adults with a mean age of 80.78 years; 18 individuals with amnestic MCI, 38 individuals with non-amnestic MCI, 83 individuals with subjective cognitive decline despite intact performance on traditional episodic memory tests, and 118 healthy controls. Unsurprisingly, in line with the wider literature regarding the sensitivity of PM to cognitive decline (Delprado et al., 2010; Blanco-Campal et al., 2009; Costa et al., 2011; van den Berg, Kant & Postma, 2012) those with amnestic MCI and non-amnestic MCI performed significantly worse than controls on

the RPA-ProMem and its subtasks. Of note, the individuals with subjectively experienced cognitive decline (but normal neuropsychological scores) scored significantly lower than controls on the long-term, more naturalistic subtasks. Although those with subjective complaints had lower mean values than healthy controls on RPA-ProMem Total score and for all the other RPA-ProMem subtasks, this did not meet the level of statistical significance.

Their findings present an interesting consideration that the time interval between task instruction and the required time for completion of the memory task may be a deciding factor in whether a relationship between subjective and objective prospective memory is observed. Rabin and colleagues conclude that their findings agree with the large body of accumulating evidence that older adults who present with significant memory complaints despite intact functioning on traditional RM tests may represent a pre-MCI condition experiencing neuropathological changes and that naturalistic PM tasks may provide a more sensitive method of detecting this subtle decline.

While a significant relationship was not found between PRMQ self-ratings and performance on any of the cognitive tests in the current study, both univariate and binary logistic regression analyses showed that a better understanding of the relationship between subjective and objective cognition can be obtained when account is taken of the complex associations of other variables such as depression, anxiety, multimorbidity and difficulty falling asleep to subjective and objective cognition. Each of these variables was a significant predictor of high versus low forgetfulness in logistic regression analyses. Prediction of whether an individual experiences high or low forgetfulness was, therefore, best achieved by a combination of these mood, health and sleep variables together with cognitive test scores.

The inclusion of the same self-assessment of demographic, mood, health, sleep and other variables in Study 2 as Study 1 also allowed a broad comparison of associations to self-reported memory complaints across the two samples and an indication of the generalisability of findings. Some differences found in univariate associations may be attributable to subtle differences in sample characteristics, perhaps partly due to overlapping but different sources of recruitment and different data collection methods. A wide range of community-based organisations was approached for participant recruitment in both studies, but, inevitably, the number and profile of participating individuals from these various organisations varied between studies. The online and postal administration of the survey in Study 1 enabled participants of that study to answer the survey anonymously, while Study 2 participants completed the survey during the cognitive evaluation and in the presence of the researcher.

Accordingly, similar to findings of Study 1, levels of self-reported anxiety and depression were significantly related with PRMQ scores. Regarding difficulty falling asleep, however, Study 1 found that those who reported difficulty falling asleep reported significantly worse RM only, while Study 2 found a significant difference in

PRMQ scores, indicating worse subjective memory, across all of the PRMQ scales in those who reported difficulty falling asleep versus no difficulty. Study 1 also showed difficulty falling asleep to be significantly associated with self-reported anxiety and depression and indicated that mood was most likely mediating the relationship between difficulty sleeping and poorer self-reported RM, since the relationship of difficulty falling asleep to RM scores disappeared after HADS anxiety and depression scores were taken into statistical account. Additionally, in contrast to these findings, Study 2 concluded that difficulty falling asleep was not significantly associated with depression or anxiety in this sample. This would indicate more generally that mood can – but does not always – influence the association of sleep problems to subjective memory failures; sleeping difficulties and abnormal sleep patterns may also independently predict memory complaints. (Leng & Yaffe, 2018). While the participants in Study 2 with multimorbidity were significantly more likely to report difficulty falling asleep, these participants were not significantly more likely to self-report greater memory difficulty, and so the relationship between difficulty falling asleep and reported memory difficulty here does not appear to have been influenced either by poor physical health.

Although PRMQ self-ratings were not significantly correlated with objective test performance, age was found to be significantly inversely correlated with MMSE total score, a finding common to other studies using the MMSE (e.g., Piccinin et al., 2013). Those who reported difficulty falling asleep also performed significantly worse on the GPCOG. The reasons for a lack of similar association to the other cognitive tests in the current battery may present an avenue for future research. Depression and anxiety were not significantly correlated with objective performance on any of the cognitive tests, a finding in contrast to studies by, for example, Steinberg et al., (2013). It is worth noting, however, that the GPCOG is reported to be minimally affected by depression (Brodaty & Pond, 2005). While subtle differences in the level of depression and anxiety may exist between Study 1 and Study 2 samples, both samples can be regarded as generally low in anxiety and depression, which may partly explain the lack of significant association to objective test scores.

The current thesis, therefore, supports the conclusions of other authors (e.g. Steinberg et al., 2013; Rabin et al., 2017) that self-reported memory failures also have validity as potential markers of concurrent conditions such as anxiety, depression, poor physical health, and sleep issues by virtue of their commonly found significant associations to these variables and conditions. These conditions warrant appropriate assessment and treatment for the restoration of subjective well-being and the prevention of possible future cognitive decline.

The presence, therefore, of variables such as depression, anxiety and difficulty falling asleep indicate the possible coexistence of subjective/objective memory and cognitive impairment. While these conditions should receive due attention and appropriate treatment in their own right, their presence should also trigger an assessment of subjective memory at a minimum, and a combination of subjective and objective cognitive assessment where applicable. Likewise, the expression of subjective memory concerns should indicate the need

to assess for depression, anxiety and sleep problems. The timely detection of these other conditions will confer benefits to an individual's wellbeing but will also confer protective benefits to their current and future cognitive health, since depression, anxiety and sleep problems are themselves established risk factors for the development of cognitive decline.

The predictive value of self-reported memory failures regarding cognitive impairment has been demonstrated in longitudinal studies and is, also, as shown by findings in this thesis, demonstrated cross-sectionally via the significant association with conditions that have the potential to confer both transitory and long-term negative effects on cognitive function. The utility of a measure of self-reported memory failures in the Primary Care setting, therefore, can no longer be refuted or just ignored. However, it is acknowledged that such a self-report measure is required to be not only reliable but also very brief, considering the short time length of a typical consultation and the fact that current clinical guidelines from the ICGP (Foley & Swanwick, 2014) and Medicare Detection of Cognitive Impairment Workgroup (Cordell et al., 2013) recommend a combination of both subjective report elicitation and administration of a brief cognitive test within the allotted time. It would be advantageous if such a self-report measure also contained items assessing subjective PM, since information about older adults' PM ability is crucial for the continued maintenance of safety and independence (Woods et al., 2008; Schmitter-Edgecombe et al., 2009). For these reasons, an item analysis of the PRMQ and the construction of a short-form PRMQ for even briefer administration in Primary Care comprised the focus of Study 3.

Using the Study 2 data, item analysis of the full-length PRMQ using Classical Test Theory techniques revealed that, overall, PRMQ items displayed sound psychometric properties. Item p-values, indicating subjective item difficulty as reflected by the relative average item means, were largely within the range of optimal difficulty of .4 to .6 recommended as ideal for inclusion in a test of ability by many psychometric test experts (e.g. Kline, 2005; Krishnan, 2013) and corrected-item total correlations demonstrated that the PRMQ had good internal consistency.

Some of the items were endorsed to a greater relative frequency, reflecting greater subjective memory difficulty and higher item p-values, by those participants who obtained a less than perfect score on one or more of the objective cognitive tests, compared to participants who obtained perfect total test score(s). These items were, thus, deemed to display the ability to positively discriminate levels of objective cognitive performance. The magnitude of this discriminative ability was denoted by a discrimination index (DI), reflecting the difference between groups in perceived difficulty of the item, and while discriminative power of the PRMQ items would not be considered high according to traditional guidelines (e.g. Tejinder, Piyush, & Daljit, 2009), those items with the highest positive DIs on two of the tests recommended for use in Primary Care (e.g. Foley & Swanwick, 2014; Cordell et al., 2013), the GPCOG and MiniCog, were prioritised for inclusion in a short form. In

acknowledgement of the fact that the MMSE is still widely used in Primary Care, although it is better at ruling out dementia than at detecting milder cognitive impairment (Cullen et al. 2007), items with positive DIs on the MMSE were also considered for inclusion. Although the CAMPROMPT is not suitable in its present lengthy form for use in Primary Care, some of the items included in the short-form PRMQ also discriminated performance on the CAMPROMPT. The final short-form PRMQ, therefore, had 7 items in total (3 measuring PM and 4 measuring RM) and a confirmatory factor analysis of the short-form PRMQ in the Study 1 sample confirmed adequate internal consistency and reliability and determined a tripartite factor structure in keeping with the full-form PRMQ (Crawford et al., 2003; Ronnlund et al., 2008; Piauilinio, et al., 2010). Thus, this short-form PRMQ provides a brief, reliable means of assessing an individual's everyday PM as well as RM failures within a time-constrained Primary Care consultation.

The importance of these features for acceptance of an instrument within the Primary Care setting are emphasised in a review conducted by the Subjective Cognitive Decline Initiative (SDI-) working group that reported that discussions regarding the selection of self-report measures of memory and cognition were often based on practical considerations beyond the study of subjective cognitive decline specifically, such as availability and brevity (Rabin et al., 2015).

While psychometric reliability, brevity and ease of availability are, therefore, recognised as key desirable features of a subjective assessment of memory or cognition, a previously cited difficulty faced by GPs and other primary care practitioners pertains to how self-reported memory concerns or failures should be interpreted, or in other words, what significance to attach to them, as GPs report it is typically difficult to differentiate significant memory complaints from the symptoms of normal aging (Cahill et al., 2006).

Study 4, therefore, provided a number of accompanying features to the short-form PRMQ, which, taken in combination, can assist practitioners with a meaningful and reliable interpretation of the aggregated total scores on each of the PRMQ Total, PM and RM scales. These additional features comprise, firstly, Irish normative data obtained from Study 1 sample means and standard deviations and presented in the form of T-scores with a mean of 50 and SD of 10 for ease of comprehension. These normative data for the short-form PRMQ provide a useful benchmark against which primary care practitioners can judge the relevance of an individual's aggregated complaints relative to older Irish adults of similar age and demographic background. Since analyses in both Study 1 and Study 2 showed no significant influence of demographic variables on PRMQ self-ratings, there was no obvious need to stratify these data by age, gender or education.

In recognition of the subtle differences between the Irish and UK samples' self-perceived memory failures as revealed in Study 1, Irish normative data based on Study 1 sample data were also obtained for the full-form PRMQ.

The provision of cut-off scores at 1.64 SD below the mean for T-scores (and above the mean for raw scores) on the normative data tables to indicate significant subjective impairment on each of the PRMQ scales should further assist practitioners' interpretation of the significance of an individual's PRMQ Total, PM total and RM total T-scores. Furthermore, in the case where the discrepancy between an individual's PM and RM ability is of interest, the practitioner is provided with critical values for judging the reliability of the PM-RM discrepancy, alongside frequency classification tables for assessing the abnormality of the discrepancy in relation to the actual frequency of occurrence of this abnormal PM-RM discrepancy in other older Irish adults. These features, therefore, go beyond the provision of normative data against which the frequency of occurrence of an older person's PRMQ failures can be compared, to assist with a more clinically meaningful interpretation of complaints.

An assessment of self-rated memory, however, even with accompanying normative data and cut-offs for clinically significant subjective impairment, as well as critical values and frequency tables for judging the reliability and abnormality, respectively, of PM-RM discrepancies, while crucial, is not *sufficient* for the adequate screening of cognitive ability in Primary Care. Numerous relevant clinical guidelines (e.g., DSM 5 American Psychological Association, 2013; Foley & Swanwick, 2014; Cordell et al., 2014) advise the combined assessment of self- and/or informant reports and objective performance for the detection of cognitive impairment. The GPCOG, Mini-Cog and MIS are the cognitive tests of choice according to the Medicare Detection of Cognitive Impairment Workgroup (Cordell et al., 2013) (although, as noted in Chapter 2, without advising readers as to the limitations of alternative tests such as the MMSE, SLUMS or MoCA, the expert group also proposed that any of these alternative tests could be used instead). Accordingly, as outlined in Chapter 2, the expert group proposed an Algorithm for Assessment of Cognition that adopts a stepwise approach to assessment, beginning with ascertainment of subjective reports, proceeding, where possible, to confirmation by an informant, and continuing through to brief cognitive assessment using one or more of the tests mentioned above.

This algorithm for assessment of cognition does not contain specific guidance as to how exactly to take account of self-reported concerns. Thus, presumably, the choice of self-report measure (if a structured, multiple item assessment is preferred) is left to the discretion of the individual practitioner or primary care team. However, as Rabin et al., (2015) highlights, a great number and type of subjective cognitive assessment measures exist, and not all of these measures apply a threshold for determining when an individual's complaints meet criteria for significant cognitive concerns and warrants classification of subjective cognitive impairment. Moreover, a recommendation of the working group on Subjective Cognitive Decline (SCD-I; Molinuevo et al., 2017) is that self-report measures should explore different cognitive domains, such as executive functions and attention. While the working group state that this is because the earliest symptoms of Alzheimer's dementia (AD) may

affect domains beyond memory, it should be noted that this recommendation also applies because the earliest symptoms of non-AD dementias (for example vascular dementia and dementia with Lewy bodies) may manifest in domains other than memory such as executive function and language (Cullen et al., 2007). The SCD-I working group also advised that regarding the monitoring of change in self-reported cognition over time, ordinal response options are preferable. The work carried out in Study 4 of the current thesis happens to address each of the issues outlined above as expressed by Rabin et al., (2017) and the SCD-I working group (Molinuevo et al., 2017) and highlights the suitability of the new short-form PRMQ as a self-report measure in Primary Care.

