IMPROVING INTENTION REALISATION USING EMOTIONAL CUES AND IMPLEMENTATION INTENTIONS

by

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Abstract

Background: Remembering to act to realise an intention in the future is an important ability that comprises several cognitive processes, known collectively as *prospective memory*. Prospective memory failures can be costly, and so the effectiveness of strategies to improve prospective memory is an important area of investigation.

Aim: To investigate whether 'if [cue] – then [response]' plans, known as implementation intentions, are effective at improving prospective memory and whether their effectiveness can be enhanced by the use of emotionally-valenced cues.

Method: A systematic review and set of meta-analyses were conducted to consolidate the current knowledge on the effectiveness of emotional cues at improving prospective memory. Two experimental studies were then conducted which utilised implementation intentions in combination with emotional cues to improve prospective memory in a computer-based task (Experiment 1) and a naturalistic hand-washing task (Experiment 2).

Results: The results of the meta-analyses confirmed that despite contradictory results, emotional cues can improve prospective memory. However, the benefit is dependent on both the valence of the emotional cues and the timing of the manipulation of the valence of the cues. The results of the two experimental studies were inconclusive as to whether the strategies of emotional cues and implementation intentions are effective together. In the first experiment, emotional cues were

effective at improving prospective memory whereas implementation intentions were not, and in the second experiment the opposite pattern was observed.

Conclusion: Although the use of emotional cues and implementation intentions were not observed to be effective together in the present research, important moderating variables were identified that improve our knowledge of the parameters of effectiveness of both implementation intentions and emotional cues. Further research is suggested to continue this line of investigation.

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Chapter One – Introduction

Many intentions cannot be fulfilled the moment one commits to do so. For example, one may have the intention to post a letter, but be unable to do so until one passes a post-box later in the day. Unfortunately, research has shown that prospective memory is often fallible. Forgetting to perform an intention is a common form of memory complaint, making up between 50% - 80% of reported memory failures of all types (Crovitz & Daniel, 1984; Terry, 1988). A recent diary study by Schnitzspahn et al. (2016) found that a quarter of their participants' intentions failed to be fulfilled, and the most common reasons for failing to realise the intentions was forgetting (45%). Unsworth, Brewer and Spiller (2012) also conducted a diary study and found that on average their participants forgot to perform 6.13 intentions over the course of a week. Out of the nine different types of cognitive failure recorded in the study, failing to remember to perform an intention immediately following an activity was the second most commonly reported cognitive failure overall.

Slightly more encouraging results have been found in other studies: Marsh, Hicks and Landau (1998) found that overall only 13% of intentions were forgotten amongst their participants, although participants' strategies for aiding their prospective memory influenced this. For participants who usually used a planner to keep track of their intentions, preventing access to this resource meant that they reported that one in five of their intentions was forgotten. When tested under experimental conditions in the lab, prospective memory performance can vary considerably depending on the nature of the task, but has been found to be as poor as performing only 18% of required prospective memory actions in some studies (Hicks, Marsh & Russell, 2000).

Failing to fulfil an intention can range from being inconsequential to disastrous, as even important actions may have to be delayed until appropriate moments. For example, remembering to take medication at a specific time every day, remembering to attend an important meeting or doctors' appointment, or remembering to perform specific safety checks at appropriate points in aviation settings. Dismukes (2012a) reports the story of the fatal crash of Flight 1141 in 1988, which has been attributed to a failure of the pilots to remember to set the plane's wing flaps to the correct position necessary for take-off. Although thankfully most intention failures are not fatal, they can be embarrassing, in particular with socially-relevant intentions. Forgetting a friend's birthday, or attendance at an important meeting can have negative social consequences. Failures of prospective memory are often seen as reflecting general unreliability, rather than cognitive mishaps (Winograd, 1988), leading to social stigma. In the context of healthcare, failing to take medication as described or forgetting to perform important protective health behaviours such as handwashing can lead to serious health problems. Forgetting has been associated with a lack of adherence to both oral contraceptive pills (Leahy, Treacy & Molloy, 2015) and general medication adherence (Woods et al., 2014).

The prevalence and potential severity of the problem of failures of prospective memory has led to research into methods for improving people's memory to act in the future. Two strategies that have been proposed to help people to remember to act are the use of implementation intentions (Gollwitzer, 1993, 1999), derived from the Rubicon Model of motivation and action (Heckhausen & Gollwitzer, 1987); and the use of emotionally salient cues to action (Clark-Foos, Brewer, Marsh, Meeks, & Cook, 2009), originating from research into prospective

memory (Ellis, 1996). Although the theoretical backgrounds of these two strategies consider the issue of forgetting to act from different perspectives, they both seek to explain why people do not remember to fulfil their intentions and to provide solutions to prevent this. Researchers have already acknowledged the similarities between the approaches and the possibility that research from each field can inform the other. Ellis and Freeman (2012) state that "[An] important development that would benefit research on delayed intentions is to integrate theoretical proposals, methods, and findings from prospective memory and implementation research" (p.22). This is a suggestion that the present research seeks to address, since it has thus far received limited attention. The two main aims of the research are:

a) To expand our current knowledge on the role of emotion in intention realisation

b) To test empirically the integration of the two strategies of implementation intentions and emotional cues at improving intention realisation in two distinctive studies

The research has a number of noteworthy features when compared with studies that have been published to date either on implementation intentions or on the use of emotional cues to improve prospective memory. First, a systematic review and meta-analysis was carried out to inform the research. This gave important conceptual clarity and a sound basis to underpin the design of the experiments. Experiment 1 uses a novel computer-based task developed to explore the effect of emotional cues and implementation intentions on prospective memory. It extends previous research and overcomes some of the limitations of previous studies.

Experiment 2 was designed to obtain data in a more naturalistic context, again integrating the two approaches of implementation intentions and emotional cues to prompt performance of a real world behaviour (handwashing) rather than a computer- based task.

Outline of Chapters

Chapter 2 reviews the literature relevant to this research. Definitions and key concepts are clarified in relation to both implementation intentions and prospective memory. The overlap between the two fields is discussed and the theoretical context for the present studies is explained, in particular the use of strategies to improve prospective memory.

Chapter 3 presents a systematic review covering in depth the state of the current literature on prospective memory and emotion and highlighting the inconsistencies in the findings. An attempt is then made to address these inconsistencies using meta-analyses to determine an overall effect of emotion on prospective memory and to identify possible moderators. Chapter 4 reports an online prospective memory experiment that tests the concurrent effects of implementation intentions and emotional cues on prospective memory. A novel visual search task was developed for this experiment. Chapter 5 describes an implementation intention experiment to determine whether implementation intentions and emotional cues can be combined to improve prospective memory for the real world intention of handwashing behaviour. Finally, Chapter 6 discusses how the findings of the previous three chapters can be taken together to fulfil the aims of the present thesis and discusses the implications for future research on enhancing prospective memory.

Chapter Two - Literature review

This chapter is structured as follows: First, the key concepts from both the pproaches of implementation intentions and prospective memory are defined and the terminology clarified. Second, the overlap between the two approaches is discussed and research which has investigated the use of implementation intentions within a prospective memory framework is reviewed. Third, the development of methods to improve prospective memory and the effectiveness of implementation intentions are discussed, concluding with recent promising work on the use of emotional cues. The literature review will highlight that although there is promising evidence for the efficacy of implementation intentions and emotional cues at improving intention realisation, further research is needed to determine how robust the effect of emotion is, and to extend previous research into investigating the effect of both strategies concurrently.

The terms ‘intention fulfilment’ and ‘intention realisation’ are used throughout this thesis to refer to successfully performing any action that an individual has planned to perform at a specific time or opportunity in the future. This is based on the definition of Smith (2012), and consistent with the usage of authors such as Scullin, McDaniel, and Shelton (2013). The term ‘intention’ is therefore used in the present research to refer to both naturalistic actions that individuals decide themselves that they wish to perform in the future, and also to prospective memory tasks given to individuals by researchers in prospective memory experiments. The term ‘prospective memory performance’ is also used to refer to the realisation of experimenter-provided intentions in prospective memory experiments.

Implementation Intentions

One way of conceptualising a failure to realise an intention is as a failure to appropriately plan the situation in which one will act and the behaviour one will engage in to realise the intention. Gollwitzer (1993) separated 'intention' into two separate concepts: *goal intentions* and *implementation intentions*. Goal intentions are broad concepts and define the certain desirable 'end state' to work towards. For example "I will get a first class mark in my degree" is a goal intention that states the final outcome that is desired but does not specify how the goal will be attained. In contrast, implementation intentions are intentions that identify the behaviour or action that will help the user fulfil the goal intention, and link this action to a suitable situation in which to perform it. Implementation intentions take the form of an 'if-then' plan to perform behaviour, such as: "If I encounter situation X, then I will perform goal directed behaviour Y!", typically accompanied by either a written or vocalised repetition of the plan which ensures that the person has formed the intention (e.g., Kroese, Adriaanse, Evers, & De Ridder, 2011; Webb et al., 2012).

Intentions made in the goal intention form are more prone to remaining unfulfilled, as they rely on the person having to self-initiate the behaviours required to fulfil them at appropriate moments. People are often engaged in other tasks or are otherwise preoccupied when an opportune moment to fulfil their intention arises (Gollwitzer, 2006). For example, one may be distracted by talking to a student when a colleague walks past, resulting in a missed opportunity to fulfil the intention of passing the colleague a message. Merely specifying the goal intention of what one wishes to achieve does not result in the elaboration necessary to predict and prepare to overcome these obstacles. On the other hand, forming an implementation intention

forces the user to explicitly link a specific cue to action with an appropriate response in advance, and has been described as "passing the control of one's behaviour on to the environment" (Gollwitzer, 1993, p.173) meaning there is less reliance on conscious control and internal triggers to action.

Forming an implementation intention when committing to a more general goal intention is one strategy that people can use to help improve intention fulfilment. Implementation intentions have been shown to be effective at aiding realisation of a wide variety of different kinds of intentions. Much of the research on implementation intentions has been in the domain of health-related intentions (Sheeran, Milne, Webb, & Gollwitzer, 2005), for example remembering to perform breast and testicular examinations (Milne & Sheeran, 2002; Orbell, Hodgkins, & Sheeran, 1997), attend breast cancer screening sessions (Steadman, Rutter, & Quine, 2003) and apply sunscreen (Craciun, Schüz, Lippke, & Schwarzer, 2011).

However, researchers have also used implementation intentions in several other diverse contexts. For example, Elliot and Armitage (2006) showed that implementation intentions were effective at helping drivers to comply with 30mph speed limits. In this experiment, drivers formed 'if-then' plans that specified on which particular roads and journeys they would try to keep within the speed limit, and linked this to a self-determined strategy that would help them to do so. They found that self-reported compliance with speed limits significantly increased in the implementation intention condition compared to a control condition, and that this effect was not explained by increases in motivation – but rather by the effect of forming the if-then plan. In another novel application of implementation intentions, Nickerson and Rogers (2010) conducted an experiment in which phonecalls were

made to 287,228 potential voting households before the U.S. election in 2008. Participants heard either a phonecall script merely encouraging them to vote, or one which additionally asked them to make an implementation intention about when and where they would vote. After the election, voter turnout records were analysed to determine whether participants in each condition voted. The results showed that forming implementation intentions increased voter turnout by 4.1%, which rose to 9.1% for households with only a single voter. Another innovative use of implementation intentions has been to reduce jet lag amongst cabin crew on long haul flights. Ruscitto and Ogden (2017) showed that implementation intentions were effective at increasing the consumption of regular meals on participants' days off which subsequently reduced self-reported jet lag amongst participants.

Implementation intentions have also been applied to the realisation of intentions to perform pro-environmental behaviours. This is a domain in which the gap between a person's intention to perform a behaviour, and the performance of the behaviour itself, is particularly pronounced (Kollmus & Agyeman, 2002). However, implementation intentions have been shown to be effective at both increasing the use of public transport (Bamberg, 2000), and increasing energy-saving behaviours amongst adolescents (Bell, Toth, Little, & Smith, 2015). Furthermore, implementation intentions have been shown to impact on social behaviours, and in traditionally marginalised social groups. Arriaga and Longoria (2011) conducted an experiment in which Latino parents in the U.S. formed implementation intentions to promote parent-teacher communication. The intervention was successful at increasing communication with the teachers of the participants' children, despite the cultural and financial barriers typically faced by this demographic group. The

research reviewed in this section represents a small sample of the wide-ranging applications of implementation intentions. Meta-analysis can be used to aggregate the results of multiple studies that employ implementation intentions, and Gollwitzer and Sheeran (2006) provide an indication of the overall effectiveness of the strategy. They conducted a meta-analysis of 94 studies with a total sample of 8461 participants, and found an overall effect size of d= 0.65 (with a 95% confidence interval of 0.6 – 0.7). This corresponds to a 'medium-to-large' effect according to J. Cohen (1992). This effect size can also be understood in terms of McGraw and Wong's (1992) 'Common Language Effect Size'. In this case, an effect size of d= 0.65 means that there is a 67% chance that someone chosen at random from an implementation intentions condition of an experiment will have a better score (on the behaviour being measured) than someone in a control condition. Several other reviews - both systematic and narrative - have demonstrated implementation intentions' ability to help fulfil a range of different types of intention (e.g., Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011; Belanger-Gravel, Godin, & Amireault, 2013; Gallo & Gollwitzer, 2007a).

Mechanisms of Implementation Intentions. Gollwitzer (1993) suggested that implementation intentions aid intention realisation through two primary mechanisms. First, specifying a certain situation in which to act increases the chance of identifying the situation when it is encountered and consequently taking the opportunity to act. This is because the cues associated with being in that situation become more highly accessible and salient. This mechanism is known as "*cue accessibility"*.

Second, mentally linking the situation to an action may result in the action being automatically executed when the situation is recognised. This mechanism is known as *"cue-response link"* (Webb & Sheeran, 2007) though it is also known by several different names in the literature, including: 'cue-response association strength' (Webb & Sheeran, 2008), 'if-then link' (de Vet, Oenema, & Brug, 2011), 'situation-response link' (Webb, Sheeran, & Luszczynska, 2009), 'response automation' (Parks-Stamm, Gollwitzer, & Oettingen, 2007), and 'automatic action initiation' (Bayer, Achtziger, Gollwitzer, & Moskowitz, 2009). For the purposes of clarity this thesis will refer to it as the 'cue-response link' throughout. The benefit of a strong cue-response link is possibly best explained from the reverse angle: *not* successfully cementing a link between the situation and a behaviour means that conscious deliberation concerning a course of action may be required upon identifying a suitable situation to act. This then wastes precious time and cognitive resources which may result in a missed window of opportunity to act, or may result in an incorrect choice of action under the influence from competing goals. The mechanisms of implementation intentions can also be conceptualised as a shift from a top-down to a bottom-up processing style (Wieber, Thurmer, & Gollwitzer, 2015). In other words, whilst remembering to perform an action is normally reliant on an internal process to initiate a response at a correct time (which may be compromised by competing demands or distractions), implementation intentions pass this control over to an external cue. Therefore, bottom-up processing of the environmental cue takes over the role as the trigger for action initiation.

The use of implementation intentions as a strategy for helping to remember to perform a delayed intention has several benefits. Although the rise in the

availability of portable devices with detailed reminder functions means that prospective memory can be increasingly 'outsourced' to technology, there are several limitations to the use of these devices (Thöne-Otto & Walther, 2012). In many circumstances, their use may not be socially acceptable (for example in an important meeting); many people - especially older adults - may not have the skills required to use them; they require the device to be present and turned on which may not always be possible; and their successful use requires that they be programmed accurately, and that people remember to program them in the first place. Such devices can also be prohibitively expensive, and may get lost or break, rendering them unusable.

In contrast, implementation intentions are a simple and straightforward strategy to use, and can be employed to help improve prospective memory in a wide range of situations and populations as previously evidenced. In comparison to technological memory aids, there is no financial cost associated with the use of implementation intentions, and the strategy is quick and easy to employ. The potential pitfall of not forming a suitable implementation intention (for example, by specifying a vague or unclear cue or response) can be overcome by following guidelines for effective implementation intentions or employing a Volitional Help Sheet (Armitage, 2009), which includes a list of theoretically effective cues and responses to choose from. The strategy of implementation intentions also has advantages over other psychological approaches to improving prospective memory. For example, increasing the perceived importance of a prospective memory intention (Kliegel, Martin, McDaniel, & Einstein, 2004) or imbuing the intention with social significance can also improve intention fulfilment (Meacham & Kushner, 1980).