Firstly, this short-form PRMQ is accompanied by normative data tables for each of its three scales with helpful cut-offs to signify subjective impairment relative to the normative sample. Secondly, PM ability, as assessed by the short-form's three PM items, is believed to draw on a wide range of cognitive processes beyond episodic retrospective memory alone, including attention, executive functions, and working memory (e.g. Martin et al., 2003). Finally, the PRMQ's likert-style response categories allows a fine-grained, more reliable analysis of change in the frequency of experienced memory failures over time when a GP requires a period of watchful waiting to determine the presence of a memory or other cognitive problem in a patient.

In addition to these aspects of the short-form PRMQ, it is, of course, of interest to determine the extent to which its items predict or are significantly associated with objective performance on cognitive tests. Using the Study 2 sample data, performance on the short-form PRMQ and the GPCOG, Mini-Cog, MMSE and CAMPROMPT were explored in a case profiling approach to determine if patterns of subjective and objective performance could be ascertained. Importantly, account was also taken in this case profiling approach of covariates found to have significant associations to memory and cognition in Study 1 and Study 2. Based on the findings of this case profiling, as outlined in Chapter 7, an algorithm for the ascertainment of cases of subtle cognitive impairment in an Irish Primary Care setting was proposed.

In alignment with best-practice clinical guidelines mentioned previously, the algorithm outlines a procedure for combined subjective and objective assessment of cognition. It includes an assessment of subjective self-reported memory, using the short-form PRMQ with accompanying normative data and cut-offs for subjective impairment, informant reports where indicated by a score of 6, 7 or 8 on the GPCOG, and an objective assessment of cognition using, where possible, the GPCOG, Mini-Cog and a brief test of PM. If using a subtask from the CAMPROMPT, findings from Rabin et al., (2014) may suggest that one of the long-term time-based tasks may be potentially most suitable. If using an objective PM subtask, performance can simply be interpreted in a binary fashion, as correct or incorrect. If an informant report is indicated by the GPCOG score, but an informant is not available to provide further information, concomitant poor performance on the clock drawing component of the GPCOG and/or Mini-Cog can be used as confirmation of the need for further cognitive investigation. Where appropriate, and in those few cases where this has not already occurred, an assessment

of mood should from part of the cognitive consultation. While the practitioner is likely to be aware of the physical health status of older individuals, a review of current treatment and management of chronic health conditions may be indicated in the presence of either significant subjective or objective cognitive impairment.

This approach to investigation is proposed based on the findings from Study 4 case profiling that highlighted sub-groups of participants with concordant and discordant relationships between their subjective and objective cognitive status.

A small sub-group of participants (n=6) with discordant impaired status reported non-impaired subjective memory, yet 5/6 individuals obtained a score of less than 9 on the GPCOG (suggesting a collateral history is required) and every one of those five individuals performed abnormally on the clock drawing component. One participant was impaired on the CAMPROMPT. Successful clock drawing is believed to draw on a wide range of cognitive processes, such as attention, executive function and others, and an abnormal clock drawing is regarded as a sensitive marker of cognitive decline (Ismail, Rajii & Shulman, 2009). Poor performance on the clock drawing component reflects diminished executive functioning, and Foley (2007) points out that poor executive function has been linked to decreased metamemory or accurate insight of one's cognitive function and may explain the discordance in this small sub-group of participants between self-reported and objective cognition. It is suggested, therefore, that abnormal performance of the clock-drawing component of either the Mini-Cog or GPCOG should signal further cognitive assessment, regardless of self-reported dysfunction or the availability or nature of informant reports.

Examination of self-reported mood, anxiety and physical health data of this subgroup of objectively impaired individuals showed that some of the individuals had moderately high levels of anxiety and depression. Cross-sectional studies have demonstrated that both anxiety (De Bruijn et al., 2014) and depression (Thomas & O'Brien, 2008) affect cognitive performance and are also established risk factors for future cognitive impairment (Da Silva, Goncalves-Pereira, Xavier, & Mukaetova-Ladinska, 2013; Diniz et al., 2013;). Two of the 6 participants reported having two or more chronic physical health conditions. This comorbidity of poor physical health with objective cognitive dysfunction is reported in the literature, although the effects of multimorbidity status on cognition may be small in a normal healthy aging population (Arts et al., 2011), and multimorbidity has been evidenced to increase the risk of developing MCI or dementia (Vassilaki et al., 2015). Acknowledging the current and future independent and additive impact of the associated conditions mood and physical health on cognitive function, review of anxiety, depression and physical health is also advised when performance on a cognitive test falls within the impaired range.

As also illustrated by the case summary data in Study 4, some older adults (n=10) reported impaired subjective memory, but examination of their cognitive tests scores revealed they were within the normal range on objective performance. Inspection of their anxiety and depression scores as obtained on the HADS indicated

that, while none could be regarded as severely anxious or depressed, some HADS subscale scores fell within the mild and moderate ranges according to the cut-offs proposed by the HADS authors (Zigmond & Snaith, 1983). Inspection of the physical health status of this subgroup of participants showed that 1 of the 10 individuals in the group reported two or more chronic physical health conditions, i.e. multimorbidity. Eight of the 9 remaining participants in the subgroup, however, reported problems with physical health. Specifically, arthritis, breathing problems, gastric problems, underactive thyroid and hiatus hernia were reported. As noted earlier, having multiple physical health problems has been linked to increased levels of subjective memory dissatisfaction (Aarts et al., 2011; Caracciolo et al., 2013).

This suggests that a discordant relationship between self-reports and objective performance, involving a high level of memory complaints but a perfect GPCOG total score, and scores in the non-impaired range on other cognitive tests, does not indicate the need for further cognitive exploration, at least at this time. Importantly, however, this scenario should trigger the assessment of anxiety and depression, since even sub-threshold levels of depression, for example, have been shown to increase self-reported memory failures (e.g. Steinberg et al., 2013). It should also signal a subjective assessment of physical health.

The remaining participant subgroups in the case profiling exercise demonstrated concordance between their subjective reports and their objective performance on the cognitive tests. Those categorised as concordant non-impaired were not impaired on the short-form PRMQ or any of the cognitive tests, and their HADS anxiety and depression scores were not high. Therefore, this subgroup is not considered to present cause for immediate concern or further evaluation of cognitive and mood status. By contrast, the group categorised as concordant impaired, i.e. impaired according to cut-offs on the normative tables accompanying the short-form PRMQ, and impaired on one or all of the cognitive tests, certainly represent a group of individuals in need of referral for more comprehensive cognitive or neuropsychological assessment. As depression and anxiety are often co-morbid with self-reported and objective cognitive dysfunction, an immediate assessment of mood, and appropriate treatment where applicable, is also advised.

Important advantages of the current proposed algorithm over, for example, the Medicare working group's Algorithm of Assessment of Cognition discussed previously, are that the subjective assessment tool proposed here, the short-form PRMQ, also assesses subjective PM ability. Clinicians will also be aided greatly in their interpretation of the potential clinical significance of these self-reports by the accompanying cut-offs on the normative data indicating subjective impairment. The GPCOG (also recommended as a frontline screening tool for use in a brief cognitive assessment by the Medicare working group) presents the added advantage of flagging, by means of specified cut-offs, those cases where an informant report on cognitive ability is advised. It also assesses a number of cognitive domains; retrospective memory, executive functions (via the clock drawing task) and temporal orientation, and we propose that abnormal performance on the clock drawing

component may suffice to indicate the need for further cognitive assessment if a GPCOG total score greater than 5 but less than 9 is obtained and the recommended informant report cannot be readily obtained.

Based on the case profiling results of Study 4 which determined patterns of performance on the short-form PRMQ and the Mini-Cog, GCCOG, MMSE and CAMPROMPT, while also taking into account relationships with depression, anxiety and, where appropriate, sleep problems and poor physical health, the algorithm can provide clear and simple guidance for clinical decision-making. These decisions pertain to the onward referral for comprehensive neuropsychological assessment, a period of watchful waiting/follow-up regarding cognitive concerns, brief self-assessment and treatment where appropriate of mood and review of medication regimen where applicable, or discharge from consultation without follow-up relating to cognitive, mental or physical health.

8.3 Strengths and Limitations of the Thesis

Strengths of the current thesis include the inclusion of a range of variables known, or suspected, to be associated with subjective and objective cognition and that are often believed to confound the relationship between subjective and objective cognition. These variables include mood state (anxiety and depression), which numerous studies have shown to frequently co-exist with memory complaints and cognitive impairment. Importantly, both conditions (particularly depression) have also been established as potential independent predictors of cognitive impairment and future dementia, further emphasising the importance of understanding the nature of their relationship to self-reported memory and cognitive test scores. Other variables with a growing evidence base pertaining to their comorbidity with poorer self-reported memory and objective performance include sleep problems and physical health conditions that were taken into statistical account alongside anxiety and depression, thereby allowing the determination of complex relationships between each of these covariates of cognitive function in addition to their relationship to subjective and objective cognitive status.

Another strength of the current research project was the inclusion of a subjective assessment and objective measure of PM by means of the PRMQ and CAMPROMPT, respectively. The PRMQ is the only standardised self-report measure currently available that includes an equal number of items assessing both PM and RM. It also comprises normative data against which an individuals' scores can be compared. The PRMQ also allows clinical evaluation of the discrepancy between PM and RM scores of an individual, should this be of interest to clinicians. Study 3 and Study 4 further assisted with the subjective assessment of memory within the time-constrained Primary Care setting with the construction of a short-form PRMQ consisting of 3 PM items and 4 RM items. The reliability of this short-form PRMQ was confirmed through CFA and reliability analyses. The meaningful interpretation of an older Irish individual's scores on both this short-form and the original long-form PRMQ is greatly enhanced by the provision of Irish normative data based on the data from the larger

sample in Study 1, alongside cut-offs for indicating subjective impairment relative to that normative sample. Again, if the discrepancy of PM and RM scores is of interest to the clinician, the new short-form PRMQ is also accompanied by critical values for interpreting the reliability of the discrepancy, as well as frequency tables for assessing the abnormality of the discrepancy relative to other older Irish adults of similar background.

The inclusion of the CAMPROMPT, as standardised naturalistic test of PM, explicitly addresses the current neglect of objective PM as a part of formal clinical assessment of cognitive impairment. This is despite the accumulating evidence base attesting to the sensitivity and predictive validity of PM in relation to current and future cognitive impairment. It also facilitated the direct determination of the relationship with subjective PM, thereby addressing the lack of concordance often observed between the cognitive domains and processes commonly assessed by objective tests and typically-used self-report measures of memory.

Finally, an important strength of the thesis is the provision of guidance and recommendations to GPs and other Primary Care professionals in the form of an algorithm for brief cognitive assessment in Primary Care, based on the profiling of patterns of performance on the short-form PRMQ and the GPCOG, Mini-Cog and CAMPROMPT. Importantly, the GPCOG and Mini-Cog are amongst the tests generally recommended as front-line components of objective cognitive assessment by key reviews of cognitive screening instruments and best-practice clinical guidelines for the detection and diagnosis of cognitive impairment and dementia in Primary Care. This algorithm, in common with other current guidelines, emphasises an older individual's self-reported memory failures as a key component of the assessment process. However, it goes further than previous guidelines and algorithms in its recommendation of the use of a specific self-report measure, the short-form PRMQ. The short-form PRMQ is briefer than the full length PRMQ, yet it maintains an adequate assessment of both PM and RM domains and demonstrates adequate reliability and psychometric properties. While the great majority of PRMQ items were shown in an item analysis to display the ability to discriminate performance, at least to some degree, on at least one of the cognitive tests used in Study 2, the short-form PRMQ was constructed so as to contain those items that displayed the greatest positive discriminate power. The additional features of Irish normative data, associated cut-offs for subjective impairment, critical values for the reliability of PM-RM discrepancies and frequency tables for judging the relative abnormality of such discrepancies should further assist Primary Care professionals in the interpretation of the clinical significance of an individual's memory complaints. Collectively, these adjunctive features of the short-form PRMQ represent an important strength of the current thesis given the difficulties traditionally inherent in distinguishing atypical subjective memory complaints from the effects of normal aging.

Obtainment of impaired versus non-impaired status on the subjective and objective components is an additional advantage of the current proposed algorithm. Discordance between subjective and objective impairment indicative of either lack of insight into cognitive difficulties on the one hand, or unnecessary worry

about one's memory on the other hand, is information that can be harnessed by the practitioner to ensure overall wellbeing.

A limitation of the current research is, of course, its cross-sectional design, which precludes any conclusions regarding causality or direction of significant relationships amongst the memory, demographic, mood, health, sleep and other variables. Crucially, the contemporaneous assessment of self-reported memory difficulties and objective cognitive performance does not typically facilitate the detection of individual cognitive decline because the time-frame does not facilitate an inter-individual assessment of change. In other words, it is very difficult to discern in a cross-sectional study the extent to which an individual's self-reported memory problems and performance on cognitive tests, particularly when test scores are within the normal range, represents a true decline from their previous level of functioning.

Regarding the cognitive tests used, while the GCOG and Mini-Cog are recommended for the purpose of brief cognitive assessment in Primary Care, the limited sensitivity, in general, of currently available tests for the detection of mild forms of cognitive impairment (as opposed to dementia) has also been acknowledged (Lonie et al., 2009).

8.4 Clinical Implications

While acknowledging the limitations, the current PhD project can be said to contribute to the current literature on the assessment of subjective and objective cognition and on the complex relationship between both self-reported memory and performance on cognitive tests. Outcomes from each of the studies in the thesis also have a number of valuable applied clinical implications for the assessment and detection of subtle cognitive impairment in Primary Care.

Given the demonstrated significant positive correlations between self-reported anxiety and depression and self-reported PM and RM difficulties in Study 1 and Study 2, the significant correlations between multimorbidity, waking earlier and day-time napping and PRMQ scores, and in Study 1, and the significant relationships between difficulty falling asleep and PRMQ scores in Study 2, these variables signal the potential co-morbid presence of subjective memory complaints and impairment. Variables significantly associated with objective performance on the cognitive tests in Study 2 also comprised anxiety, depression, and, regarding total scores on the GPCOG, difficulty falling asleep. Binary logistic regression analyses in Study 2 revealed that multimorbidity (as well as anxiety, depression and difficulty falling asleep) significantly and independently increased the likelihood of classification as a reporter of a high frequency of memory failures.

Taken together, these results clearly demonstrate the interrelationships of a range of variables with subjective and objective cognition. These interrelationships have important implications for the approach to and nature of cognitive assessment in Primary Care and point to the concurrent validity of associated conditions such as

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anxiety, depression, sleep problems and potentially poor physical health for indicating the possible presence of subjective cognitive impairment. Detection of these conditions should, therefore, trigger a brief cognitive assessment such as outlined in the current proposed algorithm. Likewise, these demonstrated associations also highlight the potential co-existence of mood, sleep and poor physical health where an individual present with memory complaints. While the Primary Care professional who has an ongoing therapeutic relationship with an individual will likely be aware of these conditions – particularly physical health status, in clinical scenarios where a practitioner is not familiar with an individual's medical history, these findings are worth taking into consideration. This is especially pertinent given the moderating and mediating effect such conditions may have on memory and cognitive functioning, and their potential as independent risk factors for future cognitive decline. Appropriate treatment of these conditions may help restore cognitive function in many cases and go some way towards preventing the possibility of more severe cognitive impairment or dementia manifesting in the future (Smart et al., 2017).

Related to the above, the current thesis contributes to wider efforts to profile the characteristics of people with early or subtle cognitive changes that may be arising due to multiple different causes and underlying aetiologies. Older individuals at early stages of cognitive decline are believed to have sufficiently intact cognition to benefit from interventions aimed at cognitive restoration or enhancement of either capabilities such as attention or compensation for subtle deficits in memory (Sohlberg & Mateer, 2001). While a review of such interventions is beyond the scope of this thesis, findings from a systematic review and meta-analysis of interventions for people aged 55 years and above with subjective cognitive impairment and normal neuropsychological test scores led Smart et al., (2017) to conclude that providing non-pharmacological interventions as part of a preventive approach to cognitive impairment could empower individuals to take proactive steps in support of their own cognitive and emotional well-being.

The algorithm proposed for brief cognitive assessment in an Irish Primary Care context places equal importance on the improved timely discernment of older adults with subtle subjective and/or objective cognitive impairment in Primary Care. It addresses previous lack of guidance regarding the subjective assessment of memory in Primary Care in ICGP guidelines (Foley & Swanwick, 2014; 2019) by recommending the short PRMQ, and provides a reliable and easy to use means of judging significant subjective impairment via Irish normative data and associated cut-offs. This is a particularly helpful practical aspect of the assessment, considering, for example, that a sizeable proportion of GPs reported that they experienced difficulty differentiating normal aging from symptoms of dementia (Cahill et al., 2006).

A shortened, yet psychometrically reliable PRMQ, with the aforementioned adjunctive features, as the subjective assessment measure of choice arguably holds good potential to assist Primary Care professionals typically faced with a wide array of subjective memory assessment approaches to choose from. However, it is

acknowledged that further efforts to validate this short-form PRMQ must be undertaken. This should involve further psychometric evaluation in other samples, including evaluation of the predictive validity of the short PRMQ.

Such evidence would greatly strengthen the recommendation based on the outcomes of this research project regarding the use of the short-form PRMQ to addresses the inclusion of PM in the clinical assessment of memory and cognition, in recognition of the widespread lack of attention to PM, despite its demonstrated sensitivity to cognitive impairment (Blanco-Campal et al., 2009; Delprado et al., 2012).

Self-ratings on the full-form PRMQ were previously shown to predict cognitive impairment and dementia in those with normal baseline cognitive performance over a 10-12-year follow-up of the Betula Cohort in Sweden (Ronnlund et al., 2015). Thus, self-reported memory failures as indicated by the short-form PRMQ may be considered by Primary Care practitioners in light of evidence of their potential predictive validity, even in those cases where an individual performs within the normal range on objective cognitive tests.

In terms of the broader implications of the findings of this thesis, they potentially raise interesting questions about the utility of self-report measures for other conditions beyond dementia/memory impairment, and whether responses to these instruments might contain useful additional information pertaining to the well-being of an individual. Self-report measures are commonly used, for example, in the assessment or screening of depression and anxiety, since laboratory tests are not useful for making a conclusive diagnosis of these mood disorders. Furthermore, observable or behavioural symptoms of clinical depression, in particular, may sometimes be minimal in spite of the great inner turmoil a person may be experiencing. Just as different types of memory failures are experienced to greater or lesser degrees, the symptoms of depression and anxiety may vary among individuals. In this respect, the importance of a multiple-item questionnaire for tapping a wide range of complaints can facilitate the understanding of an individual's particular symptom profile. However, the significant association found in the present research, as well as the extant literature, between self-reported mood and subjective memory failures suggests that high levels of self-reported depression and/or anxiety, as measured by self-report tools, should trigger an awareness in the clinical professional of the potential co-morbid presence of cognitive problems that may warrant at least brief cognitive assessment.

Another broad implication of the thesis findings concerns the phenomenon within the health system of individuals exaggerating symptoms in order to receive attention from healthcare practitioners, and institutional considerations in this regard. Rohling, Allen & Green (2002) conducted a chart review of 561 patients involved in compensation claims to examine the effects of effort on neuropsychological assessment and test performance patterns among genuine and exaggerating patients with and without neurological findings such as traumatic brain injury, neurological disease and mood disorders, with the aim of assisting the identification of symptom exaggeration. By regressing cognitive subdomain scores onto a symptom validity test composite

and assigning individuals to Genuine or Exaggerator groups based on the symptom validity test composite, the authors concluded that clinicians might avoid falsely identifying genuine patients as exaggerating by incorporating their self-reports of psychiatric symptoms and memory complaints into the diagnostic process. Their findings speak to the importance of incorporating self-reports into clinical assessment not only for eliciting symptom profiles for appropriate treatment, but as a means of validation for objective test performance.

Study 4 illustrated that a mismatch or discordance can occur between the level of one's insight into their cognitive difficulties and their objective cognitive function, as measured by current standard objective tests. In clinical contexts, if this discordance concerns poor objective performance in the face of few self-reported cognitive difficulties, an individual might be viewed as overly self-confident in the state of their cognitive functioning. Alternatively, someone, who on the basis of normal performance on objective test, is seen to over-report self-perceived cognitive difficulty, may appear to be either underestimating their cognitive ability, may be regarded as one of the so-called worried well, or even as exaggerating their cognitive symptoms. With regards to the question of older adults needing to exaggerate symptoms in order to feel properly cared for within the healthcare system in Ireland, however, such an issue arguably applies to conditions less stigmatising than dementia and cognitive impairment. Indeed, the literature emphasises a delay in approaching healthcare providers after the first signs of memory and cognitive dysfunction become apparent to an individual and/or their family, and the myriad reasons for this reluctance to self-report difficulties have been touched on in Chapter 1. While a mismatch between self-reported cognitive difficulties and objective performance on cognitive tests may appear to suggest an exaggerated self-perception of subjective cognitive difficulty, this thesis has presented the argument based on the findings of Study 1, Study 2 and Study 4, as well as the wider literature, that such self-reports should not be merely dismissed, but rather, may point to the presence of other underlying difficulties of comparable consequence to health, such as depression, anxiety or sleeping difficulties, that warrant appropriate investigation. It behoves healthcare institutions tasked with caring for these individuals to give due consideration to the possibility that what might first appear as an exaggeration of self-perceived cognitive difficulties may actually be signalling the presence of other potential health difficulties.

8.5 Directions for Future Research

As previously mentioned, future investigations of the short-form PRMQ should focus on investigating its psychometric properties and reliability in other samples. The predictive validity of the short-form PRMQ in terms of future cognitive impairment and dementia should also be investigated, in light of the results of case profiling in Study 4 that highlighted concurrent associations with cognitive performance, as well as the evidence in the wider literature that self-ratings on the original PRMQ predict future dementia (Ronnlund et al., 2015).

The current algorithm provides a means of profiling older adults experiencing subjective memory impairment and or subtle cognitive impairment in an Irish Primary Care context. The effectiveness of the current algorithm

for the improved timely detection of cognitive impairment could be evaluated in a Primary Care setting by means of a series of case settings obtained in routine clinical practice over a period of time.

Profiling of the individuals with subjective and/or objective cognitive decline, and their associated conditions is an important first step in the identification of those who will benefit most from non-pharmacological interventions that have the potential to restore cognitive functioning and from secondary prevention of further cognitive decline (Smart et al., 2017; Rabin et al., 2017). Future research should, it is contended, build on the knowledge of the characteristics of older adults with subjective and/or subtle objective cognitive dysfunction afforded by use of the proposed algorithm and investigate the effectiveness of promising non-pharmacological interventions (Smart et al., 2017) and social prescriptions for this subgroup of individuals.

The finding of a significant relationship between the likelihood of day-time napping and poorer self-reported memory is a noteworthy one in light of the small amount of research conducted to date that has focused on this particular sleep behaviour. Excessive daytime sleepiness/napping has been shown to significantly predict future cognitive impairment and dementia in a small number of prospective cohort studies (Tsapanou et al., 2015; Foley et al., 2001; Jaussent et al., 2012; Elwood et al., 2011). Daytime napping may, therefore, represent one of a number of changes in sleep patterns that might be observed many years before the clinical manifestation of dementia (Leng & Yaffe, 2018). Leng & Yaffe (2018) highlight that the benefits for older adults of sleep interventions and treatments for improving the quality of sleep have been demonstrated, but that very few studies have looked at the cognitive benefits of such interventions. Studies using objective measures of napping are also lacking. Suggested avenues for future research, therefore, involve the longitudinal follow-up of subjectively and objectively measured daytime napping in relation to subjective and objective cognition, and the initiation of sleep hygiene programmes and evaluation of the cognitive benefits of sleep interventions for napping.

8.6 Concluding Statement

In summary, the current thesis illustrates that self-reported memory failures may not predict objective cognition as measured by some of the currently recommended standardised cognitive tests. However, identification of significant self-report problems and identification of variables that are significantly associated with self-reported memory problems is an extremely valuable endeavour from a case-finding perspective. The reasons for memory complaints and poor or less than optimal performance on cognitive tests are myriad and range from factors such as mood state (Alexopoulos, 2005), poor physical health (Loprinzi, 2016), medication side-effects (e.g. Stewart et al., 2005; Ortinski & Meador, 2004), sensory impairment (Plassman et al., 2008), tiredness and fatigue, test anxiety (Sarason, 1984), to actual cognitive impairment (Mattos et al., 2003). As discussed in Chapters 1 and 2, not every older adult with subtle or mild cognitive dysfunction will go on to develop dementia. Many individuals may experience a reversal of their cognitive symptoms if the underlying

reason(s) for their cognitive difficulty are detected and treated appropriately in a timely manner. Since many of these underlying conditions are also believed to be risk factors for cognitive impairment, information on associations with subjective cognitive difficulty is valuable for assisting the identification of older adults who may be particularly vulnerable to further cognitive decline.

Based on the outcomes of four related studies, this thesis takes a biopsychosocial approach in the provision of a brief and reliable method for the assessment of subtle subjective and objective cognitive dysfunction in Irish Primary Care, taking into account the influence of a number of other variables and conditions beyond objective memory impairment. The resulting algorithm should assist with the timely detection and potential amelioration of current and future cognitive decline, and other conditions, in Primary Care, with the ultimate goal of maintaining the cognitive health and subjective wellbeing of older adults – at least for as long as possible.

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Appendix A:

Physical health conditions considered - brief overview of condition and impact on cognition

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Cardiovascular Disease: Cardiovascular disease (CVD), as defined by the Mayo Clinic, generally refers to conditions that involve narrowed or blocked blood vessels that can lead to a heart attack, chest pain (angina) or stroke. Other heart conditions, such as those that affect the muscle, valves or rhythm of the heart, are also are considered forms of heart disease. The TILDA study data showed that cardiovascular disease is common in the elderly in Ireland (Barrett, Burke, Cronin, Hickey and Kamiya (2011). It is a well-established risk factor for development of cognitive impairment and dementia (Lopez et al., 2003). Late life depression often lies on the causal pathway between CVD and cognitive impairment (Butters et al., 2008). Elderly people with cardiovascular disease (CVD) often report cognitive problems including reduced processing speed, problems with sustained attention, verbal fluency and short-term memory, before the onset of dementia (Gunstad et al., 2006).