However, these strategies may be difficult or impractical to implement for many real-life intentions, as both are likely to require the use of significant resources (i.e., attitude change interventions, rewards, or willing accomplices).

In summary, specifying an intention to act in an implementation intention format is a simple, cost-free and well-established strategy for aiding intention realisation by helping to overcome problems of translating intentions into actions. Specifying in advance a cue to action and a response and linking them together in an 'if-then' plan means that the effort of detecting a suitable opportunity to act and choosing an appropriate response is spared from the influence of competing goals or other distractions at that moment in time.

Prospective Memory

A second approach to investigating failures to realise intentions is the cognitive approach of prospective memory, which can be defined as the memory to perform an action at an opportunity in the future (Dismukes, 2012b). A failure to perform this action is considered primarily to be due to the limits of the cognitive processes associated with detecting and accurately responding to the opportunity, such as attention and task-switching.

The term 'prospective memory' can be used to refer to both the actions that one intendeds to perform in the future ("I must remember to do this prospective memory action") and to the processes that underpin these tasks "I must use my prospective memory to perform the action" (Ellis & Freeman, 2012). Although the basic definition as stated above is that prospective memory is the memory to perform an action in a situation in the future, this definition is clearly vague and may

unintentionally include several behaviours not typically considered ‘prospective memory’. For example, having a whimsical fancy to visit Australia at some point in the next few years can arguably fit the definition of intending to perform an action in the future, but would not be considered a reflection of prospective memory. As such, McDaniel and Einstein (2007) outline five parameters to more clearly define prospective memory:

1. The action to be performed must not be immediately executed. This ensures the ‘prospective’ mechanisms of memory are tested to a reasonable extent – asking someone to perform an action immediately after hearing instructions would be considered by most psychologists to be a test of short term memory, which has its own field of investigation.
2. The prospective memory task must be performed concurrently with at least one other task or ongoing activity. This prevents simple tasks that cannot be executed immediately from being included in the definition, as these are unlikely to require prospective memory processes. For example, one may have the intention to exchange an item of clothing at a shop. This is unlikely to be forgotten if it is the only purpose of driving to the shop despite the fact that it may take some time to get there, as the intention can be kept in mind. However, prospective memory processes may come in to play if there are other tasks that need to be completed in the meantime.
3. The future opportunity in which to perform the action is in a constrained timeframe. This means that tasks in which the cue to action is very unspecific, such as “in the next few months I will wash my car” are not considered prospective memory tasks.

4. The action must be performed within a reasonable timeframe. Therefore, tasks which take a long time such as reading a book or taking a holiday are not considered prospective memory tasks even if they may fit the other criteria.
5. There must be an initial conscious intention to complete the action. This parameter prevents things like classical conditioning from being included in the definition.

Types of Prospective Memory

Prospective memory can broadly be split into two categories: event-based and time-based (Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). Event-based prospective memory refers to prospective memory actions that need to be completed in response to a specific event. Naturalistic events that may be commonly associated with prospective memory tasks include seeing a colleague (to pass on a message), passing a postbox (to post a letter) or walking past a corner shop (to pick up some milk). The other type of prospective memory is time-based, which refers to prospective memory actions that need to be completed at a certain time, for example picking up a child from school at 3.30pm, or ringing a friend in an hours' time when they are home from work. Time-based prospective memory is associated with a different set of cognitive processes to event-based prospective memory (McDaniel & Einstein, 2007; Park et al., 1997; Sellen, Louie, Harris, & Wilkins, 1997) and has its own set of theories and methodological paradigms used to investigate it. Of particular note is that time-based prospective memory is thought to rely more on internal processes to prompt intention realisation, as opposed to external cues used in event-based prospective memory (Sellen et al., 1997). The benefits of the strategies of implementation intentions and emotional content are thought to work by

enhancing the accessibility of specific external cues, and therefore the use of the term prospective memory and the discussion of findings and methodological paradigms in this thesis is henceforth restricted to event-based prospective memory. Time-based prospective memory is briefly discussed in Chapter 3, as some time-based prospective memory studies were included in the meta-analyses. However, detailed discussion of time-based prospective memory is beyond the scope of this thesis.

The field of prospective memory has developed at an increasing rate over the last 20 years (Gonen-Yaacovi & Burgess, 2012). There are several competing and complementary theories, including the preparatory attentional and memory processes model (Smith & Bayen, 2004), the multiprocess theory (Einstein et al., 2005), and the retrieval mode + target checking theory of monitoring (Guynn, 2003, 2012). The dual task paradigm (Einstein & McDaniel, 1990) has been established as the prevalent methodology for investigating prospective memory in the laboratory. The dual tasks are typically computer-based and comprise a prospective memory task to remember to perform an action at a specified instance, performed simultaneously with an ongoing task that simulates distraction and imposes the prospective delay. The flexibility of the paradigm has allowed it to be adapted for the investigation of specific research questions, for example by analysing costs to the ongoing task (e.g., Smith, 2003) or suspending the prospective memory task for a portion of the experiment (Scullin, Einstein, & McDaniel, 2009). Overall, these advances have allowed researchers in the past decade to make vast leaps in our understanding of the cognitive mechanisms underlying intention realisation.

Mechanisms of Prospective Memory

In contrast to the implementation intentions approach described earlier, which proposes only schematic mechanisms of how intentions are realised, the prospective memory approach offers a more detailed theoretical explanation. The process model of prospective memory (Kliegel, Altgassen, Hering & Rose, 2011; Kliegel, Martin, McDaniel & Einstein, 2002) offers a useful framework for understanding prospective memory in its entirety. The model separates the fulfilment of delayed intentions into four distinct phases, each of which is associated with a set of factors that moderate performance at that phase. These factors include task-based factors associated with the intention itself, external environmental and situational factors, and person-based factors which represent the cognitive processes employed during each phase. The first phase is *intention formation*, in which the intention is decided upon and committed to. This phase is moderated by the cognitive processes such as planning; as well as task-factors such as the importance of the intention. The *intention retention* phase follows, which requires the use of retrospective memory to keep the intention in mind (although not necessarily in consciousness) until the opportune moment to act arises. Executive processes of monitoring, cognitive flexibility and inhibition are required at the *intention initiation* phase to successfully detect the cue to action or an opportune moment to act. This is followed by the *intention execution* phase, during which the intended action is performed. In naturalistic settings, this final stage is likely to be highly influenced by external factors, and requires cognitive flexibility in order to interrupt any ongoing tasks to perform the intended action.

Other theories are primarily concerned with understanding precisely which types of cognitive processes underlie cue detection in intention realisation under different conditions. Detection of cues has been proposed to occur through either resource-demanding monitoring processes or resource-free spontaneous retrieval processes (Einstein et al., 2005). The two main theories of prospective memory are the preparatory attentional and memory processes model (Smith & Bayen, 2004) and the multiprocess theory (Einstein et al., 2005). These theories are both concerned with describing which types of processes are used in a prospective memory task, although they disagree on whether cognitive resources used to monitor for cues to action are always necessary (Smith & Bayen, 2004) or whether in some cases cue detection may be automatic and not require cognitive resources (Einstein et al., 2005). This debate has suffered from accusations of poor clarification of terminology and predictions on both sides (Einstein & McDaniel, 2010; Smith, 2010) and evidence is heavily based on laboratory-based tasks, meaning the theories have limited practical significance. Other research has attempted to explain in more detail how the cognitive processes underlying monitoring operate (Guynn, 2003, 2012), and how prospective memory intentions are retrieved upon cue detection (McDaniel, Guynn, Einstein, & Breneiser, 2004) although these too are concerned primarily with analysing the specific cognitive processes being used. As the aim of the current thesis is to test the functional effectiveness of specific strategies at improving prospective memory, it is outside the remit of the work to discuss the detailed predictions and tenets of the above theories which concern the broader theoretical underlying mechanisms.

One clear conclusion from the theoretical work is that the exact operation of the cognitive processes underlying prospective memory is dependent on a range of factors which are difficult to isolate (Scullin et al., 2013). It has been acknowledged that in everyday life the multiple possible processes that underlie cue detection and response retrieval are likely to "operate in concert… such that either process may support prospective memory at any given time." (McDaniel et al., 2004, p.613). This complexity means that there are many possible reasons for failing to remember to fulfil an intention. For example, there may be a lack of cognitive resources directed towards monitoring for the cue, or there may be properties of the cue that make it especially unsuited to triggering the prospective memory response spontaneously. However, whilst this complexity means it is difficult for the theories to predict which kinds of process underlie specific any specific instance of intention realisation, the wealth of possible reasons for prospective memory failure consequently predict many ways in which prospective memory can be improved. The prospective memory approach can therefore suggest several strategies to improve intention realisation, which will be discussed later.

Integrating Implementation Intentions and Prospective Memory Approaches

The social-cognitive approach used by implementation intention researchers has primarily considered the issues of motivation and volition with regards to intention fulfilment, and has neglected the investigation of the underlying cognitive processes (Achtziger & Gollwitzer, 2008). In contrast, the prospective memory approach has focused on the cognitive mechanisms of how intentions are encoded and retrieved, at the expense of interest in the motivational and volitional processes (Ellis & Freeman, 2012). The two approaches therefore take different viewpoints

when considering the cause of a failure to realise an intention: An implementation intention psychologist may find it interesting to find out that the reason that a participant failed to realise their intention of turning up to an appointment with an experimenter was because they consciously decided that another goal was more important. A cognitive psychologist concerned with the processes related to remembering to perform the intention is likely to be slightly more displeased that their participants are not taking their experiment seriously (a concern expressed by Einstein & McDaniel, 1990).

The applications of implementation intentions are therefore far broader than merely helping someone to remember to perform an action in an appropriate situation, as they can be used to overcome other obstacles to intention fulfilment by suppressing unwanted responses (Gallo & Gollwitzer, 2007b), ignoring distractions (Parks-Stamm, Gollwitzer, & Oettingen, 2010), helping to break habits by specifying alternative courses of action (Adriaanse, Gollwitzer, De Ridder, de Wit, & Kroese, 2011), disengaging from unsuccessful goal-striving behaviour (Henderson, Gollwitzer, & Oettingen, 2007) and increasing self-efficacy (Bayer & Gollwitzer, 2007). In contrast, the cognitive approach has provided a wealth of knowledge on how situational conditions influence intention fulfilment, including the demands of any ongoing tasks (Marsh, Hancock, & Hicks, 2002; Marsh, Hicks, & Cook, 2005), the relative importance of the intention compared to ongoing tasks (S. Walter & Meier, 2014), the salience of cues to action (Hicks, Cook, & Marsh, 2005), and the length of the delay between encoding the intention and the opportunity to realise it (McBride, Beckner, & Abney, 2011).

The social cognitive approach and the cognitive approach contribute different pieces to the puzzle of understanding the realisation of delayed intentions, and therefore the two approaches complement one another. The existence of the similarities in interests between implementation intentions and prospective memory researchers has triggered recent interest in integrating the findings of both areas. In particular, the impressive findings of how implementation intentions can improve intention realisation (Gollwitzer & Sheeran, 2006) have attracted the attention of prospective memory researchers.

Implementation Intentions in Prospective Memory Tasks

Recently, prospective memory researchers have begun to see how the use of implementation intention instructions can improve performance on laboratory-based prospective memory tasks. This research represents a different kind of test for implementation intentions which have been utilised primarily to help realise everyday intentions with clear benefits, such as taking a vitamin pill (Sheeran & Orbell, 1999). In contrast, prospective memory tasks are typically performed on a computer, and participants are asked to realise intentions that may seem arbitrary (e.g., "respond to animal words beginning with the letter 'C'", Knight et al., 2011).

Despite these differences, several studies have demonstrated the benefits of implementation intentions in a variety of different prospective memory experiments including lexical decision tasks (Meeks & Marsh, 2010; Rummel, Einstein, & Rampey, 2012), picture categorisation tasks (McCrea, Penningroth, & Radakovich, 2015), word categorisation tasks (McDaniel & Scullin, 2010), trivia question tasks (McFarland & Glisky, 2012) and colour-matching tasks (Smith, Rogers, McVay,

Lopez, & Loft, 2014). However, some experiments have only found a benefit in certain populations, e.g. older adults (Zimmermann & Meier, 2010).

It is worth noting that there has been some variation in the exact formulation of implementation intentions in prospective memory studies. Many studies have employed an imagery component involving imagining performing the prospective memory response in the specified situation (e.g., McDaniel, Howard, & Butler, 2008), which is not typically included in the formulation of implementation intentions in implementation research (Knauper et al., 2011). However, McFarland and Glisky (2012) showed that 'if-then' plans, imagery, and combined plan + imagery formulations of implementation intentions were equally effective.

A recent review of the literature on implementation intentions and prospective memory by X.J. Chen et al. (2015) was accompanied by a meta-analysis to determine the overall effectiveness of the strategy for improving prospective memory. An effect size of $d = 0.51$ was calculated, indicating a medium-sized effect (J. Cohen, 1988). However, not all studies included in the review reported benefits of implementation intentions. A study by Schnitzspahn and Kliegel (2009) found that implementation intentions were not effective at improving prospective memory for very old adults (*M* age: 81.5) and a study by Chasteen, Park and Schwarz (2001) also failed to find a benefit of implementation intentions in a computer-based prospective memory task in older adults. These negative results point to the presence of moderating variables for the effectiveness of implementation intentions. For example, it has been shown that cognitive ability can moderate the effectiveness of implementation intentions in older adults (Brom et al., 2014), and it is also possible that the type of prospective memory task may influence the effectiveness of the

strategy. Smith, Rogers, McVay, Lopez, and Loft (2014) suggest that performance on prospective memory tasks in which the prospective memory cues are not processed to a deep level (such as in the task used by Chasteen et al., 2001) may not be improved using implementation intentions, as a minimum amount of processing of a cue is necessary for implementation intentions to facilitate prospective memory.

Whilst acknowledging that implementation intentions may not be effective in all situations, the evidence suggests that overall the strategy is effective at improving prospective memory on laboratory-based prospective memory tasks as well as in naturalistic situations. It is easy to see how the postulated mechanisms of action of implementation intentions - an increase in the accessibility of the cue and an increase in the strength of the cue-response link - are triggered in comparison to typical prospective memory instructions. Neither of these benefits feature in typical prospective memory instructions that are commonly delivered in an off-the-cuff format without emphasis on either mechanism (e.g., Brewer, Knight, Meeks, & Marsh, 2011; Meeks & Marsh, 2010). In contrast, forming an implementation intention not only forces one to prepare to encounter the prospective memory cue ("*IF* I am in this situation…") but also to explicitly commit to performing the response ("*THEN* I will…"), resulting in the boosts to cue accessibility and the cue-response link.

Improving Intention Realisation

Returning to the overarching issue of intention realisation, it is clear that encoding a future intention in a specific 'if-then' implementation intention format is

a useful strategy to improve prospective memory ability, and thus aid people in realising their intentions.

The question then arises as to what other features of intentions can be manipulated to maximise the chances of intention realisation? Research from both the implementation intention and prospective memory domains have provided answers to this question using both the results of applied research and as a by-product of theoretical work on the processes underlying intention realisation. One obvious starting point has been to consider whether the *content* of the intention can be strategically manipulated to maximise the chances of intention realisation, and in particular the cue to trigger the required behaviour. The next section of this chapter describes research from both implementation intention and prospective memory research that has looked at the role of cues in realising intentions and strategies for improving intention realisation.

The Importance of Cues in Intention Realisation

In both implementation intention research and prospective memory research, a lot of effort has been devoted to researching how we encode and detect the opportunities to act that trigger the implementation intention or prospective memory response. The most common terminology is to refer to this component of both implementation intention and prospective memory as the 'cue' to action, and this is the term that will be used throughout this thesis. However, the term is sometimes also referred to in the implementation intention literature as the 'critical situation' (Webb & Sheeran, 2008) and in the prospective memory literature as the 'target' or 'target event', particularly in laboratory studies (McDaniel & Einstein, 2000).