Hormonal problems: Hormonal problems may encompass self-reported imbalances of various hormones (e.g. estrogen, testosterone, adrenaline, cortisol, growth hormone) as well as various disorders of the endocrine system, whether these are reproductive endocrine disorders, calcium-related endocrine disorders (osteoporosis, Vitamin D deficiency, Paget's disease, renal stones, hypercalcemia), metabolic (e.g. diabetes mellitus, obesity, dyslipidemia), or glandular (adrenal, pituitary, thyroid) endocrine disorders. A range of hormones, including thyroid hormone (Ahmed et al., 2008), estrogen (McEwen, 2001) and testosterone (Beauchet, 2006) influence the brain and cognitive processes directly. Self-reports reflect this effect – for instance, a community survey found that women going through the menopause, which is accompanied by a marked drop in estrogen levels, were several-fold more likely to complain of memory problems than women in the comparison group after controlling for age and race, with no significant difference is depressive symptoms between the groups (Devi, Hahn, Massimi and Zhivotovskaya (2005).

Various hormonal therapies also have documented effects – positive and negative - on cognitive functioning (e.g. Tan and Culberson, 2003; Gussekloo, Van Exel, de Craen, Meinders, Frolich and Westendorp, (2004). For example, early initiation of estrogen hormone replacement therapy (immediately post-surgical menopause or at younger age) in women may provide cognitive benefits, particularly to verbal memory (Resnick, and Henderson, 2002; Maki, Zonderman & Resnick, 2001), but there is clinical evidence that hormone therapy in older menopausal women (age 65 and above) does not confer these benefits (Zandi et al., 2002). Indeed the Women's Health Initiative Memory Study found an increase in dementia risk among older women receiving hormonal therapy (Shumacker et al., 2004).

Hormonal problems also influence cognition via influencing the vascular and immune system (Henderson, 2008) and by causing stress in the body (Lupien, Maheu, Tu, Fiocco & Schramek, 2007; McEwan, 2013) and affective problems (Hunt et al., 2000).

Breathing problems: There are a number of disorders of breathing commonly found in the community and primary care, for example, Chronic Obstructive Pulmonary Disease (Bednarek, Maciejewsksi, Wozniak, Kuca, & Zielinksi, 2007) sleep apnea (Epstein et al., 2009), asthma (Stallberg et al., 2009). Breathing problems may also occur as a consequence of other illnesses, e.g. cancer (Graves et al., 2007), obesity (Young et al., 2002).

Asthma is a common medical condition involving transient difficulties with breathing (Yawn, Wollan, Kurland & Scanlon, 2002). It is proposed that symptoms of the condition such as transient hypoxia (shortage of oxygen) can lead to poorer cognition in asthma patients because hypoxia negatively impacts the hippocampus (Leblond & Krnjevic, 1989). People with asthma also have high rates of depression (Goodwin, Fergusson & Horwood, 2004) and anxiety disorders (Goodwin, Fischer & Goldberg, 2007) which are often associated with cognitive problems. Moreover, corticosteroid treatment for asthma is associated with cognitive effects (Brown, 2009). There is a paucity of information to date on the specific relationship between asthma and cognition (Caldera-Alvarado, Khan, DeFina, Pieper and Brown, 2013). However, one study looked at the relationship in older adults, and found that, when controlling for demographic characteristics, self-rated status, inhaled corticosteroid use, asthma was associated with a 78% increased risk of cognitive impairment as defined by scores on the Montreal Cognitive Assessment (MoCA).

Diabetes: The association between both Type 1 (Brands, Biessels, Haan, Kappelle and Kessels, 2005) and type 2 diabetes (Stewart and Liolitsa, 1999; Strachan, Reynolds, Marioni & Price, 2011) and modest changes in cognition is well established. Longitudinal population-based studies have shown that the rate of cognitive decline is accelerated in elderly people with type 2 diabetes (Allen, Frier & Strachan, 2004). A quantitative meta-analysis of longitudinal studies confirmed diabetes as a risk factor for MCI, AD, VD and any dementia (Cheng, Huang, Deng & Wang, 2012), and it has been shown to affect the brain and cognitive processes independent of other vascular risk factors such as hypertension, obesity and dyslipidemia (Kumari, Brunner and Fuhrer, 2000).

Chronic pain: There are anatomical, neurochemical, and molecular substrates common to both cognitive processing and the processing of pain, and evidence for their involvement in objective pain related cognitive impairment from clinical and preclinical studies (Moriarty, McGuire & Finn, 2011). The prevalence of clinically relevant cognitive impairment has been shown to be higher in chronic pain patients in comparison with the general population (Rodriguez-Andreu et al., 2009). Cognitive side effects may also be caused by analgesic medications. People with chronic pain have performed poorly compared to controls on psychometric tests of learning and memory (Antepohl, Kiriloog, Andersson & Gerdle, 2003; Bosma & Kessels, 2002), and also on general measures of cognition, such as the MMSE (Meyer, Xu, Thornby, Chowdhury & Quach, 2000; Oosterman, Dijkerman, Kessels & Scherder, 2010). Objective deficits in attention (Alanoglu et al., 2005; Bosma & Kessels, 2002) and deficits in controlled executive type functions (Verdejo-Garcia, Lopez-Torrecillas, Calandre, Delgado-Rodriguez & Becahara, 2009; Weiner, Rudy, Morro, Slaboda & Lieber, 2006) have also been evidenced. However, there are also studies that report no association between chronic pain and impaired cognitive function (e.g. Scherder et al., 2008; Suhr, 2003). It should be noted that pain may be a symptom of other disorders such as Fibromyalgia and diabetes, and often co-occurs with anxiety and depression, stress and fatigue, which are also

known to impact cognition and memory (Moriarty, McGuire & Finn, 2011). Pain was found to be one of the strongest predictors of impaired simple and complex activities of daily living in older people in the general population in Ireland (Barrett, Burke, Cronin, Hickey & Kamiya, 2011).

A smaller number of studies have investigated the subjective cognitive complaints of people with chronic pain and have found such complaints to be prevalent (McCracken & Iverson, 2001; Schnurr & MacDonald, 1995; Munoz & Esteve, 2005). Self-reported difficulties with attention are common (McCracken & Iverson, 2001; Monoz & Esteve, 2005). Munoz and Esteve (2005) found that depression and anxiety accounted for memory complaints more than age and pain chronicity in a sample of chronic pain patients.

Arthritis: Arthritis is the most common joint disease (Issa & Sharma, 2006). According to Arthritis Ireland, there are more than 100 different types of arthritis, ranging from the very common to the extremely rare. Many of these conditions share similar arthritis symptoms, such as joint pain and inflammation but all have unique symptoms also. Some of the main types include Osteoarthritis, Rheumatoid Arthritis, Fibromyalgia, Psoriatic Arthritis, Gout, Lupus. Arthritis results in pain which, as outlined above, may adversely affect memory and attention. It also commonly results in fatigue which can affect cognitive ability (Hewlett et al., 2005).

Conditions arising from dysfunction of the Enteric Nervous System (ENS): General gastric problems, Ulcerative colitis ("ulcers"), Crohn's Disease and Thyroiditis are conditions of the enteric nervous system (ENS).The ENS includes a number of neural circuits that control motor functions, local blood flow, mucosal transport, and secretions, and modulates immune and endocrine functions (Costa, Brookes & Hennig, 2000). The ENS and Central Nervous System (CNS) (consisting of the brain and spinal chord) are linked bidirectionally by the sympathetic and parasympathetic pathways forming the brain-gut axis. Recent and emerging research on the brain-gut-enteric axis is showing how neurochemical communication along this axis contributes to good health as well as a broad spectrum of pathological conditions, including ulcers, Crohn's disease and thyroiditis, amongst other problems.

Gastric problems may include reflux, heartburn, bloating, stomach cramps, pain, nausea, and gastric tumours. Gastrointestinal reflux diseases is an umbrella term for a range of gastric and oesophageal symptoms that comprises a frequent reason for consultation in primary care (El-Serag, Hill & Jones, 2008). It has been found to be associated with an increased risk of a subsequent diagnosis of oesophageal cancer, oesophageal stricture, chronic cough, sinusitis, chest pain, angina, gallbladder disease, irritable bowel syndrome or sleep problems (El-Serag, Hill & Jones, 2008).

Ulcerative Colitis is a gastro-intestinal tract disease, and a disease of the Enteric Nervous System (ENS) that falls under the umbrella of Inflammatory Bowel Syndrome (IBS). One cause of ulcers is a bacterium, Helicobacter Pylori (Hp), a high prevalence of which has been documented in patients with Alzheimer's Disease (Kountouras et al., 2009).

Crohn's disease, also falling under the umbrella of IBS, is a chronic inflammatory disease of the intestines, affecting both colon and small bowel, often leading to severe disability

Pain is often a symptom of ulcers (Dimenas et al., 1994) and Crohn's disease (Van Assche et al., 2010) and pain has been shown to interfere with memory and cognitive processes (Dick & Rashiq, 2007).Disorders of the ENS more generally are also believed to be connected to stress (Bhatia & Tandon, 2005; Kiliaan et al., 1998), and stress is a predictor of both self-reported memory problems (Elfgren, Gustafson, Vestberg & Passant, 2010) and objective cognitive performance (Caswell, Vitaliano, Croyle & Daruwala, 2003). Anaemia – symptoms of which include fatigue and memory problems - also commonly co-occurs with Crohn's disease and other disorders of Irritable Bowel Syndrome (Gasche, Lomer, Cavill & Weiss, 2017).

Thyroid disorders present in various forms, but all of involve thyroidal inflammation. They include but are not limited to hypothyroidism (underactive), hyperthyroidism (overactive; commonly caused by Graves disease), and cancer-related thyroid issues.

Overt *hypo*thyroidism and subclinical *hyper*thyroidism have both been associated with objective cognitive impairment and dementia (Hogervorst, Huppert, Matthews & Brayne, 2008). Specific to the effects on PM performance, one study reported an interesting non-linear effect of hyperthyroidism (Livner, Wahlin & Backman, 2009). People with autoimmune thyroid disease often present with subjective complaints of cognitive impairment (Burmeister et al., 2001). A survey study of self-reported neuropsychiatric complaints in patients with Grave's Disease (the most common cause of hyperthyroidism) outlined self-reported problems in cognitive functioning (Stern et al., 1996).

Multimorbidity: Multimorbidity describes the co-occurrence of two or more chronic medical conditions within one person, and is highly common in older people (Aarts et al., 2011). Some studies have shown an association between the total number of comorbid conditions and poor performance on memory tests (Comijs et al., 2009). Multimorbidity in a Dutch sample was associated with subjective memory complaints and the relationship differed according to gender and age. The association with perceived forgetfulness was stronger among people aged 55 to 69 years than among those aged 70 and above. Men who perceived themselves as forgetful and who suffered from multimorbidity reported a larger increase in their memory problems than did women who also perceived themselves as forgetful and suffered from multimorbidity (Aarts et al., 2011).

Alcohol: Ireland has one of the highest levels of alcohol consumption in the European Union (European Commission, 2010). It is well established that habitual excess alcohol intake is harmful to the brain and cognitive function (Chick et al., 1989), interfering for example with the ability to form new long-term memories (White, 2003). Long term excessive intake is associated with cognitive impairment and dementia (Kim et al., 2012). However, some studies have documented better cognitive test scores among moderate drinkers (e.g. Dufouil, Ducimetiere and Alperovitch, 1997; Stampfer, Kang, Chen, Cherry & Godstein, 2005). In terms of the association between alcohol use and self-reported memory failures, it was difficult to identify studies that reported specific findings on this relationship.

Appendix B: Study 1 Call for Volunteers

Call for Volunteers: New study on everyday memory functioning in older adults

Healthy volunteers, age 50 years and older, are needed to take part in an anonymous questionnaire study looking at everyday memory functioning and memory lapses. This research forms part of a larger research project examining aspects of memory in healthy aging and dementia. In order to understand memory decline in conditions such as dementia, we need to know about how memory functions in individuals without dementia. It is important, therefore, to study memory in healthy older adults. Thus, we are seeking volunteers without a history of dementia.

Background to the study: We are interested in finding out more about the type of memory mistakes people make in normal everyday life, how often these mistakes occur and the possible relationship between memory errors and factors such as age, gender, education level, mood and fatigue**.** Many people complain about their memory, especially as they get older. There are many possible reasons for forgetting and memory mistakes do not automatically mean a memory disorder. This study will allow us learn more about normal rates and types of forgetting.

Who is involved? My name is Sophia Kilcullen and I am a PhD student doing research on memory in older adults in collaboration with Dr. Kate Irving and Prof. Teresa Burke, DCU School of Nursing and Human Sciences. This research is funded jointly by the Health Service Executive (HSE) and the Atlantic Philanthropies and it forms part of the DCU Dementia Elevator project.

What will the study involve? If you volunteer to take part in this study, you will be asked to complete a relatively short anonymous questionnaire that asks questions about your everyday memory, current mood-state, socio-demographics, health status and health history. These questions will take less than 30 minutes to complete. Your name or address will not be required. You can choose to complete this questionnaire on-line (via computer) or as a paper-and-pencil questionnaire.

Why is this study beneficial? If we know more about how often healthy people forget, the types of things they forget, and the factors that influence forgetting, GPs will be able to judge how serious reported memory problems might be and how they can help people to improve and protect their memory.

How can I take part? If you are interested in knowing more about this research study, or you think you would like to participate, please contact me on 01-7006083, or by email at Sophia.kilcullen4@mail.dcu.ie. Arrangements will then be made for you to access the online survey (either from home or by coming to meet us in DCU), of it you prefer, to receive a pen-and-paper version of the study materials (information sheet and questionnaire). Alternatively, you can go directly to the secure study website at https://dcusnhs.eu.qualtrics.com/SE/?SID=SV_efIw8BCOvKg45P7   where you will be directed to a detailed information sheet about the study, the informed consent form and the questionnaire.

Please note:

1. *Only those who provide informed consent will be eligible to take part in the study. Informed consent to participation will be documented through a series of questions that you will need to answer but you will not be required to provide your name.*

2. *The information you give us is for research purposes only. Given the anonymous nature of the study, you will not receive individual feedback about your memory or mood state.*

If, for any reason, you have any concerns about your memory or your emotional well-being, you should consider consulting your GP for advice.

Appendix C: Study 1 Plain Language Statement

Plain Language Statement

Title of Research Study: Survey of Everyday Memory

Principle Investigator: Sophia Kilcullen (Tel: 01 7006083) E: sophia.kilcullen4@mail.dcu.ie
Co-investigators: Dr.Kate Irving, DCU School of Nursing and Human Sciences (Tel: 01 7007985)
Prof. Teresa Burke, DCU School of Nursing and Human Sciences (Tel: 01 7007955)

Introduction: Thank you for expressing an interest in this study. You are being invited to take part, on a voluntary basis, in this research study (funded by The Atlantic Philanthropies and the HSE), which is being carried out by Sophia Kilcullen, a PhD candidate in the School of Nursing and Human Sciences in Dublin City University (DCU) in part fulfilment of a PhD. Before you decide whether or not to participate, please read the following information carefully. If you require further information, or would like to ask any questions, please contact the research team – contact details are above.

Background and aims of the study: Many people experience memory slips and failures, especially as they get older. There are many possible reasons for these and they do not automatically indicate a memory disorder. We are interested in knowing how people rate their memory in various everyday contexts. In particular, we would like to know how well you are able to remember future plans and intentions as well as events and information from the past. Although this information is important for understanding what is usual in terms of the types of memory difficulties people experience, this information is not yet available for the Irish population.

Am I eligible to take part in the study? To take part in this study, you need to be aged 50 years or older, living independently in the community, be fluent in English and not have a history of dementia, neurological condition such as Parkinson's disease, stroke, tumour, multiple sclerosis etc., significant psychiatric illness, learning disability or significant hearing or visual impairment.

What does participation in the study involve? If you agree to take part in this study, you will be asked to answer some questions about your everyday memory, current mood state, socio-demographics, health status and health history. You will not, however, be asked to provide either your name or address, and no other personally identifiable information about you will be collected. Questionnaires will take approximately 30 minutes to complete. Only the research team will have access to the data and the information will be kept confidential and securely stored at all times.

Are there any risks associated with the study?: As this study asks you for your opinions about your memory and mood, it is possible that you may become concerned about your memory or emotional well-being as you work your way through the questionnaire. If at any stage during completion of the questionnaire, you feel distressed or concerned, you can withdraw without completing it and you will not have to provide any explanation of your decision. If you have any current concerns, you might wish to speak with your GP or someone else before making a decision about whether or not to participate.

Are there any benefits (direct or indirect) to my involvement in the research study? The information you and others give about everyday memory slips will, when analysed, help GPs and other practitioners more accurately judge the significance of memory complaints and help them to make appropriate decisions about how best to

deal with these so that the potential risk of further decline is avoided. This may or may not benefit you directly, but will benefit other people in the future who experience a decline in their memory abilities.

How will the information I provide be protected? How will my identity be protected? If you agree to take part, you will be asked to complete an anonymous questionnaire. Neither your name nor address will be required. No information that could potentially identify you will be collected. Any data (name, address, phone number) provided by you in the event that you request a hardcopy questionnaire will be destroyed as soon as the hardcopy questionnaire has been sent to you. Findings published from this study in reports and journal articles will not contain any personally identifiable information.

What will happen to the data? The data collected for this study will be summarised and will be presented in a PhD thesis to be submitted to DCU. The data may also be used for anonymised publication in journals or reports. Information will be stored for a maximum of 10 years. Thereafter, all documentation and electronic files will be destroyed permanently. As the data you provide will be anonymous, it will not be possible to receive individual feedback nor to access or retract your answers. However, a one-page summary of the research findings will be available upon request following submission and examination of the thesis.

Involvement in the Research Study is voluntary and you have a right to withdraw: Participation in this study is completely voluntary and there will be no penalty for withdrawing from the study. However, given the nature of the study, it will not be possible to withdraw your data after it has been submitted to the research team as we will have no way of knowing which questionnaire is yours. Whether or not you wish to take part in the study, you might be interested in obtaining some information related to memory, healthy ageing and dementia. If you are interested in improving your awareness about these topics, please see DCU Dementia Elevator project at http://dementiaelevator.ie/training-programmes/dementia-awareness-training. For video information about healthy brain practices that may help prevent dementia you can visit the webpage www.freedemliving.com from the Neuroenhancement for Independent Living (NEIL) centre in Trinity College Dublin.

What to do if there are concerns about the study: If you have any concern about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Office of the Vice-President for Research, Dublin City University, Dublin 9. You may also contact the project supervisors, Dr. Kate Irving (Tel: 01 700 7985) and Prof. Teresa Burke (Tel: 01 700 7955).

What should I do now? If you are interested in completing the study, **please proceed to the Informed Consent Form**

Appendix D: DCUREC Approval

FACULTY OF SCIENCE AND HEALTH
School of Nursing and Human Sciences Research Ethics Advisory Committee

19th December 2014

Applicants: Sophia Kilcullen, Dr. Kate Irving, Prof. Teresa Burke

Project Title: Exploring the relationship between self-reported and objective memory performance in older adults.

SNHS Review Reference: SNHSEAC/2014/12/R3

Dear Sophia,

The School of Nursing and Human Sciences (SNHS) Ethics Advisory Committee (EAC) reviewed your ethics application form for the project: Exploring the relationship between self-reported and objective memory performance in older adults.

The approach that the SNHS EAC takes is to make recommendations on your submission. These should be discussed with your supervisor(s) and taken into account in preparing your final submission to DCU Research Ethics Committee (REC). Please note that the comments from the SNHS EAC *do not* constitute ethics approval. The following comments are given to help facilitate your application through the DCU REC. The EAC recommends that you address the following points prior to submitting your application to DCU REC. You do not need to reply to the EAC about these points.

Please include digital signatures of supervisors.

Section 2.1. Please clarify that study 2 participants engaging in cognitive screening will be recruited separately to study 1 participants, whose identity is anonymous.

Section 2.4(a) participant vulnearability and **section 3.1** risk assesment of low to moderate risk level for studies 1 and 2 respectively appear to support the suggested expedited submission route. It may be also useful to insert a summary statement in section 3.1 supporting expedited submission indicating that potentially sensitive information will not be collected in Study 1 (as indicated in section 3.6) , and that data collection in any event is anonymous; and that participant vulnerability for both studies in terms of capacity to consent is managed by strict inclusion criteria; also, the immediate and/or long-term consequences associated with data collected in both studies are managed by (a) request to involve participant's GP in the decision phase of participating in the study; and (b) opportunity to received feedback in Study 2 by trained clinical personnel.

Also, please clarify if Memory Works participants must be current clients and/or clients within a specified number of years since the MMSE etc. assessment.

1

Appendix E: Study 1 Consent Form

Informed Consent Form

Title of Research Study: Survey of Everyday Memory

Principle Investigator: Sophia Kilcullen (Tel: 01 7006803) E: sophia.kilcullen4@mail.dcu.ie
Co-investigators: Dr. Kate Irving, DCU School of Nursing and Human Sciences
(Tel:017007985)
Prof. Teresa Burke, DCU School of Nursing and Human Sciences (Tel: 01 7007955)

Background and aims of the study:

Many people experience memory slips and failures, especially as they get older. There are many possible reasons for these and they do not automatically indicate a memory disorder. We are interested in knowing how people rate their memory in various everyday contexts. In particular, we would like to know how well you are able to remember future plans and intentions as well as events and information from the past. At the moment, there is no such information available about the general population in Ireland, even though this information is necessary for understanding what is usual in terms of the types of memory difficulties people report.

Participant – please complete the following [tick Yes or No for each question]

Have you read the Plain Language Statement?	□Yes	□ No
Do you understand the information provided?	□Yes	□ No
Have you had an opportunity to ask questions and discuss this study?	□Yes	□ No
Have you received satisfactory answers to all of your questions?	□Yes	□ No
Can you confirm that you are aged 50 and above?	□Yes	□ No
Can you confirm that you have not been diagnosed with dementia?	□Yes	□ No
Can you confirm that you do no suffer from a neurological condition such as Parkinson's disease, stroke, tumour, etc., significant psychiatric illness, learning disability, or sever visual or hearing impairment?	□Yes	□ No

Participation is voluntary: I have read this consent form. I have had opportunity to ask questions about the consent form and all the questions have been answered to my satisfaction. I freely and voluntarily agree to be part of this research study, which respects my legal and ethical rights. I am aware that I may withdraw at any time right up to the point at which I submit my data to the research team, without giving reason, and without this decision affecting me in any way.

Confidentiality of information: My identity and other personal information will not be collected, and therefore cannot be used or published. Any information which has the potential to be personally identifiable will be removed to protect confidentiality. Confidentiality is assured but I am aware that confidentiality of information can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim, or mandated reporting by some professions. However, as my information is anonymous, such actions, should they occur, will not bear any direct consequences for my privacy.

Potential concerns about memory and/or emotional well-being: I am aware of the possibility that answering questions about my memory and current mood may cause me to feel concerned about my memory and/or my emotional well-being. I am aware that I should discuss any concerns with my GP.

Consent: I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form.

I understand that by completing and returning the attached questionnaire, I am indicting my consent to participant

Appendix F: Study 1 Survey

Survey of Everyday Memory Lapses

PRINCIPAL INVESTIGATOR and RESEARCHERS
Ms. Sophia Kilcullen, Dr. Kate Irving, Prof. Teresa Burke,
School of Nursing and Human Sciences, Dublin City University (DCU)

Plain Language Statement

Title of Research Study: Survey of Everyday Memory

Principle Investigator: Sophia Kilcullen (Tel: 01 7006083) E: sophia.kilcullen4@mail.dcu.ie
Co-investigators: Dr.Kate Irving, DCU School of Nursing and Human Sciences (Tel: 01 7007985)
Prof. Teresa Burke, DCU School of Nursing and Human Sciences (Tel: 01 7007955)

Introduction: Thank you for expressing an interest in this study. You are being invited to take part, on a voluntary basis, in this research study (funded by The Atlantic Philanthropies and the HSE), which is being carried out by Sophia Kilcullen, a PhD candidate in the School of Nursing and Human Sciences in Dublin City University (DCU) in part fulfilment of a PhD. Before you decide whether or not to participate, please read the following information carefully. If you require further information, or would like to ask any questions, please contact the research team – contact details are above.

Background and aims of the study: Many people experience memory slips and failures, especially as they get older. There are many possible reasons for these and they do not automatically indicate a memory disorder. We are interested in knowing how people rate their memory in various everyday contexts. In particular, we would like to know how well you are able to remember future plans and intentions as well as events and information from the past. Although this information is important for understanding what is usual in terms of the types of memory difficulties people experience, this information is not yet available for the Irish population.

Am I eligible to take part in the study? To take part in this study, you need to be aged 50 years or older, living independently in the community, be fluent in English and not have a history of dementia, neurological condition such as Parkinson's disease, stroke, tumour, multiple sclerosis etc., significant psychiatric illness, learning disability or significant hearing or visual impairment.

What does participation in the study involve? If you agree to take part in this study, you will be asked to answer some questions about your everyday memory, current mood state, socio-demographics, health status and health history. You will not, however, be asked to provide either your name or address, and no other personally identifiable information about you will be collected. Questionnaires will take approximately 30 minutes to complete. Only the research team will have access to the data and the information will be kept confidential and securely stored at all times.

Are there any risks associated with the study?: As this study asks you for your opinions about your memory and mood, it is possible that you may become concerned about your memory or emotional well-being as you work your way through the questionnaire. If at any stage during completion of the questionnaire, you feel distressed or concerned, you can withdraw without completing it and you will not have to provide any explanation of your decision. If you have any current concerns, you might wish to speak with your GP or someone else before making a decision about whether or not to participate.

Are there any benefits (direct or indirect) to my involvement in the research study? The information you and others give about everyday memory slips will, when analysed, help GPs and other practitioners more accurately judge the significance of memory complaints and help them to make appropriate decisions about how best to deal with these so that the potential risk of further decline is avoided. This may or may not benefit you directly, but will benefit other people in the future who experience a decline in their memory abilities.

How will the information I provide be protected? How will my identity be protected? If you agree to take part, you will be asked to complete an anonymous questionnaire. Neither your name nor address will be required. No information that could potentially identify you will be collected. Any data (name, address, phone number) provided by you in the event that you request a hardcopy questionnaire will be destroyed as soon as the hardcopy questionnaire has been sent to you. Findings published from this study in reports and journal articles will not contain any personally identifiable information.