There are numerous reasons why there is so much interest in the mechanisms associated with cue detection and the factors relating to this. First, the detection of a cue to action is important to successful intention realisation. If someone does not notice a cue to action, then they must rely on their internal processes to remember to realise their intention, which are less reliable (Gollwitzer & Cohen, 2012). Therefore, the choice of a suitable cue that has the highest chance of detection is important for successful intention fulfilment. Research has shown that failures of prospective memory are rarely to do with failing to remember the response required (Brandimonte & Passolunghi, 1994; A.-L. Cohen, Dixon, Lindsay, & Masson, 2003; McDaniel et al., 2004; Schnitzspahn, Horn, Bayen, & Kliegel, 2012) and are more likely to do with failure of the prospective processes: detecting a cue to action. In a structured interview conducted after a prospective memory experiment, Shum, Cahill, Hohaus, O'Gorman, and Chan (2013) found that 71% of participants who forgot to perform the prospective memory response blamed the lack of a strong cue to action.

Kliegel et al.'s (2002) process model of prospective memory also supports the assertion of the importance of prospective memory cues. In an empirical test of their model, they found that retrospective memory for intentions was very high, suggesting that prospective memory failures do not commonly occur during the *intention retention* phase of prospective memory. Relatedly, *intention execution* is likely to be strongly influenced by external factors, such as the complexity of the ongoing activities that a person is engaged in when detecting the cue to action. These external factors are likely to be difficult to predict and control, and thus attempting to improve prospective memory at this stage is not likely to be fruitful. Instead,

focusing on the *intention formation* and *intention initiation* stages of prospective memory, both of which are influenced by the choice of cue, would appear to be more prudent.

Second, in terms of everyday intention realisation, it is the cue component of both prospective memory and implementation intentions that is most malleable. In many cases in the real world where one intends to complete an action in the future, the choice of action itself is limited as it is determined by what one wants to achieve. For example, if you wish to send a birthday present to a relative who lives many miles away, the course of action is likely limited to posting a parcel. Similarly, if one wishes to eat more fruit and vegetables then the possible responses that will fulfil this intention are also limited. However, there are many possible opportunities to act in which the above responses can be performed. There may be many possible opportunities in the week preceding the birthday in which one could post the parcel, and many opportunities in which one could act to eat more fruit and vegetables. Therefore, in practical terms, determining a good opportunity to act and a suitable cue to action is often the fundamental choice needed in forming a future intention.

Despite the importance of successful cue detection for intention realisation, there are several common barriers that can impair cue detection ability. In particular, when people are heavily engaged in a concurrent activity and under conditions of high cognitive demand, prospective memory performance suffers. McDaniel and Scullin (2010) found across three experiments that prospective memory performance suffered dramatically (a drop of around 50%) when people were under high cognitive demand (by being required to continuously generate random numbers) compared to standard cognitive demand. Prospective memory performance is also

poorer when people are engaged in an ongoing activity that is complex (Marsh et al., 2002), requires divided attention (McDaniel, Robinson-Riegler, & Einstein, 1998) or is particularly absorbing and engaging (McDaniel & Einstein, 2000). These findings are recognisable in everyday experiences: we more commonly forget to do things when we are heavily engaged and interested in something else.

Improving Cue Detection

It is clear that whilst cue detection is important for intention realisation, it can be a difficult task when - as is common in everyday life - our attention is focused on other activities. In order to address this issue, research in both the fields of implementation intentions and prospective memory has investigated several factors to determine the most effective type of cue.

One such example is that cues that have been primed to occur in a specific context are more effective than those that have not. Nowinski and Dismukes (2005) illustrated this using a prospective memory experiment in which participants were asked to respond to words denoting the names of fruits, which could appear in the context of one of two ongoing tasks. Participants were primed to expect the word to appear in one of the tasks in particular (e.g., an anagram-solving task), by using that task as an example. Participants were more likely to respond to prospective memory cues that appeared in the primed task than the un-primed task.

The relationship between the cue and the response is another variable that can impact on the effectiveness of a cue. Several studies have shown that when the cue and the response have a high semantic association (e.g., seeing the cue word ‘pencil’, and responding by saying ‘sharpen’), prospective memory performance is improved

compared to low association cue and response pairs (McDaniel et al., 2004; Pereira, Ellis, & Freeman, 2012; Marsh, Hicks, Cook, Hanson, & Pallos, 2003).

Whilst prospective memory can undoubtedly be improved through these mechanisms, there are limitations to both approaches. The context in which a cue appears may not always be stable, and thus difficult to predict. For example, one may have the intention to pass a colleague a message, and expect that the next opportunity to do so will be at a meeting later in the day. If one unexpectedly met them at a bus-stop prior to this, the disconnect between the expected and actual contexts may result in a suitable opportunity to realise the intention being missed. Regarding the cue-response association mechanism, the majority of studies investigating this have been conducted using lab-based prospective memory paradigms and have employed a single cue with either a high or low associated response. However, in everyday life our intentions are commonly driven by the response that we wish to achieve, rather than the cue to trigger such a response. As such, for some intentions, such as a need to complete a tax return form, it may be difficult to assign a cue with a high association due to the paucity of obviously relevant cues.

Instead, the present research focuses on mechanisms that employ manipulations of factors inherent to the cue alone, that may be more applicable to interventions to improve prospective memory for a variety of intentions. Two of the most robust findings, discussed in detail below, are that increasing the specificity and salience of the cue leads to improved cue detection.

Cue Specificity

Prospective memory research on the specificity of cues has focused on whether a cue encoded as an exemplar or a category member affects intention realisation. In other words, whether the exact cue that is later to be detected is specified when encoding the intention ("When I see the word 'vulture' I will press the '7' key") or whether only a category to which the cue belongs is stated ("When I see an animal word. I will press the '7' key"; Wesslein, Rummel, & Boywitt, 2014). Several studies have demonstrated that prospective memory performance is improved when specific encoding of cues is used compared to categorical encoding (Einstein, Richardson, Guynn, Cunfer, & Mcdaniel, 1995; Ellis & Milne, 1996; van den Berg, Aarts, Midden, & Verplanken, 2004; Wesslein et al., 2014).

Researchers in the field of implementation intentions have also investigated the importance of cue specificity. De Vet et al. (2011) found that specificity moderated the effectiveness of implementation intentions that their participants generated to help realise their intentions to exercise more. Specificity was assessed by the number of prompts covered in the contents of the implementation intentions participants formed (the prompts being: *what, where, when (day), when (time),* and *how long*). They found that the number of specific implementation intentions (that answered all five prompts) was the best predictor of later physical activity, suggesting that plans with more specific cues were more effective. Gollwitzer, Wieber, Myers, and McCrea (2009) report the results of an unpublished study by Wieber, Odenthal, and Gollwitzer (2009) demonstrating a similar effect. Participants took part in a simulated driving task and made an implementation intention to either respond to a specific cue ("a black and white curved road sign") or an abstract one

("a dangerous situation"). They found that participants successfully realised the intention of adapting their speed more often when using the specific implementation intention.

The above research suggests that specific cues are more effective at being detected and thus realising specific one-time intentions, however there is also a drawback associated with them. The issue is that some intentions may require the response to be performed in multiple situations for the intention to be realised. For example, the intention to wash one's hands after a variety of different activities in healthcare settings (e.g., after touching a patient; before performing an aseptic procedure; World Health Organisation, 2009). The literature reviewed previously suggests that a specific cue should be specified for each of these situations in order for the intention to be realised at every necessary opportunity. However, there are problems associated with forming multiple implementation intentions in order to do this: Verhoeven, Adriaanse, de Ridder, de Vet, and Fennis (2013) showed that forming multiple implementation intentions that specified different situations in which to reduce unhealthy snacking was ineffective at assisting intention realisation. The authors suggest that the reason that multiple plans are ineffective is that interference occurs when forming multiple plans for the same intention which dilutes the effectiveness of each plan, as no negative effect was found from forming multiple implementation intentions for unrelated intentions.

Further evidence that specifying multiple cues is detrimental to intention fulfilment comes from the prospective memory work of Einstein, Holland, McDaniel, and Guynn (1992) who found that prospective memory performance was impaired when participants had to respond to any of four possible cue words during a

lexical decision task, compared to only a single cue word. Other studies have found that multiple cues did not affect prospective memory performance directly (A.-L. Cohen & Gollwitzer, 2008; Einstein et al., 2005; Meier & Zimmermann, 2015), but that they increased 'prospective memory load', meaning that participants took longer to respond during the concurrent ongoing task. This pattern of responses suggests that people adapt their strategy and allocate more resources to the prospective memory task when it is harder (Einstein et al., 2005; Meier & Zimmermann, 2015). However, in all three of these studies the ongoing task was not cognitively demanding and allowed for the use of such strategies to compensate for having to remember multiple cues. It is likely that when engaged in more cognitively demanding ongoing tasks that it may not be possible to employ such strategies and that intention fulfilment may suffer.

One possible way of overcoming this issue is if specific visual cues are employed that could be placed in multiple situations. In the example of the intention to wash one's hands in a variety of different contexts, one could form a single implementation intention with a cue that could be placed in multiple locations (e.g. next to a patient, next to aseptic procedural equipment) in order to trigger the response. An implementation intention specifying this cue in specific terms could then be created in order to maximise the chances of detection for this cue. This suggestion is tested empirically in Chapter 5.

Cue Salience

As well as increasing the specificity of cues, another way to enhance cue detection is by increasing the salience or distinctiveness of the cues. This finding

from the prospective memory literature is particularly relevant to the use of visual cues as discussed above, as salience is easily measured and manipulated for cues in this form. This section presents evidence for the benefit of salient cues and the variety of ways in which salience can be increased.

As might be expected, increasing the perceptual distinctiveness of prospective memory cues aids their detection, such as by increasing the size of the prospective memory cue (Uttl & Graf, 2000, as cited in Graf & Uttl, 2001). Similarly, presenting the prospective memory cue in uppercase words in the context of an ongoing task with lowercase words improves intention realisation (Brandimonte & Passolunghi, 1994). A.-L. Cohen et al. (2003) found a similar benefit for perceptual distinctiveness. Their prospective memory task was to press a key when a specific letter was displayed as part of a letter string used for an ongoing visual search task. When the letter used as the prospective memory cue was displaced from the letter string and presented on a separate line (thus making it perceptually distinctive), prospective memory performance was better. The benefits of visually salient cues to prospective memory have been shown to apply even when the cues are presented outside the focus of attention for the ongoing task (Hicks et al., 2005).

Salience can also be manipulated through semantic means. McDaniel and Einstein (1993) showed that unfamiliar meaningless words used as prospective memory cues improved intention realisation when presented in the context of familiar words. Brandimonte and Passolunghi (1994) extended these findings by showing that both semantic familiarity and semantic distinctiveness improved intention realisation. Unfamiliar words used as cues resulted in better prospective

memory performance than familiar words, but the context in which they were presented also affected performance. Familiar words presented within a set of unfamiliar words resulted in better prospective memory performance because the words were distinctive due to their familiarity. Recent research by Thomas and McBride (2016) showed that prospective memory cues belonging to a different semantic category than ongoing-task items also improved intention realisation. Prospective memory cues that were the names of body parts resulted in greater prospective memory performance when presented in a word rating task containing mostly words that were the names of fruits, compared to when the same prospective memory cues were presented in a word rating task of body part words.

Distinctiveness has even been shown to improve prospective memory when manipulated subconsciously. Lee and McDaniel (2013) conducted an innovative experiment in which prospective memory cues were embedded in an ongoing anagram-solving task. The prospective memory cues were either easy to solve or difficult to solve anagrams presented as part of a block of either easy or difficult anagrams. The results showed that discrepant prospective memory cues (e.g. easy anagrams presented in a block of difficult ones) produced greater performance than congruent cues. Importantly, a pilot study confirmed that the distinctiveness of the prospective memory cues (the difficulty of the anagrams) was not consciously detectable. This demonstrated that not only the inherent salience of the cues but also the context in which they are presented can influence prospective memory performance.

Increasing Cue Saliency with Emotion

Whilst the beneficial effects of increasing cue salience through perceptive and semantic means are well documented (McDaniel & Einstein, 2000, 2007), less is known regarding a recent promising line of research to increase the salience of cues by imbuing them with emotional properties. Emotion is inescapable in everyday life and has been described as a powerful feedback system that helps influence our cognitive processes in order to help us make adaptive responses to our environment (Baumeister, Vohs, DeWall, & Zhang, 2007). As such, the relationship between cognition and emotion has been well studied, and a large body of research is discussed below that has shown that emotional content has many beneficial effects on cognitive performance.

One main finding from this literature is that memory for items that have been previously seen (retrospective memory) has been shown to be enhanced by emotion. There is a well-documented observation that emotional stimuli are better remembered than non-emotional stimuli (see Buchanan & Adolphs, 2002 for a review). Bradley, Greenwald, Petry, and Lang (1992) found that participants had a significantly better memory for pictures rated as highly emotionally arousing, and highly pleasant or unpleasant, both in an immediate recall task and in a recall task a year later. As well as pictures, emotionally arousing words have also been found to have preferential memory effects. A series of experiments by Kensinger and Corkin (2003) found that not only did participants remember more negative emotional stimuli than neutral stimuli, they also remembered more details relating to the words (for example, the colour the word was printed in). Strict controls, including matching words for length, frequency, ease of visually imagining the word and a condition

where neutral words were categorically similar revealed that emotional words had a unique benefit compared to neutral words.

Emotion has also been shown to have beneficial effects on attention (Vuilleumier, 2005). For example, emotional targets have been shown to attract attention to a greater extent than neutral targets in visual search tasks (Frischen, Eastwood, & Smilek, 2008), meaning they are highly salient. Furthermore, eye movement studies have shown that emotionally-valenced pictures can capture attention involuntarily (Nummenmaa, Hyona, & Calvo, 2006). Emotional stimuli may even increase basic perceptual processing: Phelps, Ling, and Carrasco (2006) found that participants exhibited enhanced perception (measured by an increase in orientation sensitivity) after viewing a fearful face rather than a neutral face, as the emotional stimuli triggered an increase in attention and perceptive ability. Although the relationship between attention and emotion may be moderated by several factors including task demands and individual differences (Okon-Singer, Lichtenstein-Vidne, & Cohen, 2013), overall it appears that emotional stimuli attract attention to a greater extent than neutral stimuli (Yiend, Barnicot, & Koster, 2013). N. A. Murphy and Isaacowitz (2008) conducted a meta-analysis of studies examining a preference for emotional stimuli and concluded that there were benefits of emotional over neutral stimuli for both attention and memory ($d = 0.29$), and the benefits were particularly pronounced for positive stimuli in older adults ($d = 0.47$).

The preferential processing that emotional stimuli receive is thought to be because these stimuli are highly relevant for the concerns of the observer (Brosch, Pourtois, & Sander, 2010). For example, a negative stimulus such as a picture of a snake may signify a threat, and a positive stimulus such as a picture of a stack of

money signifies something desirable. In both cases, it is evolutionary advantageous to be able to attend to these stimuli quickly for further processing and evaluation. This preferential processing, outlined in the studies above, means that emotional stimuli should be extremely suited to being employed as cues for intention realisation, given their inherent attention-attracting properties and benefits in memory. The use of specific visual cues - in order to combat the previously mentioned issues with using multiple or unspecific cues - also lend themselves to the application of emotional enhancement. Certain types of visual cue such as faces have been shown to have high emotional value (Okon-Singer et al., 2013), meaning that emotional-valence and arousal are easily manipulated in this type of cue.

The idea that emotional cues may influence intention realisation has not gone unnoticed by prospective memory researchers, and in recent years there has been a surge of interest in examining the interaction between emotion and prospective memory. Several studies have been conducted exploring the effect of emotional cues on prospective memory performance, and the results are promising. Rummel, Hepp, Klein, and Silberleitner (2012) found benefits for prospective memory performance for both positive and negative cues compared to neutral, as did May, Manning, Einstein, Becker, and Owens (2015). However, some researchers have only found benefits from positive cues and not negative (Altgassen, Henry, Burgler, & Kliegel, 2011) and some researchers have found detrimental effects of emotional cues (Graf & Yu, 2015). The inconsistencies in the literature will be discussed in depth in Chapter 3.