What will happen to the data? The data collected for this study will be summarised and will be presented in a PhD thesis to be submitted to DCU. The data may also be used for anonymised publication in journals or reports. Information will be stored for a maximum of 10 years. Thereafter, all documentation and electronic files will be destroyed permanently. As the data you provide will be anonymous, it will not be possible to receive individual feedback nor to access or retract your answers. However, a one-page summary of the research findings will be available upon request following submission and examination of the thesis.

Involvement in the Research Study is voluntary and you have a right to withdraw: Participation in this study is completely voluntary and there will be no penalty for withdrawing from the study. However, given the nature of the study, it will not be possible to withdraw your data after it has been submitted to the research team as we will have no way of knowing which questionnaire is yours. Whether or not you wish to take part in the study, you might be interested in obtaining some information related to memory, healthy ageing and dementia. If you are interested in improving your awareness about these topics, please see DCU Dementia Elevator project at http://dementiaelevator.ie/training-programmes/dementia-awareness-training. For video information about healthy brain practices that may help prevent dementia you can visit the webpage www.freedemliving.com from the Neuroenhancement for Independent Living (NEIL) centre in Trinity College Dublin.

What to do if there are concerns about the study: If you have any concern about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Office of the Vice-President for Research, Dublin City University, Dublin 9. You may also contact the project supervisors, Dr. Kate Irving (Tel: 01 700 7985) and Prof. Teresa Burke (Tel: 01 700 7955).

What should I do now? If you are interested in completing the study, **please proceed to the Informed Consent Form**

Informed Consent Form

Title of Research Study: Survey of Everyday Memory

Principle Investigator: Sophia Kilcullen (Tel: 01 7006803) E: sophia.kilcullen4@mail.dcu.ie
Co-investigators: Dr. Kate Irving, DCU School of Nursing and Human Sciences
(Tel:017007985)
Prof. Teresa Burke, DCU School of Nursing and Human Sciences (Tel: 01 7007955)

Background and aims of the study:

Many people experience memory slips and failures, especially as they get older. There are many possible reasons for these and they do not automatically indicate a memory disorder. We are interested in knowing how people rate their memory in various everyday contexts. In particular, we would like to know how well you are able to remember future plans and intentions as well as events and information from the past. At the moment, there is no such information available about the general population in Ireland, even though this information is necessary for understanding what is usual in terms of the types of memory difficulties people report.

Participant – please complete the following [tick Yes or No for each question]

Have you read the Plain Language Statement?	□Yes	□ No
Do you understand the information provided?	□Yes	□ No
Have you had an opportunity to ask questions and discuss this study?	□Yes	□ No
Have you received satisfactory answers to all of your questions?	□Yes	□ No
Can you confirm that you are aged 50 and above?	□Yes	□ No
Can you confirm that you have not been diagnosed with dementia?	□Yes	□ No
Can you confirm that you do no suffer from a neurological condition such as Parkinson's disease, stroke, tumour, etc., significant psychiatric illness, learning disability, or sever visual or hearing impairment?	□Yes	□ No

Participation is voluntary: I have read this consent form. I have had opportunity to ask questions about the consent form and all the questions have been answered to my satisfaction. I freely and voluntarily agree to be part of this research study, which respects my legal and ethical rights. I am aware that I may withdraw at any time right up to the point at which I submit my data to the research team, without giving reason, and without this decision affecting me in any way.

Confidentiality of information: My identity and other personal information will not be collected, and therefore cannot be used or published. Any information which has the potential to be personally identifiable will be removed to protect confidentiality. Confidentiality is assured but I am aware that confidentiality of information can only be

protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim, or mandated reporting by some professions. However, as my information is anonymous, such actions, should they occur, will not bear any direct consequences for my privacy.

Potential concerns about memory and/or emotional well-being: I am aware of the possibility that answering questions about my memory and current mood may cause me to feel concerned about my memory and/or my emotional well-being. I am aware that I should discuss any concerns with my GP.

Consent: I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form.

I understand that by completing and returning the attached questionnaire, I am indicting my consent to participant.

Survey of Everyday Memory Lapses

Research Team: Ms. Sophia Kilcullen, Dr. Kate Irving, Prof. Teresa Burke,
School of Nursing and Human Sciences, Dublin City University (DCU)

Socio-demographic Questions

All information you provide is completely anonymous

What is your age in years? _____

What is your gender?
□ Male
□ Female

What is your marital status?
□ single
□ married
□ civil partnership
□ cohabiting (living together with romantic partner)
□ separated
□ divorced
□ widowed

Please indicate the highest level of education you have completed to date:
□ Primary level
□ Secondary level Intermediate Certificate/Junior Certificate
□ Post Leaving Certificate course
□ Vocational training apprenticeship
□ Third level degree
□ Higher graduate diploma
□ Masters degree
□ PhD

How many years in total have you spent in formal education (school, college, university)?
□ 0-6
□ 7-10
□ 11-13
□ 14-17
□ 18-19
□ 20 or above

Occupation

Below is a list of different types of jobs. Please indicate which type best describes your job *now*, or (if you are retired or unemployed), the job you last held?

□ Manager (e.g. managing director, senior government official, hotel or restaurant manager, etc.)
□ Professional (e.g. medical doctor, teacher, engineer, artist, accountant, etc.)
□ Technician or associated professional (e.g. engineering technician, photographer, ICT operations technician, etc.)
□ Clerical support worker (e.g. receptionist, office supervisor, clerical worker, etc.)
□ Service and sales worker (e.g. shopkeeper, chef, childcare worker, etc.)
□ Skilled agriculture, forestry and fishery worker (e.g. forestry worker, vegetable grower, farmer, etc.)
□ Craft and related trades worker (e.g carpenter, builder, jewellery maker, baker, etc.)
□ Plant and machine operator or assembler (e.g. machine operator, van driver, etc.)
□ Elementary occupation (e.g. cleaner, farm labourer, building construction labourer, etc.)
□ Other (please specify): _____

Current medical history

Do you currently have any of the physical conditions listed below? If so, please tick the relevant condition(s)	How long has it been since you were diagnosed? Please tell us using *years* and/or *months*
Cardiovascular disease (heart disease)	
Hormonal problems	
Breathing problems	
Gastric problems	
Diabetes	
Chronic pain	
Arthritis	
Ulcerative colitis ("ulcers")	
Thyroiditis (Thyroid problems)	
Crohn's disease	
Other (please specify here): _____	

Alcohol
Do you drink alcohol?
□ Yes
□ No

Have you ever felt that you needed a drink first thing in the morning (an "eye-opener") to steady your nerves or to get rid of a hangover?
□ Yes
□ No

Sleep

Do you generally find it difficult to *fall asleep?*
□ Yes
□ No

***When* did you begin to find it difficult to fall asleep?**
□ Less than one month ago
□ 1-2 months ago
□ 3-6 months ago
□ 7-12 months ago
□ 1-2 years ago

□ 3-5 years ago
□ 6-10 years ago
□ 11 or more years ago

***How often* do you find it difficult to fall asleep?**
□ 7 nights per week
□ 4-6 nights per week
□ 2-3 nights per week
□ 1 night per week

**Below are some possible *reasons* for your difficulty falling asleep Please select *all reasons that apply:*

□ Anxiety
□ Diet
□ Caffeine
□ Pain
□ Physical condition (please specify: e.g. requiring frequent trips to bathroom, etc.)
□ Inactivity
□ Other reason(s) (please specify): _____

Do you ever wake up *during the night?*
□ Yes
□ No

***When* did you begin to wake up during the night?**
□ Less than one month ago
□ 1-2 months ago
□ 3-6 months ago
□ 7-12 months ago
□ 1-2 years ago
□ 3-5 years ago
□ 6-10 years ago
□ 11 or more years ago

***How often* do you wake up during the night?**
□ 7 nights per week
□ 4-6 nights per week
□ 2-3 nights per week
□ 1 night per week

Below are some possible *reasons* for you waking up during the night. Please select _all reasons that apply:_

□ Anxiety
□ Diet
□ Caffeine
□ Pain
□ Physical condition (please specify: e.g. requiring frequent trips to bathroom, etc.)
□ Inactivity
□ Other reason(s) (please specify): _____

Do you wake up *earlier than you intended?*

□ Yes
□ No

***When* did you begin to wake up earlier than you intended?**

□ Less than one month ago
□ 1-2 months ago
□ 3-6 months ago
□ 7-12 months ago
□ 1-2 years ago
□ 3-5 years ago
□ 6-10 years ago
□ 11 or more years ago

***How often* do you wake up earlier than you intended?**

□ 7 nights per week
□ 4-6 nights per week
□ 2-3 nights per week
□ 1 night per week

Below are some possible *reasons* for your waking up earlier than you intended. Please select _all reasons that apply_.

□ Anxiety
□ Diet
□ Caffeine
□ Pain
□ Physical condition (please specify: e.g. requiring frequent trips to bathroom, etc.)
□ Inactivity
□ Other reason(s) (please specify): _____

On average, *how many hours* do you sleep per night? _____

***Since when* has this been the average number of hours you sleep per night?**

□ Less than one month ago
□ 1-2 months ago
□ 3-6 months ago
□ 7-12 months ago
□ 1-2 years ago
□ 3-5 years ago
□ 6-10 years ago
□ 11 or more years ago

Below are some possible *reasons* for the average number of hours you sleep per night. Please select *all reasons that apply*:

□ This is the number of hours sleep my body needs to feel rested
□ Anxiety
□ Diet
□ Caffeine
□ Pain
□ Physical condition (please specify: e.g. requiring frequent trips to bathroom, etc.)
□ Inactivity
□ Other reason(s) (please specify): _____

Do you ever take medication or alcohol to help you sleep?
□ Yes
□ No

Do you ever take naps during the day?
□ Yes
□ No

What is your usual bed time?
□ Before 10pm
□ Between 10pm and 11pm
□ Between 11pm and midnight
□ Between midnight and 1am
□ After 1am
□ Other _____

Questions about your Mood

Please read each of the following 14 statements and click the box that comes closest to how you have been feeling in the <u>past week</u>. Don't take too long over your replies; your immediate reaction to each item will probably be more accurate than a long thought out response.

I feel tense or "wound up."
□ Most of the time
□ A lot of the time
□ From time to time, occasionally
□ Not at all

I still enjoy the things I used to enjoy.
□ Definitely as much
□ Not quite as much
□ Only a little
□ Hardly at all

I get a sort of frightened feeling as if something awful is about to happen.
□ Very definitely and quite badly
□ Yes but not too badly
□ A little, but it doesn't worry me
□ Not at all

I can laugh and see the funny side of things.
□ As much as I always could
□ Not quite so much now
□ Definitely not so much now
□ Not at all

Worrying thoughts go through my mind
□ A great deal of the time
□ A lot of the time
□ From time to time, but not too often
□ Only occasionally

I feel cheerful
□ Not at all
□ Not often
□ Sometimes
□ Most of the time

I can sit and feel relaxed
□ Definitely
□ Usually
□ Not often
□ Not at all

I feel as if I'm slowed down
□ Nearly all the time
□ Very often
□ Sometimes
□ Not at all

I get a sort of frightened feeling like "butterflies" in the stomach
□ Not at all
□ Occasionally
□ Quite often
□ Very often

I have lost interest in my appearance
□ Definitely
□ I don't take as much care as I should
□ I may not take quite as much care
□ I take as much care as ever

I feel restless as if I have to be on the move
□ Very much indeed
□ Quite a lot
□ Not very much
□ Not at all

I look forward with enjoyment to things
□ As much as I ever did
□ Rather less than I used to
□ Definitely less than I used to
□ Hardly at all

I get sudden feelings of panic
□ Very often indeed
□ Quite often
□ Not very often
□ Not at all

I can enjoy a good book or radio or TV programme
□ Often
□ Sometimes
□ Not often
□ Very seldom

Questions about your Everyday Memory

Below are some questions asking you about everyday slips or failures you may experience with your memory. These questions come from the Prospective and Retrospective Memory Questionnaire developed by Smith, Della Sala, Logie and Maylor (2000). Please indicate the frequency with which you experience each of the following memory slips by clicking the box beside the reply most relevant to you.

Responding positively to these questions does <u>not</u> automatically indicate that you have a memory disorder.

Do you decide to do something in a few minutes time and then forget to do it?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you fail to recognise a place you have visited before?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you fail to do something a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you forget something that you were told a few minutes earlier?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you forget appointments, if you are not prompted by someone else or by a reminder such as a calendar or diary?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you fail to recognise a character in a radio or television show from scene to scene?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you forget to buy something you had planned to buy, like a birthday card, even when you see the shop?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you fail to recall things that have happened to you in the last few days?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you repeat the same story to the same person on different occasions?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you intend to take something with you, before leaving a room or going out, but minutes later leave it behind, even though it's there in front of you?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you mislay something that you have just put down, like a magazine or glasses?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you fail to mention or give something to a visitor that you were asked to pass on?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you look at something without realising that you have seen it moments before?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

If you tried to contact a friend or relative who was out, would you forget to try again later?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you forget what you watched on television the previous day?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

Do you forget to tell someone something you had meant to mention a few minutes ago?
□ very often
□ quite often
□ sometimes
□ rarely
□ never

You have now completed this survey. Thank you for your participation. We provide a recap of the purpose of the study and some additional information on the next page.