The strong theoretical reasons underpinning the benefits of emotional cues in intention realisation, based on the wealth of literature from the domain of cognition

and emotion (e.g., Yiend et al., 2013) and the promising results of recent studies in the laboratory (e.g., May et al., 2015) suggest that investigation of the idea that emotional cues can enhance intention realisation is worth pursuing, although the inconsistencies in the literature mean that clarification of the conditions under which emotional cues improve prospective memory is first required. To this end, the clear first step in this investigation is to review and synthesise the literature on emotion and intention realisation to come to an understanding of the degree to which, and under what conditions, emotion is likely to affect prospective memory and intention realisation. This will be addressed by the systematic review and meta-analyses presented in Chapter 3.

The Current Programme of Research

Failing to realise a delayed intention can have potentially fatal consequences, but the use of two complementary strategies has the potential to improve intention realisation. Derived from the social-cognitive approach to intention realisation, implementation intentions are if-then plans that specify exactly how a person should act upon encountering a suitable cue to action to realise their intentions, and have been shown to improve prospective memory. The cognitive approach of prospective memory has presented promising evidence that the use of emotionally-valenced cues to action also enhance intention realisation.

Whilst both strategies have been shown to be effective individually, there has yet to be any research that has investigated utilising both strategies simultaneously, i.e., specifying an emotional cue in the 'if' portion of an implementation intention. Both strategies are likely to improve prospective memory at the *intention initiation*

phase of prospective memory (Kliegel et al., 2002), by improving the likelihood that a cue to action is detected and acted upon. It is possible that the combination of both strategies may not be more effective than either strategy alone due to ceiling effects resulting from targeting the same phase of prospective memory, and the influence of external factors in prospective memory performance. However, an alternative prediction is that implementation intentions that specify emotional cues would produce a synergistic effect: Implementation encoding is thought to result in a shift toward bottom-up processing of cues, and to lower the threshold at which conscious resources are required to detect suitable opportunities to act (Wieber et al., 2015). Emotional cues are highly salient, and thus should be particularly suited to triggering prospective memory intentions, especially if the threshold for detection is lower. This echoes a suggestion by Webb and Sheeran (2008) that "any procedure that increases the accessibility of the specified opportunity [cue accessibility] or promotes stronger cue–response associations [cue-response link] has the potential to enhance the impact of forming implementation intentions on goal attainment" (p.389).

The present research seeks to investigate the question of whether both strategies are effective together at improving prospective memory performance, whilst contributing more generally to our knowledge of the use of cues in prospective memory. Specifically, the aims of the research are to: (a) establish the extent to which emotional cues are effective at triggering prospective memory and to explore any moderating variables of these effects, and (b) empirically test whether both strategies, when used concurrently, can improve prospective memory.

These aims will be achieved in the following way. First, a systematic review and meta-analyses will be conducted to provide an overall estimate of the influence of emotional cues on prospective memory based on our current knowledge, and to test moderating variables of this influence. The results of this study will inform the design of two experiments that address the question of whether the two strategies of implementation intentions and emotional cues can be effectively combined to enhance intention realisation. The first experiment, presented in Chapter 4, will test the use of the two strategies using a novel online methodology, based on the prospective memory dual task paradigm. The design of this study also allows the assessment of the relative strengths of the strategies. Chapter 5 will extend this investigation of using both strategies concurrently in an implementation intention experiment to enhance the real world behaviour of handwashing. Taken together the results of all three chapters will provide a more detailed understanding of whether intention realisation can be enhanced by both emotional cues and implementation intentions and this will be discussed in Chapter 6.

Chapter Three: A Systematic Review and Meta-Analyses of the Effect of Emotion on Prospective Memory.

As discussed in Chapter 2, the use of emotionally-valenced prospective memory cues is a promising avenue for improving intention realisation. The prevailing view in the wider literature of emotion and cognition is that emotion enhances both memory and attention towards stimuli (Brosch et al., 2010; Hamann, 2001; N. A. Murphy & Isaacowitz, 2008; Yiend, 2010). Emotional cues are therefore likely to improve prospective memory performance as the above processes are involved in the encoding and detection of prospective memory cues. However, the specific use of emotional cues in prospective memory paradigms has not been researched extensively, and the current literature that has investigated the effects of emotion on prospective memory performance directly is contradictory. The present chapter presents the results of a systematic review of the literature and a series of meta-analyses that were performed to achieve the following aims:

a) To bring together for the first time all the available literature that has looked at the effect of emotional cues on prospective memory performance.
b) To quantify an overall direction and magnitude of the effect size of emotional cues on prospective memory performance.
c) To investigate potential moderating variables that may explain the contradictory results concerning the effect of emotional cues on prospective memory.

The chapter is structured as follows: First, the evidence for the influence of emotional stimuli on cognition in general is reviewed, with a focus on the cognitive processes such as memory and attention that are likely to be relevant to prospective memory performance. This section is split into how emotional stimuli, and by extension emotional cues, may affect the separate mechanisms of encoding and detection in prospective memory. Second, the contradictions present in the current available literature on the use of emotional cues in prospective memory are briefly reviewed. Third, potential moderators of the influence of emotional cues are discussed. The method for conducting the systematic review and meta-analyses is then presented, followed by the results and a discussion of the findings, with respect to the theoretical and practical implications.

The Influence of Emotion on Cognition

The feedback theory of emotion (Baumeister et al., 2007) describes two ways in which emotion influences our cognition: Through full-blown conscious moods, and brief 'twinges' of emotional appraisal that arise automatically when a stimulus is perceived. The latter of these two mechanisms - the brief 'affective responses' that accompany the perception of stimuli - have been shown to influence our behaviour indirectly through higher-level cognitive processes (Baumeister et al., 2007; Robinson, Watkins, & Harmon-Jones, 2013), such as prospective memory. In other words, the affective responses to stimuli used as cues to trigger prospective memory can have an influence on the cognitive processes underlying prospective memory and thus moderate prospective memory performance.

The process model of prospective memory (Kliegel et al., 2002) splits prospective memory into four processes of formation, retention, initiation, and execution. The two processes in particular in which factors relating to the cue (such as emotionality) are thought to influence prospective memory the most are the processes of forming the intention, and initiating the prospective memory response. These processes have also been referred to as processes of 'encoding' and 'retrieval' (Ellis & Freeman, 2012; Hannon & Daneman, 2007; Kvavilashvili & Ellis, 1996). In the present chapter, the term 'encoding' is used to refer to forming a prospective memory intention, and the term 'detection' is preferred to 'retrieval' to refer to the second process. The focus of interest here is on the manipulation of a variable relating to the cue (in this case, emotional valence), and the words 'encoding' and 'detection' lend themselves more easily to discussing the role of the cue is prospective memory. The encoding process represents the formation of a prospective memory intention. It is the act of encoding in memory the cue or stimulus that will trigger the behavioural response and the response itself, and cognitively linking them together. Detection refers to the act of later encountering the prospective memory cue and recognising it as the pre-defined opportunity to act to perform the prospective memory response. These processes may be separately affected by emotion, but there may also be synergistic effecst of emotion on prospective memory through both the encoding and detection processes. Hannon and Daneman (2007) found that manipulating the salience of a prospective memory cue at both encoding and detection had a greater influence on prospective memory than when only a single process was affected. It is possible that emotional stimuli influence prospective memory through both the encoding and detection processes. A wealth of

research has been conducted on the effects of emotional stimuli on cognition more generally, and the findings from this literature that are relevant to how emotion may affect the processes of encoding and detecting prospective memory cues are reviewed here.

Emotion and cue encoding. Emotion has been shown to influence how stimuli are encoded in memory (Dolan, 2002; Kensinger, 2009; Mather, 2007). For example, viewing emotional stimuli has been shown to increase the allocation of attentional and visual processing resources that facilitate encoding (Calvo & Lang, 2004; Nummenmaa et al., 2006; Phelps et al., 2006; Pilarczyk & Kuniecki, 2014). Emotion may also enhance memory consolidation procedures (Mather, 2007). Emotional material has been shown to activate the amygdala when being encoded (Hamann, 2001) and this may underlie a differential encoding process comparative to non-emotional items which results in both enhanced long-term (Hamann, Ely, Grafton, & Kilts, 1999) and short-term memory (Hamaan & Mao, 2001, cited in Hamann, 2001) for emotional stimuli. These influences on encoding could lead to improvements in prospective memory when applied to prospective memory cues, as a stronger memory and mental representation of the features of an encoded cue should facilitate subsequent cue detection and thus enhance prospective memory. However, the influence on encoding and subsequent prospective memory performance may be valence-specific. Negative stimuli are thought to promote perceptual processing, whereas positive stimuli are thought to promote semantic processing (Kensinger, 2009; Kensinger & Schacter, 2008; Mickley & Kensinger, 2008). In other words, the perceptual details of negative stimuli are more likely to be encoded, compared to 'gist' and conceptual information about positive stimuli. Both

perceptual and semantic processing can underlie the detection of prospective memory cues (McGann, Ellis, & Milne, 2003). Therefore, either benefits or impairments to prospective memory performance could be expected when emotional cues are encoded, depending on the valence of the prospective memory cues and the type of processing utilised to detect them.

Emotion and cue detection. The emotional content of prospective memory cues may also influence prospective memory retrieval processes by facilitating the detection of the cues. Emotional stimuli have been shown to attract attention compared to neutral stimuli (see Brosch et al., 2010 for reviews; Yiend, 2010). McDaniel and Einstein's (2000) multiprocess framework suggests that both conscious monitoring and automatic spontaneous retrieval strategies can be used to detect prospective memory cues. Research from the broader literature on emotion and cognition suggests that employing an emotional cue could be beneficial for prospective memory in both conscious monitoring and automatic spontaneous retrieval. For example, when effortful monitoring strategies are used, emotional targets have been shown to attract attention to a greater extent than neutral targets in visual search tasks (Frischen et al., 2008; Ohman, Flykt, & Esteves, 2001; Williams, Moss, Bradshaw, & Mattingley, 2005). Concurrently, emotion may be beneficial for spontaneous memory retrieval: Eye movement and ERP studies have shown that valenced pictures can capture attention involuntarily (Brosch et al., 2010; Carretie, Hinojosa, Martin-Loeches, Mercado, & Tapia, 2004; Nummenmaa et al., 2006). These effects may be underpinned by enhanced sensory processing of emotional stimuli (Vuilleumier, 2005).

Empirical Research on Emotional Cues and Prospective Memory

Despite the established benefits of emotional stimuli on attention and memory in the broader literature of emotion and cognition, direct empirical evidence for a benefit of emotional cues in prospective memory is mixed. Some studies report a benefit of emotional cues (Altgassen, Phillips, Henry, Rendell, & Kliegel, 2010; May et al., 2015; Rummel, Hepp, et al., 2012); some studies report a detrimental effect of emotional cues (Ballhausen, Rendell, Henry, Joeffry, & Kliegel, 2015; Graf & Yu, 2015; N. T. Walter & Bayen, 2016); some studies report a beneficial effect, but only for one particular valence (Altgassen et al., 2011; Mioni et al., 2015; Rendell et al., 2011) and some studies report no difference between emotional and neutral cues (Cona, Kliegel, & Bisiacchi, 2015; Marsh et al., 2009).

The present systematic review and meta-analyses seek to address these contradictions and provide clarity to the issue of whether emotional cues influence prospective memory. In addition, in order to investigate the likely mechanisms through which emotional cues influence prospective memory, the timing of the emotional manipulation (i.e., whether the valence of the cues is manipulated during the encoding or detection process) is coded and tested as a moderator in the present meta-analyses. Studies investigating emotional cues in prospective memory have used a variety of different manipulations that can be easily grouped based on the prospective memory process that the manipulation influences. For example, (Henry et al., 2015) employed a manipulation that only manipulated the valence of the prospective memory cues during the encoding process. They did this by telling participants the semantic category to which the prospective memory cues belonged, and presenting a valenced exemplar of the category during encoding (e.g., a

negatively valenced image from the category of 'insects'). However, the prospective memory cues presented during the detection phase were neutral in valence.

The specificity of the cues given to participants at encoding can also be used to code for the prospective memory process influenced by emotionally valenced cues. In some prospective memory studies, participants are merely given the category to which the prospective memory cue belongs, for example "animals" (Clark-Foos et al., 2009). In the other studies, participants are given the exact cues they will later have to detect (e.g., the word "terrorist", May et al., 2015). The use of categorical and specific cues can be mapped on to manipulations that respectively influence the detection process only, or both the encoding and detection processes. In the study by Clark-Foos et al. (2009), participants encoded the semantic category to which the prospective memory cues belonged, but no exemplar was presented. Subsequently, the cues presented during the detection phase were varied on their emotional valence. Therefore, the valence of the cues was only manipulated during the detection phase. In contrast, May et al. (2015) presented the exact cues (emotional or neutral) that participants had to detect at both the encoding and detection phases. Calculating separate effect sizes for the influence of emotional cues on the separate processes of prospective memory can help determine the likely mechanisms underlying any overall effect on prospective memory performance.

Potential Moderators

Methodological. Differences in the methodologies used in prospective memory experiments may also explain the aforementioned discrepancies in the findings of studies investigating prospective memory and emotion. One clear

difference between prospective memory experiments investigating the influence of emotion is the type of cues used (words or pictures) in the prospective memory task. The study by Graf and Yu (2015) employed picture cues (e.g., a picture of a puppy) whereas the studies by Altgassen et al. (2011) and May et al. (2015) used words (e.g., "happiness", "passion"). Research has shown that when valence is not controlled for, prospective memory is better when pictures compared to words are used as cues (McDaniel et al., 1998). However, there is not yet any research that tests directly how the superior effect of pictures in prospective memory may interact with affective valence. Research in other domains investigating the interaction between stimulus type and affect has primarily been in the neuroimaging literature (e.g., Flaisch et al., 2015; Leclerc & Kensinger, 2011) and has not focused on behavioural outcomes. However, De Houwer and Hermans (1994) found that emotional pictures received preferential affective processing compared to emotional words. In their experiment, the affective categorisation of words was influenced by incongruent affective pictures, but the reverse effect was not observed. These results suggest that any potential benefit of emotional cues in prospective memory may be stronger for pictures rather than words.

The results from the aforementioned studies suggest a more complex interaction than an enhanced emotional effect for picture cues. Altgassen et al.'s (2011) study employed words but found a benefit only for positive but not negative cues, whereas May et al. (2015) found benefits for both positive and negative word cues. Graf and Yu (2015) used picture cues but found a detrimental effect of emotional cues, whereas other studies, for example Altgassen et al. (2010) found

benefits for emotional cues in older adults using pictures. Quantitative investigation using meta-analytic techniques should help to clarify the effects of cue type.

Age. Age moderates both prospective memory ability and emotional effects on cognition such that prospective memory ability is poorer in older adults (Henry, MacLeod, Phillips, & Crawford, 2004), yet older adults show enhanced memory and attention for positive stimuli (Mather & Carstensen, 2005). In addition, age differences in prospective memory can be influenced by properties of the prospective memory cues and tasks (Ihle, Hering, Mahy, Bisiacchi, & Kliegel, 2013; Kliegel, Phillips, & Jager, 2008). Several studies have provided direct tests of the moderating effect of age on the influence of emotion on prospective memory including May et al. (2015), Schnitzspahn et al. (2012) and Altgassen et al. (2010). These studies have tested both younger (typically around 20 years old) and older (typically around 70 years old) adults on the same prospective memory tasks, though again with conflicting results. For example, Schnitzspahn et al. (2012) found a benefit for emotional cues in older adults only. However, May et al. (2015) found benefits for emotional cues in both younger and older adults. The overall effect of manipulating the valence of cues on younger and older adults is not clear due to the conflicting results in the literature, and as such, a test of this moderator would be valuable.

Overall, the wider literature on emotion and cognition indicates that emotional stimuli have beneficial effects on memory and attention. The extent to which these cognitive processes are used in prospective memory suggests that the use of emotional cues may enhance prospective memory. Enhanced memory effects are likely to come from employing emotional cues in the prospective memory encoding process, whereas enhanced attention to emotional cues is likely to benefit

the detection process. The valence of the cues may also be important in determining their influence on cognitive processes (Kensinger, 2009). However, the literature that has directly investigated emotional cues and prospective memory has produced a number of conflicting findings. Systematic synthesis of the research findings to date should help to clarify the influence of emotional stimuli on prospective memory and the separate effects of positive and negative cues, as well as the possible moderating effects of any methodological and age differences between experiments.

The Present Research

Previous research suggests that the influence of emotion on prospective memory may be complex. Due to the conflicting findings reported in many studies, it is currently unclear as to both the extent and direction of any influence that emotion exerts on prospective memory through manipulating the affective valence of prospective memory cues (at either the encoding process, detection process or both). This influence is likely to occur in everyday life: We make positive and negative affective responses to goal-related stimuli such as prospective memory cues as well as extraneous stimuli. Therefore, understanding the distinct effects of this influence of emotion on prospective memory is important to develop our understanding of how prospective memory operates in everyday life. Furthermore, the use of moderator analysis will allow the identification of potential variables that can limit or increase the effectiveness of emotion at improving prospective memory.

The present research uses the novel approach of systematic review and meta-analyses to aggregate and provide structure to the fragmented literature on prospective memory and emotion, and to identify areas for future research and

questions to answer in regards to the way in which emotions influence the operation of prospective memory. In particular, the meta-analyses will attempt to quantify the separate effects of emotional cues at encoding and detection, and for both positive and negative valences.

Eligibility Criteria

The inclusion criteria were: Any empirical study that had tested prospective memory performance as a dependent variable (i.e., the proportion of prospective memory cues correctly responded to) and had manipulated the affective valence of prospective memory cues. Both between-subjects and within-subjects experimental designs were eligible for inclusion. Although there is some debate over whether including both types in a meta-analysis is suitable (Lipsey & Wilson, 2001), other authors state that it is not a problem (Borenstein, Hedges, Higgins, & Rothstein, 2009; Lakens, 2013). Because of the relatively few studies in the current meta-analyses, it was decided that including these studies would be more beneficial than detrimental. Between-subjects designs required that participants were randomly assigned to a condition, and within-subjects designs (92.6% of included studies) required that the order of cue valence was randomised or counterbalanced. As discussed in Chapter 2, prospective memory is commonly referred to as the memory to perform an action at a designated point in the future (McDaniel & Einstein, 2000), however this definition is broad enough to include many types of behaviour that would not be considered examples of prospective memory. For example, experimental paradigms that employ cue-response instructions such as Stroop or lexical decision tasks do not test normal prospective memory ability as the instructions are commonly executed immediately. As such, the parameters of

prospective memory tasks described by McDaniel and Einstein (2007) were employed as inclusion criteria. These stipulate that a task only measures prospective memory if the cue-response behaviour to be performed comes after a suitable delay, is concurrent to another task or activity, and employs constraints on the timeframes for both initiation and completion of the prospective memory response, such that the response must be performed soon or immediately after cue detection. A typical prospective memory paradigm therefore involves receiving instructions for a prospective memory task (to perform an action in response to a specific cue), followed by engagement in another 'ongoing' task, during which the prospective memory cue is presented (explicitly or not).

The following exclusion criteria were also applied: First, any studies in which the data did not allow a comparison between the different emotional valences. Second, studies that only compared between levels of the same valence of affect (Hallam et al., 2015) or looked only at the level of arousal regardless of valence (Burkard, Rochat, & Van der Linden, 2013) were excluded. Third, any studies in which the participants were solely from clinical samples (for example, diagnosed with anxiety or depression, e.g Rude, Hertel, Jarrold, Covich, & Hedlund, 1999) were excluded, as these conditions have been shown to influence prospective memory ability (S. Chen, Zhou, Cui, & Chen, 2013; Rude et al., 1999) and susceptibility to emotional manipulations (Gotlib, Jonides, Buschkuehl, & Joormann, 2011). If sufficient data were available to allow calculation of effect sizes from non-clinical control groups in these studies, then these were included. Studies that measured the speed of response to prospective memory cues, rather than the proportion of prospective memory cues successfully responded to (i.e. prospective

memory performance) were also excluded (Maglio, Gollwitzer, & Oettingen, 2014; Scholz et al., 2009) as this is not a typical measure of prospective memory performance. Studies not reported in English (e.g., Lu, Sun, & Liu, 2008; Yin & Huang, 2016) were also excluded.

Information Sources

The online databases of *Ovid PsychINFO, Web of Science, EthOS, ProQuest Dissertations and Theses Global, Google Scholar* and the *Journal of Articles In Support of The Null Hypothesis* were searched from inception to 7th July, 2016. The literature search was conducted in Summer 2016.

Literature Search

The databases listed above were searched using pre-specified key terms. In order to capture studies published in different research fields, several different terms were used to search for concepts relating to both prospective memory and emotion. The keywords relating to emotion were: *emotion, valence, affect*, positiv*, negativ*, fear, disgust,* and *anger.* The keywords relating to prospective memory were: *"prospective memory", "implementation intention*", "action plan*", "future memory"* and *"delayed intention*".* Each possible combination of emotion and prospective memory key words were used as search terms in databases with the AND operator. The ancestor and descendant approaches (DeCoster, 2009) were then employed to identify further literature that may not have been picked up by the search terms used in the database searches. The ancestor approach involved searching for possible relevant 'ancestor' studies in the reference lists of the final papers included in meta-analyses and in relevant recent meta-analyses and review

articles in the field. The descendant approach used the 'cited by' function in the databases to reveal any relevant studies that had themselves referenced any of the included papers. Finally, all lead authors of the included papers were contacted via email to ask for any unpublished research related to the topic, an approach that yielded one additional set of data. The initial literature search returned 61 possible papers to include based on the title and abstract. The ascendancy approach returned 21 papers, and the descendancy approach returned 1 paper for a total of 74 after duplicates had been removed (see Figure 1 for PRISMA flow diagram of review).

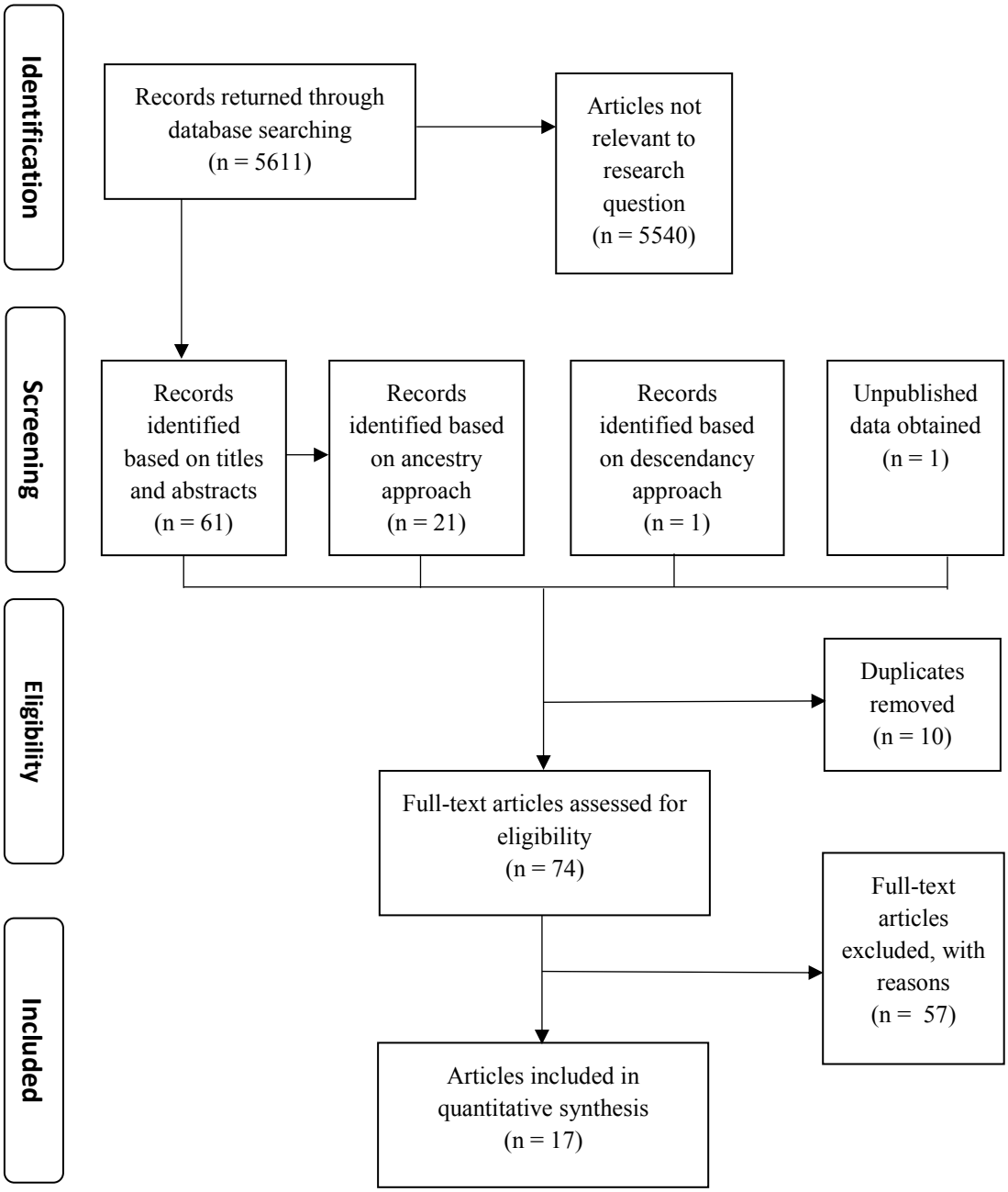

Figure 1. PRISMA Flow Diagram of the Studies in the Review.

Study Selection

The results of the systematic search were assessed for further reading based on the relevance of the titles and abstracts. Following this, the full text for each of these papers was accessed and reviewed in detail against the inclusion and exclusion criteria for the meta-analyses. 57 papers were excluded at this stage as they did not fit the inclusion criteria. The breakdown of these exclusions was: 25 did not include a test of prospective memory, 15 did not include emotion as an independent variable, 4 were review studies or experimental protocols, 4 were not reported in English, 4 did not measure prospective memory accuracy as a dependent variable, 3 only looked at a clinical sample, 1 measured only the arousal of the emotional stimuli and not the valence, and 1 presented duplicate data (May, Owens, & Einstein, 2012). This left the results from 17 articles to be analysed.

Data Collection Process

All papers were read in detail to extract the required information. If the information was not presented in the paper, or if clarification was needed on a particular item, then the lead author of the paper was contacted to obtain it.

Data Items

The following information was coded for each study by the first author: (1) participant demographics; (2) study design (within or between subjects); (3) the valences of the emotional cues; (4) the timing of the emotional manipulation (i.e., whether the valence of the cue had been manipulated at encoding only, detection only, or both); (5) the format of the cues used (words or pictures); and (6) the sample of participants (younger or older adults). To code for the timing of the manipulation,

the instructions for the prospective memory task given to participants were inspected. Studies that presented participants with only the category of the prospective memory cue at encoding (e.g. "animals", Clark-Foos et al., 2009), but later manipulated the valence of the actual prospective memory cues embedded in the ongoing task were coded as manipulating detection only. Studies that presented participants with the exact (emotional or neutral) cues at encoding that they would later see embedded in the ongoing task were coded as manipulating both encoding and detection. The encoding only code was used for studies that had explicitly manipulated the valence of the cue at encoding only (e.g., Henry et al., 2015) or had presented emotional images representing the cue at encoding only (e.g., Mioni et al., 2015). Age was coded using criteria employed by previous meta-analyses in the field (Henry et al., 2004; Ihle et al., 2013; Kliegel et al., 2008) in which samples with a mean age of 60 or above are coded as older adults, and samples with a mean age of between 18 and 59 are coded as younger adults. Samples for which mean age was not reported but were described as undergraduate students were classified as younger adults. In the final analysis, all reported younger adult samples had a mean age of 47.1 or below, and all older adult samples had a mean age of 67.3 or above.

Summary Measures

The effect size of d_{unb} was calculated for each experiment. This notation is used on the advice of Cumming (2012) to avoid confusion over the inconsistent and contradictory use of the terms "Hedges' *g*" and "Cohen's *d*". Following the guidelines of Cumming (2012), the equations used to calculate the effect sizes are also reported in Appendix A. Separate effect sizes were calculated for each emotional valence comparison possible for each study (positive versus negative,

positive versus neutral, negative versus neutral). For the positive versus neutral and negative versus neutral comparisons, effect sizes representing a benefit for valenced manipulations (e.g., a greater number of successful prospective memory task responses) were coded as positive (+ve). Effect sizes representing a detrimental effect for valenced manipulations compared to neutral were coded as negative (-ve).

For the positive versus negative comparisons, effect sizes representing a benefit for positively-valenced manipulations were coded as +ve and benefits for negatively-valenced manipulations as –ve. Effect sizes were primarily calculated using means and standard deviations reported in the papers or obtained from the authors. If this was not possible then the data were extracted from figures using image editing software or were calculated from the reported inferential test statistics if available. Confounding effects of other variables manipulated in a study were minimised by calculating effect sizes using control conditions. (e.g., Rummel, Hepp, et al., 2012 manipulated both the affective valence of the prospective memory cues as well as the mood of the participant, and therefore the effect sizes were calculated using the neutral condition of the mood variable in order to retain consistency with the other studies included in the same meta-analysis). Cohen's power primer (J. Cohen, 1988) was used to help interpret the importance of the effects, with *d'*s of 0.2 considered "small", 0.5 "medium", and 0.8 "large". A 95% confidence interval for each effect size was calculated, and each effect size was tested for statistical significance using the lower-confidence limit (LCL) test (Hedges, Cooper, & Bushman, 1992). On the advice of Cumming (2012), interpretation of the results will focus primarily on the magnitude of the effect sizes and confidence intervals rather than the statistical significance.

When a paper included separate studies in which different samples of participants were tested, separate effect sizes were calculated for each sample allowed by the inclusion criteria.

Synthesis of Results

Separate meta-analyses were conducted for the different valence comparisons, in order to investigate whether positive or negative emotional manipulations had differential influences on prospective memory. This was partly based on the distinct theoretical differences of the influence of valence (e.g., Clore & Huntsinger, 2007) but also the practical limitations of meta-analysis, which requires independence of effect sizes. Valence was manipulated as a within-subjects variable in the majority of the studies, meaning that only one emotion effect could be included from each experiment in the same meta-analysis. Thus, separate meta-analyses were conducted for the effect sizes calculated for the comparison of negatively-valenced emotional influences compared to neutral, positively-valenced emotional influences compared to neutral, and positively-valenced emotional influences compared to negatively-valenced emotional influences.

The distinct influences of valenced cues on the separate process of prospective memory discussed in the introduction were investigated with the use of a meta-ANOVA. A separate effect size for the influence of emotional cues on each process (encoding, detection, encoding and detection) was calculated for each valence comparison. Therefore, nine different sub-meta-analyses were performed in total to calculate the unique effect of either negative or positive cues on each

prospective memory process, including a comparison between negative and positive cues.

Meta-Analytic Procedure

A random-effects model was used for each meta-analysis to allow for between-studies variance (Cumming, 2012). Following the advice of Hunter and Schmidt (2004), a correction for measurement error in the dependent variable was applied to the meta-analyses where possible. The procedure corrects for biases in the measurement of the dependent variable to give a more accurate estimate of the overall effect on the *construct* of interest, in this case prospective memory, rather than on the (potentially imprecise) measurement of the construct. The correction is based on the reliability of the measurement, and depending on the information available, can be applied individually to each effect size before the meta-analysis or to the overall effect size after aggregation. In the present analysis of the influence of emotional cues, the correction was applied individually to each study. Mioni, Rendell, Stablum, Gamberini, and Bisiacchi (2014) provided data on the reliability of the virtual week task used in three of the studies and Kelemen, Weinberg, Alford, Mulvey, and Kaeochinda (2006) provided data on the reliability of the dual task paradigm used in the remaining studies. The results of the corrected analyses are referred to in the text in the present paper, but the uncorrected results are also presented alongside the corrected results in Table 2.