Thank you for your participation in this research on everyday memory.

Why are we carrying out this study?
Many people experience memory slips as they get older. These may be due to many reasons and are not always a sign of a memory disorder. This study is concerned with the type of everyday memory failures otherwise healthy older adults experience and how often they occur.

How was this achieved?
Taking part in this study required you to complete the Prospective and Retrospective Memory Questionnaire (PRMQ), a questionnaire measuring the frequency of failures to remember intentions for the future and events and information from the past. You were also asked to answer questions about your socio-demographics, current mood status and health status.

Main research question:
We are primarily interested in how often these types of memory slips happen to you in your daily life and whether you experience a particular type of slip more than others.

Why is this important to study?
This information about what is usual in the general population in terms of memory failures can help health professionals make better judgements about the potential seriousness of a person's individual memory complaints and to make appropriate care and referral decisions where needed.

What if I want to know more?
Individual feedback about your memory is not possible, owing to the anonymous nature of the information you have given us. However, if you would like a one-page summary of the findings of the study when it is completed and submitted for examination, please contact me at sophia.kilcullen4@mail.dcu.ie, or research supervisors, Dr. Kate Irving (kate.irving@dcu.ie) and Prof. Teresa Burke (teresa.burke@dcu.ie).

If you have any concerns about your memory or emotional well-being after taking part in this study, we advise you to discuss these concerns with your GP.

If you have any concerns about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Office of the Vice-President for Research, Dublin City University, Dublin 9. You may also contact the project supervisors, Dr. Kate Irving (Tel: 01 700 7985) and Prof. Teresa Burke (Tel: 01 700 7955)

If you are interested in participating in more research please see the following page for information on the opportunity to take part in a separate research study looking at the effects of brain training on memory and cognition.

Cognitive Reserve Training Study

PRINCIPAL INVESTIGATORS AND RESEARCHERS

Dr. Lorraine Boran, Dr. Kate Irving, Ms Lisa McGarrigle

School of Nursing and Human Sciences, DCU

CALL FOR VOLUTEEERS: THE COGNITIVE RESERVE TRAINING STUDY

We are looking to recruit healthy adults (aged 50 or over), including adults who believe they are experiencing memory loss (aged 50 or over), to take part in a brain training study. The goal of the study is to investigate the effects of an innovative type of computerised brain training on cognitive reserve. Cognitive reserve can be understood as the ability of the brain to cope with brain damage or age-related cognitive decline. This study predicts general improvements in cognitive reserve and broader cognitive abilities as a result of regular training using an online brain trainer we have developed.

As the training phase of the study will involve training online we are specifically looking for older adults with access to a computer and the internet. Participants will be required to play the brain training game online at home for approximately 50 minutes per day, 3 days a week, for 6 weeks in total. We will assess aspects of cognitive functioning in Dublin City University before and after training.

To find out more please contact: Lisa McGarrigle: Phone - 017006179; email:lisa.mcgarrigle5@mail.dcu.ie

Please note:

1. Only those who provide informed consent will be eligible to take part in the study. You will be asked to sign a consent form that will then be linked to your study data through a unique numerical code.

2. This study is not a comprehensive medical and psychological assessment. However, should you have any concerns about your memory, you can request a copy of your test scores for the attention of your GP. **If, for any reason, you have any concerns about your memory, you should consider consulting your GP for advice**

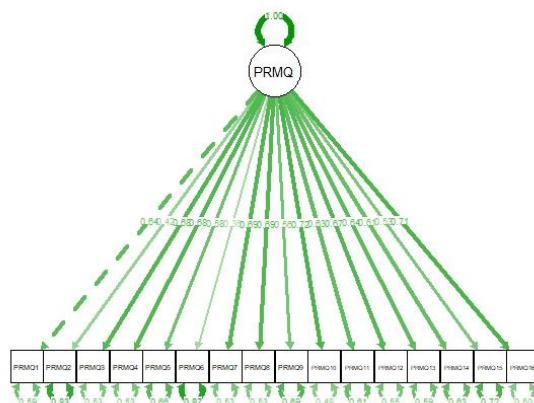## Appendix G: Supporting Data for Study 1 CFA Models

Model 1: One Factor Model

Table G.1: Standardised and Unstandardised Coefficients for One-Factor Model of PRMQ (Model 1)

PRMQ Item	Latent Construct	Standardized coefficients	Unstandardized coefficients	SE	P-value
PRMQ1	PM	0.584	1.000	0.025	.000
PRMQ3	PM	0.634	0.541	0.027	.000
PRMQ5	PM	0.589	1.100	0.026	.000
PRMQ7	PM	0.648	1.147	0.029	.000
PRMQ10	PM	0.618	1.002	0.025	.000
PRMQ12	PM	0.575	0.536	0.024	.000
PRMQ14	PM	0.494	1.115	0.022	.000
PRMQ16	PM	0.608	1.099	0.026	.000
PRMQ2	RM	0.335	0.845	0.016	.008
PRMQ4	RM	0.673	1.067	0.023	.004
PRMQ6	RM	0.352	1.061	0.020	.016
PRMQ8	RM	0.659	0.997	0.023	.005
PRMQ9	RM	0.487	0.789	0.016	.003
PRMQ11	RM	0.578	0.858	0.015	.002
PRMQ13	RM	0.482	0.872	0.020	.008
PRMQ15	RM	0.534	1.045	0.021	.007
PM	**GM**	**0.951**	**3.074**	**0.436**	**.000**
RM	**GM**	**0.951**	**3.085**	**1.176**	**.009**

PM: Prospective Memory; RM: Retrospective Memory

Model 2: Two-factor Model: PM and RM as uncorrelated factors
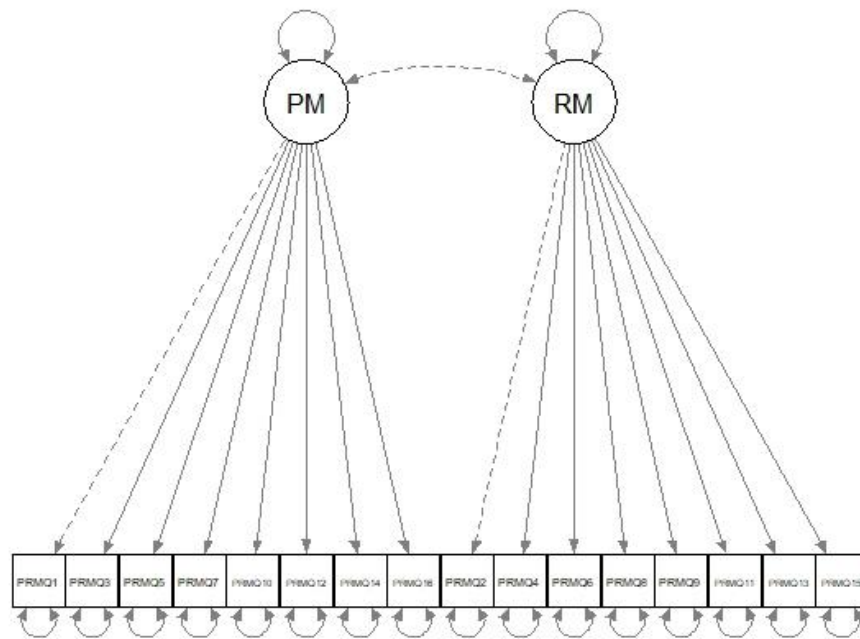
Table G.2: Standardised and Unstandardised Coefficients for Uncorrelated Factors Model of PRMQ (Model 2)

PRMQ Item	Latent Construct	Standardized coefficients	Unstandardized coefficients	SE	P-value
PRMQ1	PM	0.670	1.000	NA	.000
PRMQ3	PM	0.680	1.050	0.077	.000
PRMQ5	PM	0.583	0.905	0.092	.000
PRMQ7	PM	0.699	1.090	0.091	.000
PRMQ10	PM	0.736	1.050	0.080	.000
PRMQ12	PM	0.676	0.962	0.097	.000
PRMQ14	PM	0.601	0.816	0.076	.000
PRMQ16	PM	0.734	1.037	0.086	.000
PRMQ2	RM	0.486	1.000	NA	.000
PRMQ4	RM	0.678	1.812	0.206	.000
PRMQ6	RM	0.491	1.417	0.160	.000
PRMQ8	RM	0.727	1.850	0.216	.000
PRMQ9	RM	0.529	1.280	0.169	.000
PRMQ11	RM	0.510	1.374	0.192	.000
PRMQ13	RM	0.729	1.426	0.155	.000
PRMQ15	RM	0.596	1.554	0.196	.000

PM: Prospective Memory; RM: Retrospective Memory

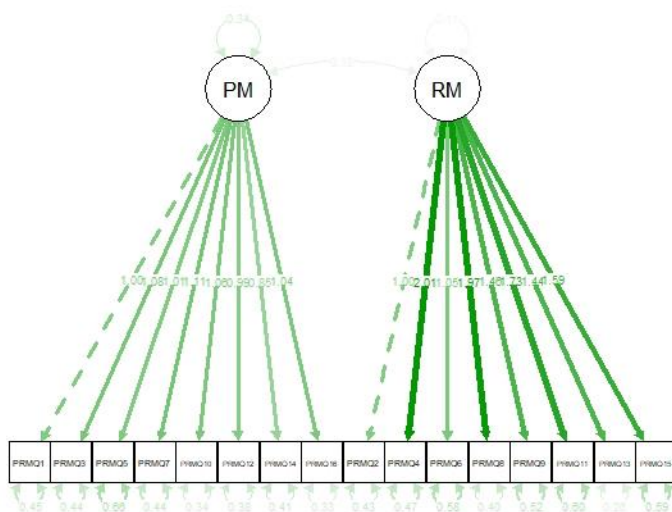**Model 3:** Two-factor Model: PM and RM as correlated factors

Table G.3: Standardised and Unstandardised Coefficients for Correlated Factors Model of PRMQ (Model 2)

PRMQ Item	Latent Construct	Standardized coefficients	Unstandardized coefficients	SE	P-value
PRMQ1	PM	0.658	1.000	NA	.000
PRMQ3	PM	0.690	1.083	0.076	.000
PRMQ5	PM	0.588	1.101	0.088	.000
PRMQ7	PM	0.700	1.111	0.091	.000
PRMQ10	PM	0.730	1.058	0.078	.000
PRMQ12	PM	0.681	0.986	0.092	.000
PRMQ14	PM	0.612	0.846	0.077	.000
PRMQ16	PM	0.725	1.042	0.081	.000
PRMQ2	RM	0.453	1.000	NA	.000
PRMQ4	RM	0.702	2.011	0.241	.000
PRMQ6	RM	0.420	1.052	0.164	.000
PRMQ8	RM	0.721	1.969	0.235	.000
PRMQ9	RM	0.561	1.455	0.196	.000
PRMQ11	RM	0.598	1.727	0.248	.000
PRMQ13	RM	0.687	1.442	0.170	.000
PRMQ15	RM	0.570	1.594	0.218	.000

PM: Prospective Memory; RM: Retrospective Memory
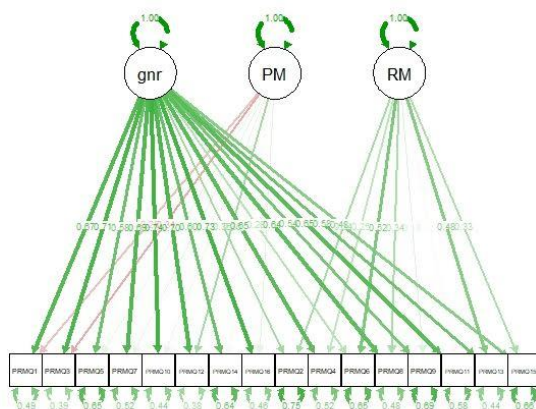
Model 5: Bi-factor Model.

Table G.4: Standardised and Unstandardised Coefficients for Correlated Factors Model of PRMQ (Model 5)

PRMQ item	Latent Construct	Standardized coefficients	Unstandardized coefficients	SE	P-value
General factor					
PRMQ1	GM	0.672	0.596	0.040	0.000
PRMQ2	GM	0.364	0.269	0.040	0.000
PRMQ3	GM	0.706	0.648	0.041	0.000
PRMQ4	GM	0.645	0.619	0.040	0.000
PRMQ5	GM	0.584	0.586	0.045	0.000
PRMQ6	GM	0.281	0.235	0.041	0.000
PRMQ7	GM	0.687	0.636	0.039	0.000
PRMQ8	GM	0.637	0.582	0.036	0.000
PRMQ9	GM	0.538	0.468	0.042	0.000
PRMQ10	GM	0.745	0.631	0.037	0.000
PRMQ11	GM	0.646	0.625	0.045	0.000
PRMQ12	GM	0.698	0.591	0.038	0.000
PRMQ13	GM	0.575	0.404	0.030	0.000
PRMQ14	GM	0.598	0.482	0.037	0.000
PRMQ15	GM	0.476	0.446	0.042	0.000
PRMQ16	GM	0.730	0.613	0.036	0.000
PM					
PRMQ1	PM	-0.249	-0.221	0.062	0.000
PRMQ3	PM	-0.337	-0.309	0.083	0.000
PRMQ5	PM	0.091	0.091	0.068	0.178
PRMQ7	PM	0.097	0.090	0.066	0.174
PRMQ10	PM	-0.069	-0.059	0.053	0.267
PRMQ12	PM	0.357	0.302	0.067	0.000
PRMQ14	PM	0.041	0.033	0.067	0.621
PRMQ16	PM	0.109	0.092	0.053	0.081
RM					
PRMQ2	RM	0.344	0.254	.045	0.000
PRMQ4	RM	0.274	0.237	.051	0.000
PRMQ6	RM	0.516	0.433	.058	0.000
PRMQ8	RM	0.337	0.308	.048	0.000
PRMQ9	RM	0.125	0.109	.051	0.032
PRMQ11	RM	-0.034	-0.033	.055	0.547
PRMQ13	RM	0.484	0.340	.044	0.000
PRMQ15	RM	0.332	0.311	.057	0.000

PM: Prospective Memory; RM: Retrospective Memory

Appendix H: Study 2 - Call for Volunteers

Call for Volunteers: New study on self-reported and objective memory functioning in older adults

Healthy volunteers, age 50 years and older, are needed to take part in a study looking at memory functioning and memory lapses. This research forms part of a larger research project examining aspects of memory in healthy aging and dementia. In order to understand memory decline in conditions such as dementia, we need to know about how memory functions in individuals without dementia. It is important, therefore, to study memory in healthy older adults. Thus, we are seeking volunteers without a history of dementia.