Heterogeneity

A measure of heterogeneity was calculated for each separate meta-analysis. Although tests using Q-values are commonly used to assess heterogeneity, these are

often underpowered when the number of studies in the meta-analysis is low, and in these situations the use of the I^2 statistic is preferred (Higgins, Thompson, Deeks, & Altman, 2003). The I^2 value represents the proportion of heterogeneity between studies that cannot be put down to chance, and should be interpreted as a percentage. Values of I^2 can be classified into low (.25), moderate (.50) and high (.75) inconsistency among studies (Higgins et al., 2003).

Table 1. *Characteristics of Studies Included in the Meta-Analyses*

								Effect size d_{unb}				
Study	Group	Emotions	Manipulation timing	Study design	Cue type	Age	*N*	Neg vs. Neut	*N*	Pos vs. Neut	*N*	Pos vs. Neg
Altgassen, Henry, Burgler, & Kliegel (2011)	Non-depressed controls	Neg, Pos, Neut	E+R	W	W	Y	29	-0.17	29	0.45	29	0.65
Altgassen, Phillips, Henry, Rendell, & Kliegel (2010)	Young adults	Neg, Pos, Neut	E+R	W	I	Y	41	0.33	41	-0.12	41	-0.45
	Older adults	Neg, Pos, Neut	E+R	W	I	O	41	0.95	41	0.82	41	-0.24
Ballhausen, Rendell, Henry, Joeffry, & Kliegel (2015)	Experiment1	Neg, Pos, Neut	R	W	W	O	24	-0.80	24	-0.10	24	0.70
	Experiment 2	Neg, Pos, Neut	E	W	W	O	24	-0.81	24	-0.67	24	0.14
Clark-Foos, Brewer, Marsh & Meeks (2009)	Experiment 1a	Pos, Neg	R	W	W	Y					30	0.66
	Experiment 1b	Pos, Neg	R	W	W	Y					30	0.37
	Experiment 1c	Pos, Neg	R	W	W	Y					30	0.45
Cona (2015)		Neg, Pos, Neut	E+R	W	I	Y	24	0.57	24	0.24	24	-0.43
Graf & Yu (2015)	Experiment 2	Neg, Pos, Neut	R	B	I	Y	130	-0.42	130	-0.46	130	-0.04
Henry et al. (2015)	Young adults	Neg, Pos, Neut	E	W	I	Y	42	-0.15	42	-0.15	42	0.00
	Young-old adults	Neg, Pos, Neut	E	W	I	O	38	-0.10	38	0.03	38	0.13

Study	Group	Emotions	Manipulation timing	Study design	Cue type	Age	*N*	Neg vs. Neut	*N*	Pos vs. Neut	*N*	Pos vs. Neg
Henry et al. (2015)	Old-old adults	Neg, Pos, Neut	E	W	I	O	29	0.09	29	-0.06	29	-0.15
Marsh et al. (2009)	Non-anxious controls	Neg, Neut	R	W	W	Y	25	0.22				
May, Manning, Einstein, Becker & Owens (2015)	Experiment 1 (young adults)	Neg, Pos, Neut	E+R	W	W	Y	40	0.69	40	0.87	40	0.23
	Experiment 1 (older adults)	Neg, Pos, Neut	E+R	W	W	O	32	0.67	32	0.77	32	0.06
	Experiment 2	Neg, Neut	E+R	W	W	O	24	0.04				
Mioni et al. (2015)	Healthy Controls	Neg, Pos, Neut	E	W	I	O	25	-0.60	25	0.76	25	1.46
Rea et al. (2011)		Neg, Neut	E+R	W	I	Y	13	-1.82				
Rendell et al. (2012)		Neg, Pos, Neut	E	W	I	Y	60	-0.40	60	0.38	60	0.83
Rendell et al. (2011)	Young adults	Neg, Pos, Neut	E	W	I	Y	30	-0.44	30	1.12	30	1.54
	Older adults	Neg, Pos, Neut	E	W	I	O	30	0.28	30	1.56	30	1.55
Rummel, Hepp, Klein & Silberleitner (2012)	Neutral mood only	Neg, Pos, Neut	R	W	W	Y	46	0.41	46	0.55	46	0.20
Schnitzspahn, Horn, Bayen & Kliegel (2012)	Young adults	Neg, Pos, Neut	E+R	W	W	Y	45	-0.07	45	0.10	45	0.16
	Older adults	Neg, Pos, Neut	E+R	W	W	O	41	0.74	41	0.63	41	-0.16
Singh & Kashyap (2016)		Pos, Neg	E+R	B	W	Y					40	0.94

Study	Group	Emotions	Manipulation timing	Study design	Cue tpe	Age	*N*	Neg vs. Neut	*N*	Pos vs. Neut	*N*	Pos vs. Neg
Walter & Bayen (2016)	Non-alcohol controls	Neg, Pos, Neut	E+R	W	I	Y	38	-0.55	38	-0.75	38	-0.27

Note. Manipulation timing: E = Encoding only; R = Retrieval only; E+R = Encoding and retrieval. Study design: W = within participants; B = between participants. Cue type: W = Words; I = Images. Age: Y = Young adults; O = Older adults. All effect sizes are corrected for measurement error.

Additional Analyses

Meta-one-way ANOVAs were planned to investigate any moderating effects on the influence of emotion on prospective memory and were executed on the basis of Borenstein et al.'s (2009) recommendation of a minimum of 10 cases for each meta-ANOVA. The moderating variables were the age of the sample and the type of cue employed (picture or word).

All meta-analyses and meta-ANOVAs were conducted using the SPSS Macros developed by Wilson, D. B. (2005), which simplify the process of conducting such analyses in SPSS and corrects for some minor wrong assumptions that are present when usual statistical operations are performed on a meta-analytic dataset (Cooper, Hedges, & Valentine, 2009).

Results

Study Characteristics

From the 17 articles identified from the literature search, 67 different effect sizes were extracted from 27 studies (Table 1). Each valence comparison was subject to a separate meta-analysis, meaning that no two effect sizes from the same study were combined in the same analysis.

Studies were coded for the timing of the manipulation (i.e., encoding, detection, both encoding and detection), as well as the potential moderating variables of cue type and sample age. Eight out of 27 studies (30%) manipulated the valence of the cue at encoding only, 7/27 (26%) manipulated the valence of the cue at detection only, and 12/27 (44%) manipulated the valence of the cue at both encoding and detection. Fourteen out of 27 (52%) studies used words as cues and 13/27 (48%)

used images as cues. In terms of age, studies typically sampled younger and older participants separately which meant that age was tested as a categorical rather than continuous moderator. Within these studies, 10/27 (37%) sampled older adults, and 17/27 (63%) sampled younger adults. Table 2 shows the results of the series of meta-analyses, moderator analyses, along with the number of studies (*k*) and total N for each analysis, the measure of heterogeneity (I^2) and the 95% Confidence Interval for each effect size.

Table 2. *Results of the Meta Analyses.*

Influence of Emotion	Emotional Contrast	*k*	Total *N*	Effect Size	95% CI	Corrected Effect Size	Corrected 95% CI	*p*	*Q*	I^2
Cue (all)	Neg vs. Neut	22	857	0.04	(-0.10, 0.19)	0.05	(-0.13, 0.24)	.608	139.00	0.85
Cue (all)	Pos vs. Neut	20	808	0.21*	(0.03, 0.40)	0.29*	(0.04, 0.53)	.021	136.52	0.86
Cue (all)	Pos vs. Neg	24	938	0.22**	(0.08, 0.36)	0.28**	(0.10, 0.47)	<.01	138.84	0.83
Cue (encoding only)	Neg vs. Neut	8	278	-0.19	(-0.42, 0.05)	-0.25	(-0.57, 0.06)	.108	18.12	0.61
Cue (encoding only)	Pos vs. Neut	8	278	0.24	(-0.05, 0.53)	0.34	(-0.05, 0.73)	.080	60.05	0.88
Cue (encoding only)	Pos vs. Neg	8	278	0.45**	(0.21, 0.70)	0.62**	(0.30, 0.95)	<.001	64.46	0.89
Cue (encoding & detection)	Neg vs. Neut	10	355	0.28*	(0.06, 0.49)	0.35*	(0.08, 0.62)	.012	64.51	0.86
Cue (encoding & detection)	Pos vs. Neut	9	331	0.26	(-0.01, 0.54)	0.33	(-0.03, 0.69)	.072	60.00	0.87
Cue (encoding & detection)	Pos vs. Neg	10	371	-0.01	(-0.22, 0.21)	-0.06	(-0.35, 0.23)	.686	29.59	0.70
Cue (detection only)	Neg vs. Neut	4	224	-0.09	(-0.44, 0.25)	-0.12	(-0.56, 0.32)	.602	21.01	0.86

Influence of Emotion	Emotional Contrast	*k*	Total *N*	Effect Size	95% CI	Corrected Effect Size	Corrected 95% CI	*p*	*Q*	I^2
Cue (detection only)	Pos vs. Neut	3	199	0.01	(-0.47, 0.49)	0.01	(-0.62, 0.64)	.978	13.90	0.86
Cue (detection only)	Pos vs. Neg	6	289	0.30*	(0.02, 0.59)	0.39*	(0.02, 0.75)	.039	8.34	0.40

Note. *k* = number of effect sizes included in the analysis. Total *N* = number of participants included in the analysis. *Q* is a measure of heterogeneity and I^2 is a measure of inconsistency. *p <.05 **p <.01

Across all effect sizes measuring the influence of emotional cues, the magnitude of the effects ranged from $d = 0.05$ to $d = 0.29$ for the different valences. There were small significant effects of the influence of positive cues (versus neutral: $d = 0.29$ [0.04, 0.53] $p = .021$; versus negative: $d = 0.28$ [0.10, 0.47] $p < .01$): Positively-valenced cues resulted in small improvements in prospective memory compared to either neutral or negative cues. In contrast, negative cues did not have a significant effect on prospective memory compared to neutral ($d = 0.05$ [-0.13, 0.24] $p = .608$). Forest plots summarise the studies included in the meta-analyses of the effects of negative versus neutral cues (Figure 2a), positive versus neutral cues (Figure 2b) and positive versus negative cues (Figure 2c).

Moderator Analyses

For each valence comparison meta-analysis, a meta-ANOVA was performed to determine whether the emotional manipulation of cues influenced encoding, detection, or both encoding and detection. In addition the moderating variables of the type of cue (words or images), and the age of the sample were tested.

Influence of emotional cues on encoding and detection. The literature suggests that manipulating the valence of the prospective memory cue may influence encoding and detection in different ways. Each valence comparison for the influence of emotional cues was tested to see if the timing of the emotional manipulation, i.e., manipulating the valence at either the encoding process only, the detection process only, or at both encoding and detection, differentially affected prospective memory. There were significant moderating effects of the timing of the manipulation for both the negative versus neutral ($p < .05$) and positive versus negative ($p < .01$)

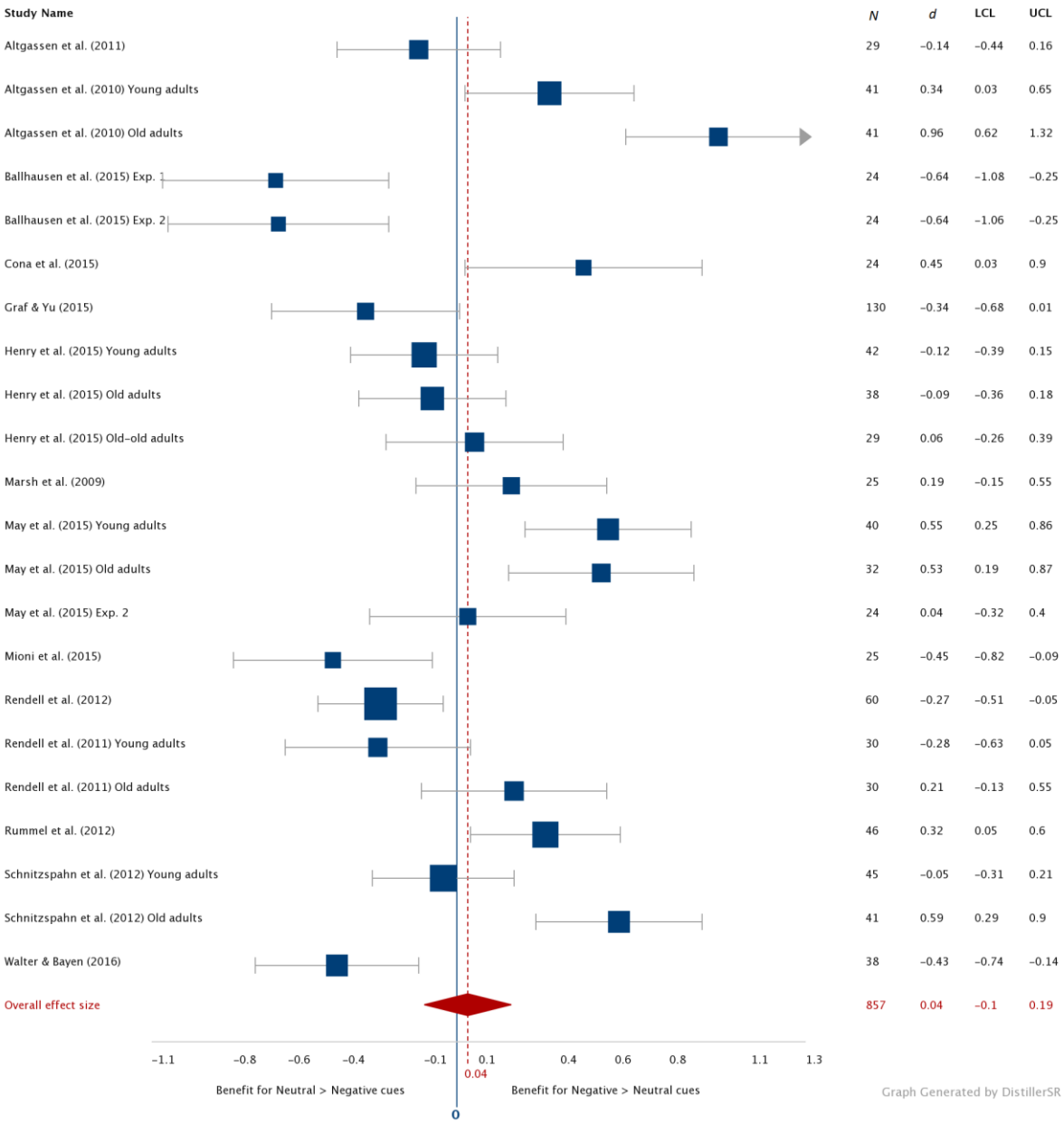

Figure 2a. Forest plot of studies included in the meta-analysis of negative versus neutral cues. The error bars represent the 95% confidence intervals of each effect size. The size of the squares represents the weighting of each study included in the analysis, based on the study sample size and variance of the effect size. The overall effect size and related confidence intervals is depicted at the bottom. The effect sizes in the graph are uncorrected for measurement error as it was not possible to accurately calculate confidence intervals for the corrected effect sizes.

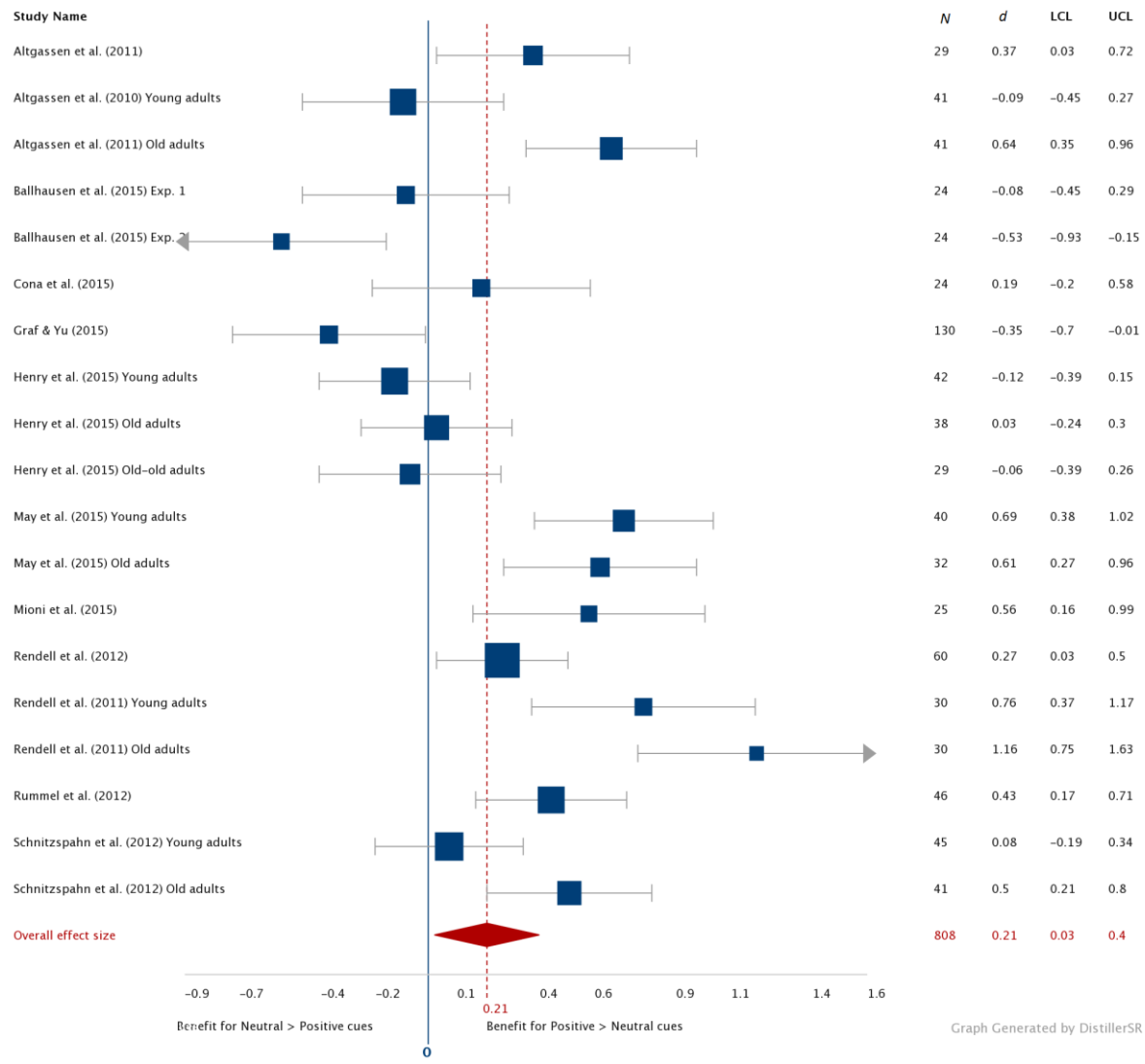

Figure 2b. Forest plot of studies included in the meta-analysis of positive versus neutral cues. For interpretation see notes on Figure 2a.

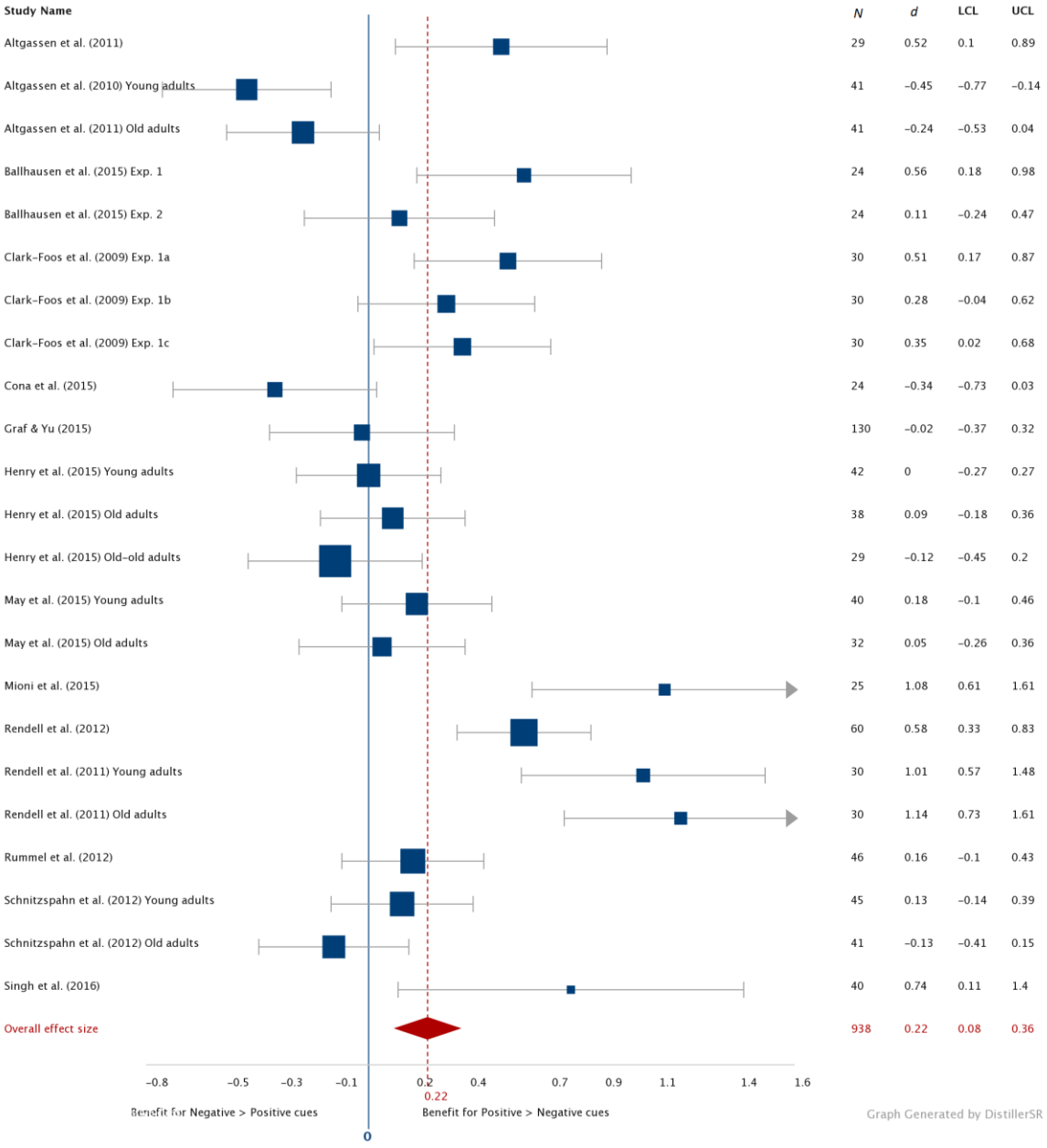

Figure 2c. Forest plot of studies included in the meta-analysis of positive versus negative cues. For interpretation see notes on Figure 2a.

comparisons. The moderating effect of timing of the manipulation for positive versus neutral comparisons was not significant (p = .641), suggesting that the influence of positive cues does not change based on the process affected.

When negatively-valenced cues were presented at encoding only, they produced a detrimental effect on prospective memory compared to neutral cues (d = -0.25 [-0.57, 0.06] p = .108). However, when negatively-valenced cues were presented at both encoding and detection, they improved prospective memory performance (d = 0.35 [0.08, 0.62] p = .012)[1]. Presenting negative cues at detection only did not appear to influence prospective memory significantly when compared to neutral cues (d = -0.12 [-0.56, 0.32] p = .602). In contrast, the effect of positive cues was similar regardless of which prospective memory process they influenced. Positive cues presented only during the encoding phase improved prospective memory (d = 0.34 [-0.05, 0.73] p = .080) to a similar extent as presenting them at both encoding and detection (d = 0.33 [-0.03, 0.69] p = .072). However, presenting positive cues at detection only did not improve prospective memory compared to

[1] When performing the meta-analysis and meta-ANOVAs of negative versus neutral cue valence, one effect size (Rea et al., 2011) was identified as an outlier using a funnel plot and was subsequently excluded from the analysis. As a random-effects model was being used, studies with small sample sizes can have a disproportionately large influence on the overall effect size (Borenstein et al., 2009). In this case, the sample size was 13, and the effect size was d_{unb} = -1.82 (after correction for measurement error), meaning that including it would have an undue influence on the calculation of the combined effect size. Separate meta-analyses were conducted both including and excluding the study in question. Although the overall effect size for negative versus neutral cues did not change dramatically when including this study (0.05 without compared to -0.01 with), the effect size of negative versus neutral cues at encoding only did. Including the effect size from the Rea et al. (2011) study resulted in an overall effect size d = 0.22, but without including this study, the overall effect size was d = 0.35. Due to the large influence of this study's effect size in comparison to its small sample size (N = 13), the decision was taken to exclude it from this and all other analyses to retain consistency.

neutral cues (d = 0.01 [-0.62, 0.64] p = .978). When comparing positive to negative cues, the timing of the emotional manipulation also moderated the effects. Due to the clear difference between the effects of negative and positive cues compared to neutral when presented at encoding only, positive cues unsurprisingly showed a large benefit when compared to negative cues when presented at encoding only (d = 0.62 [0.30, 0.95] p <.001). When the affective valence of cues was manipulated at both encoding and detection, the difference between positive compared to negative cues was small (d = -0.06 [-0.35, 0.23] p = .686). Studies presenting emotional cues only during the detection phase found a benefit for positive over negative cues (d = 0.39 [0.02, 0.75] p = .039).

Influence of age and cue type. The moderators of sample age and cue type (pictures or words) were also tested to see whether the influence of emotional cues differed between the levels of these variables. These moderator analyses were, like the analyses above, also performed on the separate meta-analyses of the influence of emotional cues for the different valence comparisons. There was no moderating effect of age for the influence of negative cues on prospective memory compared to neutral cues (p = .745). Negative cues showed no overall influence for either older adults (d = 0.09, p = .605) or younger adults (d = 0.01, p = .929). However, for the overall significant influence of positive cues compared to neutral, there appeared to be stronger benefits for older adults (d = 0.41, p = .030) than younger adults (d = 0.19, p = .246), although this difference was not statistically significant (p = .398). This pattern was repeated for the benefit of positive cues over negative cues (older: d = 0.34, p = .064; younger: d = 0.26, p = .071).

There were no significant differences for the moderator of cue type for any of the valence comparisons. Negative cues showed no overall influence compared to neutral regardless of whether they were words (d = 0.11, p = .507) or images (d = -0.01, p = .966). Similarly, the significant overall benefit of positive cues compared to neutral did not differ depending on whether words (d = 0.33, p = .095) or images (d = 0.26, p = .115) were used as the cues. The benefit of positive over negative cues was also similar regardless of cue type (words: d = 0.32, p = .052; images: d = 0.27, p = .090).

Discussion

The present research represents the first attempt to review systematically the fragmented literature on influence of positively- or negatively-valenced cues on prospective memory performance. Three separate meta-analyses were conducted to distinguish between the different valences of the emotional influence. The results showed that there were small benefits to prospective memory of using positively-valenced cues compared to either neutral or negative cues, but no benefits to using negatively-valenced cues. However, moderator analyses showed that the influence of negatively-valenced cues was dependent on whether they influenced either only the encoding or detection processes, or both. The implication is prospective memory performance can be moderated through the manipulation of the affective valence of the prospective memory cues, however this effect is likely to work through multiple mechanisms. The influence of emotional cues differs depending on which prospective memory processes (encoding or detection) the influence affects. The results of the analyses for the separate influences of emotion are discussed below.

Overall, prospective memory performance was better when positively-valenced cues were used compared to neutral cues (d = 0.29). In contrast, there was no overall benefit for negative over neutral cues (d = 0.05). However, the timing of the emotional manipulation, i.e. whether the cues were presented at the encoding process only, the detection process only, or both the encoding and detection processes significantly moderated the effect of negative cues. The results suggest that emotional cues may affect prospective memory performance through different mechanisms, and that this effect may be valence-specific.

At encoding, positively valenced cues improved prospective memory compared to neutral cues, but negatively-valenced cues produced a detrimental effect on subsequent prospective memory performance. In contrast, when manipulating the valence of the cues at both encoding and detection, both positive cues and negative cues improved prospective memory performance in comparison to neutral cues. Furthermore, manipulating the affective valence of the cues only during the detection process showed much weaker effects compared to neutral cues. The difference in the magnitude of the influences of cue valence - especially negative cues - on the separate processes of prospective memory suggests that multiple mechanisms may underlie the influence of emotional cues on prospective memory.

Whilst the attention-grabbing nature of emotional stimuli (Frischen et al., 2008; Nummenmaa et al., 2006) has been suggested as a possible mechanism underlying the benefit of cue valence on prospective memory (May et al., 2015), the present results do not fully support this suggestion. Studies manipulating the valence of the prospective memory cues only during the detection process did not demonstrate substantial benefits to prospective memory, suggesting that increased

attention to prospective memory targets alone is not sufficient to improve prospective memory. The process model of prospective memory (Kliegel et al., 2002) states that although factors relating to the prospective memory cue itself may influence prospective memory at the time when the cue needs to be detected, the primary executive processes required during the this stage relate to working memory and cognitive flexibility. Thus, manipulating the emotionality of the cues during this stage alone may not have a strong enough influence to overcome other task demands that influence these executive processes.

However, studies presenting emotional cues at both encoding and detection showed small-to-medium benefits for prospective memory (J. Cohen, 1988). One explanation for why effects were found when manipulating valence at both encoding and detection, but not at detection only, may be that it is necessary to have previously encoded the emotional cues in order to reap the benefits of any enhanced attention-grabbing properties provided during the detection process. Studies that manipulated the valence of cues at detection only did so by providing the category to which the cue belonged in the prospective memory instructions (e.g. “pictures of animals”, Ballhausen et al., 2015) whereas studies manipulating cues at both encoding and detection provided the exact cues that would later be seen in the cue detection phase. Emotional stimuli are likely to grab attention during the cue detection phase but may fail to trigger the prospective memory response if the stimuli themselves have not previously been encoded and linked with the response. In contrast, encoding the exact emotional stimuli as the prospective memory cue with the response means that not only is attention drawn to the cue during the detection process, but that the cue is subsequently likely to be detected as relevant to

the prospective memory intention, triggering the response. This suggestion is consistent with the findings of Hannon and Daneman (2007) who conducted the only empirical study to date that explicitly manipulated the salience of cues at encoding, detection and both encoding and detection. They found that whilst manipulating the salience of cues during detection can influence prospective memory, a stronger influence comes from a direct match between encoded cue and that observed during the detection process. Thus, consistent with the findings of the present analyses, increasing the salience of the cue during the detection process is more effective at improving prospective memory when the detected cue more closely resembles the encoded cue.

Positive and negative cues showed similar benefits (compared to neutral) when presented at both the encoding and detection processes. In contrast, positive and negative cues showed differential effects when manipulated at encoding only. Presenting positive cues at encoding improved prospective memory performance in comparison to neutral cues, whereas presenting negative cues impaired it. There is evidence from the broader literature that negatively-valenced stimuli receive enhanced perceptual processing and impaired semantic processing (Kensinger & Schacter, 2008; Mickley & Kensinger, 2008; Sakaki, Gorlick, & Mather, 2011). This leads to a focus on and enhanced memory for the intrinsic perceptual details of the negative item (Kensinger, Garoff-Eaton, & Schacter, 2006; Pierce & Kensinger, 2011). In the context of prospective memory cues, an enhanced focus on the perceptual details of a cue would likely enhance subsequent detection and recognition of the same cues, a finding supported by the results of the meta-analysis showing improved prospective memory performance for negative cues presented at

both encoding and detection. However, an enhanced focus on the perceptual details of a cue and diminished processing of the semantic properties of a cue could also explain the detrimental effect of negative stimuli presented at encoding only. If perceptual processing is used to encode the cue rather than semantic, then subsequent cues that share the same semantic context as the encoded cue but are not perceptually similar may not be detected as easily. For example, if one focused on the perceptual details of a picture of a negatively-valenced image of a rat at encoding, but the later cues belonging to the category of animals are dogs, then their detection may be impaired. In contrast, presenting positively-valenced stimuli at encoding improved prospective memory performance. Processing positive stimuli has been shown to activate semantic and conceptual processing to a greater extent than perceptual processing (Kensinger, 2009; Kensinger & Schacter, 2008; Mickley & Kensinger, 2008). This enhanced conceptual processing may facilitate the subsequent detection of cues that are semantically related to the encoded cues, even if they are not perceptually similar. The differences between semantic and perceptual processing in prospective memory cue detection have been investigated using neuroimaging (Cousens et al., 2015), however there is little behavioural data available. This should be seen as a possible avenue for further research to explain the differences between positive and negative cues when valence is manipulated during the encoding phase.