Background to the study: We are interested in finding out more about the type of memory mistakes people make in normal everyday life, how often these mistakes occur and the possible relationship between self-reported memory errors and performance on memory tests. This study will allow us learn more about the nature of memory in healthy older adults.

Who is involved? My name is Sophia Kilcullen and I am a PhD student doing research on memory in older adults in collaboration with Dr. Kate Irving and Prof. Teresa Burke, DCU School of Nursing and Human Sciences. This research is funded jointly by the Health Service Executive (HSE) and the Atlantic Philanthropies and it forms part of the DCU Dementia Elevator project.

What will the study involve? If you volunteer to take part in this study, you will be asked to you will be asked to answer some questions about your everyday memory, current mood-state, socio-demographics, health status and health history. We will also require you to complete some tests designed to assess your memory. Altogether, this will take between 60 and 90 minutes.

Why is this study beneficial? The information you give us in this study will help us understand the relationship between people's complaints about their memory and their actual memory performance. This can help us to develop better methods of screening for memory decline in the future.

How can I take part? If you are interested in knowing more about this research study, or you think you would like to participate, please contact me on 01 7006083, or by email at Sophia.kilcullen4@mail.dcu.ie We will then send you a detailed information sheet related to the study so that you can make a decision about whether or not to get involved.

Please note:

1. *Only those who provide informed consent will be eligible to take part in the study. Informed consent to participation will be documented through asking you to sign a consent form that will then be linked to your study data through a unique numerical code.*
2. *Because of the nature of this study, you cannot receive a diagnosis about your memory as a result of your participation in this study. However, should you have any concerns about your memory, you can request a copy of your test scores for the attention of your GP.*

If, for any reason, you have any concerns about your memory or your emotional well-being, you should consider consulting your GP for advice.

Appendix I: Study 2 - Plain Language Statement (PLS)

Information Sheet for Community Participants

Title of Study: Investigating Relationships between Self-reported Memory and Objective Memory Performance

Principle Investigator: Ms. Sophia Kilcullen (Tel: 01 700 6083)
                                                   Email: Sophia.kilcullen4@mail.dcu.ie

Co-investigators: Prof. Kate Irving, DCU School of Nursing and Human Sciences (Tel: 01 700 7985)

          Prof. Teresa Burke, DCU School of Nursing and Human Sciences (Tel: O1 700 7955)

Introduction: You are being invited to take part in a research study. The research is funded by The Atlantic Philanthropies and the HSE and is being carried out by Sophia Kilcullen, a PhD candidate in the School of Nursing and Human Sciences in Dublin City University (DCU) in part fulfilment of a PhD. Before you decide whether or not to participate, please read the following information carefully. If you require further information, or would like to ask any questions, please contact the research team – contact details are above.

Background and aims of the study: Older adults can be accurate assessors of their own memory and many experience memory slips and failures in their daily life. These are due to a number of possible reasons and may not automatically mean you have a memory disorder. Within general practice, most cases of mild memory impairment are overlooked and it would be beneficial to find methods of earlier detection. There are many reasons for this, but one may be the lack of sensitive tools for detecting early memory impairment in places like the GP clinic. We are interested in examining how accurate and useful recommended screening tools and other tests of memory are in the assessment of people with and without memory complaints.

Am I eligible to take part in the study? To take part in this study, you need to be aged 50 years or older, living independently in the community, be fluent in English and not have a history of dementia, neurological condition such as Parkinson's disease, stroke, tumour, multiple sclerosis etc., significant psychiatric illness, learning disability or significant hearing or visual impairment.

What does participation in the study involve? If you agree to take part in this study, you will be asked to attend DCU at a time that suits you to answer some questions about your everyday memory, current mood state, socio-demographics, health status and health history. You will also be asked to complete some tests that measure different aspects of memory including how well you can remember events and information from the past as well as intentions for the future. Altogether, your participation will take about 90 minutes.

Are there any risks associated with the study? As this study asks you for your opinions about your memory and mood, and requires your performance on memory tests, it is possible that you may become anxious or concerned about your memory or emotional well-being. If at any stage during your participation you feel concerned, you can withdraw without any consequences. In addition, you are advised to discuss your concerns with your local general practitioner (GP). Poor performance on any of the tests can be due to a number of possible reasons and will not automatically mean the presence of a memory disorder.

Are there any Benefits (direct or indirect) to my involvement in the Research Study? Your participation in this study will help to clarify the relationship between people's memory complaints and their performance on memory tests that are currently recommended as dementia screening tools. In particular, it will provide information about the sensitivity and accuracy of the various measures for people who report different levels of memory failures. This may or may not benefit you directly, but will benefit other people in the future who experience a decline in their memory abilities. This study is for research purposes only. It is not a comprehensive medical and psychological assessment of memory. Therefore, you will not receive any form of diagnosis as a result of taking part. However, if you are concerned about your memory, you can request feedback from Prof. Teresa Burke (research supervisor and senior clinical neuropsychologist) about your test performance and a copy of your test results can be provided for your GP.

How will the information I provide be protected? How will my identity be protected? If you agree to take part, all information collected will be kept strictly confidential within the limitations of the law. Your name and any other

personally identifiable information will be stored separately from your test data and will only be accessible to the research team. Findings published from this study in reports and journal articles will not contain any personally identifiable information. If you request individual feedback about your test performance, this will be provided by one of the research supervisors (Prof. Teresa Burke, who is a senior clinical neuropsychologist). Your GP may directly request a summary report of your test scores and, with your permission, this will be provided to them.

What will happen to the data? The data collected for this study will be summarised and will be presented in a PhD thesis to be submitted to DCU. The data may also be used for anonymised publication in journals or reports. Information will be stored for a maximum of 10 years. Thereafter, all documentation and electronic files will be destroyed permanently. A one-page summary of the research will be available upon request following submission and examination of the thesis. Although individual feedback will not be offered as a routine part of the research, as mentioned above, you may request feedback on your test performance for the attention of your GP if you have concerns about your memory.

Involvement in the Research Study is voluntary and you have a right to withdraw: Participation in this study is completely voluntary and there will be no penalty for withdrawing from the study. Whether or not you wish to take part in the study, you might be interested in obtaining some information related to memory, healthy ageing and dementia. If you are interested in improving your awareness about these topics, please see DCU Dementia Elevator project at http://dementiaelevator.ie/training-programmes/dementia-awareness-training. For video information about healthy brain practices that may help prevent dementia you can visit the webpage www.freedemliving.com from the Neuroenhancement for Independent Living (NEIL) centre in Trinity College Dublin.

What to do if there are concerns about the study: If you have any concern about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Office of the Vice-President for Research, Dublin City University, Dublin 9. You may also contact the project supervisors, Porf. Kate Irving (Tel: 01 01 7007985) and Prof. Teresa Burke (Tel: 01 700 7955).

What should I do now? If you are interested in completing the study, **please proceed to the Informed Consent Form**

Appendix J: Study 2 - Consent Form

Title of Study: Investigating Relationships between Self-Reported Memory and Objective Memory Performance

Principle Investigator: Ms. Sophia Kilcullen (Tel: 01 700 6083)

Email: Sophia.kilcullen4@mail.dcu.ie

Co-investigators: Prof. Kate Irving, DCU School of Nursing and Human Sciences (Tel: 01 700 7985)
Prof. Teresa Burke, DCU School of Nursing and Human Sciences (Tel: 01 700 7955)

Background and aims of the research:

Older adults can be accurate assessors of their memory, and many experience everyday memory slips. These can be due to many possible causes and may not automatically mean you have a memory disorder. Nevertheless, it is important to investigate individual complaints about memory with appropriate and sensitive screening tools to detect possible memory impairment as early as possible and prevent further decline. This study is examining how accurate and useful recommended dementia screening tools and other tests of memory are in the assessment of people with and without memory complaints.

Participant – please complete the following [tick Yes or No for each question]

Have you read the plain language statement?   □Yes   □ No

Do you understand the information provided?   □Yes   □ No

Have you had an opportunity to ask questions and discuss this study?   □Yes   □ No

Have you received satisfactory answers to all your questions?   □Yes   □ No

Can you confirm that you are aged 50 or above?   □Yes   □ No

Can you confirm that you have not been diagnosed with dementia?   □Yes   □ No

Can you confirm that you do not suffer from neurological condition   □Yes   □ No

such as Parkinson's disease, stroke, tumour, multiple sclerosis etc.,

significant psychiatric illness, learning disability or significant hearing

or visual impairment?

Participation is voluntary: I have read this consent form. I have had opportunity to ask questions about the consent from and all the questions have been answered to my satisfaction. I freely and voluntarily agree to be part of this research study, which respects my legal and ethical rights. I am aware that I may withdraw at any time, without giving reason, and without this decision affecting me in any way. I have received a copy of the plain language statement.

Confidentiality of Information: I understand that my consent form containing my name and any other potentially identifying information will be stored separately from my test data. Therefore, my test scores and other data provided will only be identifiable to the research team, and all my data will be stored securely. Confidentiality is assured but I am aware that confidentiality of information provided can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim, or mandated reporting by some professions. However, as explained above, due to the care taken to ensure my data is not directly identifiable, this will not have effect my privacy. Finally, I am aware that my GP may request and be provided with a summary report of my test scores.

Potential concerns about memory and/or emotional well-being: I am aware of the possibility that answering questions about my memory and current mood and performing memory tests may cause me to feel anxious or concerned about my memory and emotional well-being. I am aware that I should discuss any such concerns with my GP. I am aware that this study is for research purposes only and that it is not a comprehensive medical and psychological assessment of memory. Thus, I will not receive any form of diagnosis as a result of participating.

Consent

I have read and understood the information in this form. My questions and concerns have been answered by the researchers and I have a copy of this consent form. In providing my signature below, I consent to take part in this research project.

Participant's signature: _____   **Date:** _____

Name in Block Capitals:_____   **Witness:** _____

Appendix K: Study 2 Debriefing Statement

Why are we carrying out this study?

Many people experience memory slips as they get older. These may be due to many reasons and are not always a sign of a memory disorder. This study is concerned with the extent to which individuals' complaints about their memory reflect their actual memory performance on cognitive tests often used for the purpose of screening for memory problems.

How was this achieved?

Taking part in this study required you to answer some questions about your everyday memory, socio-demographics, current mood state and health status. You were also required to complete some cognitive tests designed to screen for memory impairment.

Main research question

We are primarily interested in finding out how sensitive and accurate recommended screening tests are for detecting early memory impairment in two groups of people: those who report problems with their everyday memory and those who do not.

Why is this important to study?

This information can help guide more accurate assessment and earlier detection of memory problems in general practice and may guide the development of effective screening tools in the future.

What if I want to know more?

Individual feedback about your memory is not offered as a routine part of the research project. Please note that this study is for research purposes only, and is not a substitute for a comprehensive medical and psychological assessment, therefore no diagnosis regarding your memory will be provided. However, if you are feeling anxious or concerned about your performance on the tests, you may request feedback in the form of a report of your test scores for the attention of your GP. Feedback will be provided by appointment with one of the research supervisors, Prof. Teresa Burke, who is a senior clinical neuropsychologist. Your GP may also directly request and be provided with information from the research team about your test performance as a routine part of general practice.

If you have any concerns about your memory or emotional well-being after participating in this study, we advise you to discuss these concerns with your GP.

If you would like a one page summary of the findings of the study when it is completed and submitted for examination, please contact me at Sophia.kilcullen4@mail.dcu.ie, or research supervisors, Dr. Kate Irving (kate.irving@dcu.ie), and Prof. Teresa Burke (Teresa.burke@dcu.ie)

If you have any concerns about this study and wish to contact an independent person, please contact: The Secretary, City University Research Ethics Committee, c/o Office of the Vice-President for Research, Dublin City University, Dublin 9, You may also contact project supervisors, Dr. Kate Irving (Tel: 01 7007985) and Prof. Teresa Burke (Tel: 01 7007955).

Please note: In the event that significant abnormalities are detected (in terms of significantly impaired cognitive test scores), a senior member of the research team will contact you and will advise you to speak with your GP who can, as per the test protocol, request and receive a summary of test results. In such cases, you will be reminded that there are many potential reasons for low test scores.