An alternative explanation for the differential effects of positive and negative cues at encoding is that there may be motivational influences on the encoding of emotional cues. Xing and Isaacowitz (2006) showed that when people are motivated to regulate their emotions, their attention allocation procedure prioritises positive

information, and neglects negative information. In other words, people are more motivated to pay attention to positive stimuli and less motivated to pay attention to negative stimuli. This finding may explain the current pattern of results: people may have attended more to the positive stimuli at encoding, thus encoding them to a deeper level and enhancing the detection of subsequent cues. In contrast, it is also possible that people were less motivated to encode negative stimuli and so spent less time or effort encoding them, resulting in poorer downstream performance of detecting relevant cues. As the contrasting effect of positive and negative cues relates to the findings of studies that manipulated the emotion of the cues at the encoding process only, these effects at encoding would have had a greater effect on subsequent overall prospective memory performance compared to studies in which the emotionality of the cues was manipulated at multiple stages.

The explanation for the differential effects of positive and negative cues at encoding is a question that requires dedicated empirical work to answer, as there may be other potential explanations for the different effects of manipulating valence at encoding that cannot be controlled for or measured in the present analyses. Research has shown that the precise instructions given to participants when encoding emotional stimuli in retrospective memory experiments can influence whether they impair or enhance memory (Kensinger, Gutchess, & Schacter, 2007; Murray & Kensinger, 2012). For example, Murray and Kensinger (2012) found that emotional stimuli only enhanced memory when encoding instructions encouraged integrating the emotional stimuli with other stimuli using imagery, and that this effect was further moderated by encoding time. Participants who spent 6 seconds encoding stimuli in this method showed worse performance than those who spent only 2

seconds encoding the material. In prospective memory experiments, encoding instructions are typically not standardized and often information on the exact instructions given to participants is not reported. Therefore, despite encoding instructions and time spent encoding being potentially important moderators, it was not possible to code for this in the present study. Future research reports in this area should look to other fields of research (e.g., medicine) that specify the kinds of information that should be reported in published research. In addition, future research should seek to investigate how task instructions in prospective memory tasks in particular interact with affective valence to influence prospective memory.

Overall, the results of the meta-analyses suggest that the influence of valenced cues on prospective memory is underpinned by several different mechanisms that result in different effects depending on the valence of the cues. Presenting emotional cues at both encoding and detection improved prospective memory performance for both negative and positive cues. This supports the encoding specificity principle (Tulving & Thomson, 1973) that states that recognition of a cue is improved when the retrieval cue is more similar to the cue that was originally encoded. The finding that emotional cues seem to enhance this effect is consistent with the suggestion of Buchanan (2007) that the affective valence of the cue is one of the variables that contribute to the similarity that prompts recognition. Encountering an emotional cue in the environment prompts an affective response, which means that memories associated with the same affective response are more likely to be brought to mind. In this case, the memories brought to mind are the encoding of the stimuli as a prospective memory cue and the associated prospective memory response. This suggestion also explains why manipulating the valence of

the cue at detection only did not produce reliable effects on prospective memory: The affective response that occurs in reaction to encountering a prospective memory cue in the environment cannot prompt the retrieval of the prospective memory response through the encoding specificity effect because the original prospective memory cues encoded did not prompt a similar affective response. The implications of this suggestion for prospective memory expand on those suggested by Hannon and Daneman (2007). These authors suggested that during encoding, one should consider multiple aspects of the retrieval cue that are likely to occur during detection in order to maximise the similarity between the encoding and detection contexts and prompt retrieval. The results of the present research expand on this by suggesting that one should seek to encode a cue that prompts a similar affective response to a cue that one expects to encounter in the environment. Future research should seek to determine whether similar affective reactions to different cues also results in improved prospective memory. Thus far, only presentation of the exact same emotional cues at encoding and detection has been investigated (for example, presenting the word "terrorist" at both encoding and detection) whereas it is plausible that different words that prompt the same affective responses at encoding and retrieval also improve prospective memory (for example, presenting the word "terrorist" at encoding, and "murderer" at detection).

The effects of two other potential moderators on the influence of valenced cues on prospective memory were also tested. The first variable tested was cue type. There did not appear to be any overall effect of whether the cues used were words or images, suggesting that both have similar influences on prospective memory. However, it is unclear whether the different types of cues may produce differential

effects in the separate processes of prospective memory (encoding and detection). Insufficient numbers of studies were available to test potential differential effects of words and pictures as a moderator in the sub-analyses, and so the possibility that pictures and words differentially affect the encoding and detection processes cannot be ruled out. More data is needed in order to draw conclusions about how different types of cues affect prospective memory, and also whether emotional effects can be extended to cues other than words or pictures, for example auditory or olfactory stimuli.

The other moderating variable tested was age, which also showed no significant moderating effects, although the benefit of positive cues appeared to be stronger for older compared to younger adults. This is consistent with the findings of a meta-analysis by N. A. Murphy and Isaacowitz (2008) who found that older adults showed a larger but not significantly different preference for positive stimuli compared to younger adults. This positivity effect of emotional stimuli in older adults may be in order to facilitate enhanced emotional regulation that occurs due to a shortened future timeframe (Mather & Carstensen, 2005).

Limitations and Avenues for Future Research

The results of the present set of meta-analyses should be interpreted with several caveats in mind. First, the small number of studies in many of the sub-analyses and the range of different prospective memory tasks used in the studies are likely to have contributed to the high heterogeneity observed in each set of effect sizes. The small magnitude of these non-significant effect sizes suggest that many of

the possible influences of emotional cues on prospective memory lack any clear supporting evidence.

Second, there are limitations within the body of studies analysed that are common to many areas of emotion research. All the studies analysed in the current set of analyses employed the trichotomy of 'positive, negative, neutral' and the reliance on valence and arousal dimensions of emotional stimuli that ignores the individual effects that discrete emotions may have. For example, although anger and anxiety are both 'negative' emotions, they have been shown to have distinct effects on cognition (Lench, Flores, & Bench, 2011). Furthermore, the reliance on arousal and valence measures to classify emotional stimuli may ignore the contribution of appraisal variables, such as novelty, personal relevance and 'emotional impact' that have not been controlled for in the present set of studies but have been shown to affect attention and recollection (F. C. Murphy, Hill, Ramponi, Calder, & Barnard, 2010) and so could also be expected to influence prospective memory. Despite this, the evidence for the influence of valenced cues on prospective memory from the present set of meta-analyses demonstrate that the dimensions of arousal and valence have the ability to capture at least some of the influence of emotional stimuli on prospective memory.

Third, limitations of the methodologies employed in the studies included in the meta-analysis may represent a source of bias in the results. Of the 27 effect sizes included in the analyses, only two studies employed between-participant designs with randomization to conditions. The remaining studies used a counterbalanced order of emotional cues. Counterbalancing can minimize the influence of serial order carryover effects associated with repeated-measures designs, however some methods

of counterbalancing do not cover all possible carryover effects (Brooks, 2012). Carryover effects may be expected in the context of presenting emotionally-valenced prospective memory cues, as affective responses to stimuli have been shown to persist after the presentation of the stimuli ends (Garrett & Maddock, 2001). Although between-participants designs also have drawbacks when used in emotion research, for example due to the influence of individual differences in emotion perception (Okon-Singer et al., 2013); a greater balance of between-subjects and within-subjects designs in future research on the topic should minimise any drawbacks associated with either design. The two experiments described in Chapters 4 and 5 employ between-subjects designs.

Conclusion

A systematic review and meta-analyses were conducted to help bring together a disparate literature on the effect of emotion on prospective memory. The aim was to quantify the influence of emotional cues on prospective memory and to identify any sources of inconsistency through moderator analyses. The results showed that whilst emotional cues can improve prospective memory performance, the influence is dependent on the prospective memory process affected by the manipulation. Manipulating the valence of the cues at detection only does not improve prospective memory. In addition, manipulating the valence of cues at encoding only produces differential effects for positive and negative cues. However, manipulating the emotional valence of a cue at both encoding and detection produces reliable increases in prospective memory performance and is a promising strategy to improve intention realisation.

Chapter Four: An Online Experiment to Test the Concurrent Use of Implementation Intentions and Emotional Cues.

The results of the systematic review and meta-analysis presented in the previous chapter established that the use of emotional cues improves prospective memory under certain circumstances. In particular, when presented at both the encoding and detection phases of prospective memory, there are reliable increases in prospective memory performance for positive (d = 0.33) and negative (d = 0.35) compared to neutral cues. These results supplement the results of a previous meta-analysis showing that implementation intentions also reliably improve prospective memory performance (X. J. Chen et al., 2015). However, there has yet to be any research on whether the strategies of emotional cues and implementation intentions can be used together to improve prospective memory. This chapter presents the results of an experiment that investigated the use of both strategies together to improve cue detection and hence prospective memory performance. The evidence for the use of implementation intentions and emotional cues is briefly recapped, followed by an explanation of the further novel aspects of this experiment.

Implementation Intentions

Implementation intentions (Gollwitzer, 1993) are 'if [cue]-then [response]' plans that boost prospective memory performance by improving the detection of critical cues when they are embedded in ongoing lexical decision tasks (Meeks & Marsh, 2010; Rummel, Einstein, et al., 2012), picture categorisation tasks (McCrea et al., 2015), trivia question tasks (McFarland & Glisky, 2012) and colour-matching tasks (Smith et al., 2014). Although some studies have failed to find a benefit of

implementation intentions in prospective memory tasks (Chasteen et al., 2001), a recent meta-analysis of 36 comparisons found that forming implementation intentions was effective overall at improving prospective memory performance in dual-task studies compared to receiving prospective memory task instructions, with an overall 'medium' effect size of $d = 0.51$ (X. J. Chen et al., 2015).

Emotional Cues

Cue detection can also be improved by increasing the salience of the cue (Hicks et al., 2005), and as discussed in Chapter 2, one method of doing this is by imbuing critical cues with emotional content. Emotional stimuli are thought to convey evolutionary importance and thus be particularly salient in terms of providing feedback to the cognitive system (Baumeister et al., 2007). As such, emotional stimuli appear more salient and attract greater attention than neutral stimuli (N. A. Murphy & Isaacowitz, 2008). Several studies have demonstrated that emotional cues can improve prospective memory over neutral cues in ongoing lexical decision tasks (May et al., 2015; Rummel, Hepp, et al., 2012), colour-matching tasks (Schnitzspahn et al., 2012) and word categorisation tasks (Altgassen et al., 2011).

Cue Valence

Notwithstanding the evidence for the effectiveness of both implementation intentions and emotional cues at improving prospective memory performance, there are still questions regarding which valence of cue is most effective. The results of the meta-analysis in Chapter 3 on the difference between positive and negative cues showed that overall, positive cues were more effective than negative cues ($d = 0.28$),

although when looking only at studies that had manipulated the valence of cues at both encoding and detection, there were equivalent effects of positive and negative cues (d = -0.06). Although this gives an indication of the overall effects of positive and negative cues, heterogeneity between the studies in these meta-analyses were high, suggesting that moderating factors may still exist. One outstanding question is whether features of the emotional cues used in previous prospective memory experiments may explain the conflicting findings reported in the literature regarding whether positive and negative cues are equivalent. Some studies have shown that both positive and negative cues improve prospective memory (e.g., Altgassen et al., 2010; May et al., 2015), whereas other studies have found benefits only for positive but not negative cues (Altgassen et al., 2011; Rendell et al., 2011). These mixed findings may be due to idiosyncrasies associated with the stimuli that are used as cues and the dual task paradigms employed in these experiments (May et al., 2015). Therefore, it would be valuable to test the effects of emotional cues using novel stimuli and tasks in order to help improve our understanding of the limitations of the effects of positive and negative emotional cues.

More specifically, previous research has employed only valenced words (e.g., May et al., 2015) or photographs (Altgassen et al., 2010) as prospective memory cues. These types of stimuli can vary along several dimensions other than emotion that can influence cognitive processing, such as the length, type, frequency and imageability of words, or contrast and level of detail in photographs. With the exception of Schnitzspahn et al. (2012), who did control for the interference of the aforementioned variables in a study using words, previous research has generally not accounted for the influence of these idiosyncrasies. This may explain the mixed

findings regarding the effect of valence if these variables have influenced prospective memory performance. In addition, the ongoing tasks used in most studies have been basic decision making tasks (e.g., word categorisation tasks) in which the prospective memory cues are presented as task-relevant stimuli that must be attended to in order to complete the task. For example, in the word categorisation task used by Altgassen et al. (2011), prospective memory cues were embedded as words that needed to be categorised in the categorisation task. Therefore, the processing of the cues was essential to the completion of the ongoing task. It is unclear whether emotional cues remain effective in tasks in which the processing of the cues is not essential and the cues do not need to be attended to directly.

The present research overcomes limitations with previous research in two key respects. First, by employing valenced basic symbols as stimuli in a novel ongoing visual search task. An advantage of valenced basic symbols is that they can convey emotional content whilst remaining perceptually very similar, meaning that differences in inherent perceptual characteristics that can confound results are minimized (Okon-Singer et al., 2013). A second way in which the present research overcomes some of the limitations associated with previous studies is by embedding the critical prospective memory cues in the ongoing visual search task as task-irrelevant distractors. The processing of such cues was not essential to the completion of the visual search task. Previous research by Schnitzspahn et al. (2012) employed non-focal prospective memory cues whose detection required a different kind of processing to the ongoing task (semantic rather than perceptual). In the present study, perceptual processing was required to detect both the prospective memory cues and to complete the ongoing task; however the processing of the cues

was less central to the completion of the ongoing task. In this respect, the present study has a degree of novelty. This is important because it is not yet clear whether the increased salience of emotional cues can aid detection when the cues are not presented as the focus of attention. The way in which the valenced cues in the present research were difficult to detect constitutes a novel test of the effectiveness of valenced cues.

Implementation Intentions and Emotional Cues

The use of implementation intentions and emotional cues show promise in helping to improve prospective memory performance. Despite this, there is currently no research as to how the use of these strategies may interact with each other. If emotional cues are more salient and implementation intentions help to increase the accessibility and detection of prospective memory cues, then there will likely be a synergistic effect of using both strategies at once. The potential to use both of these strategies together – that have been shown individually to improve prospective memory performance – is a clear logical step to improving prospective memory ability.

The Present Research

In the present study, the effect of implementation intention instructions (versus standard prospective memory instructions) and emotional cues (positive versus negative versus neutral) were tested together for the first time in a fully factorial design. In addition, a novel set of stimuli were used as cues and a novel visual search task was employed. The ongoing visual search task was to count the number of occurrences of a specific symbol in an array. Participants were also given

the prospective memory task of typing a letter instead of a number response to the ongoing task on the trials in which they detected the prospective memory cue. It was predicted that prospective memory performance would be improved when participants: (a) formed implementation intentions, (b) were exposed to emotional cues, and (c) prospective memory performance would be optimised when participants both formed implementation intentions and were exposed to emotional cues.

Method

Participants

N = 422 participants were recruited from an online volunteers email list. The list is administered by the University of Sheffield and includes staff and students (undergraduate and postgraduate) from all faculties and departments. All staff and students at the university are automatically subscribed and receive emails unless they opt-out. All participants were compensated with entry into a prize draw to win a £50 shopping voucher. Participants were instructed to only participate in the study if they could commit to paying full attention to it, and to not complete it on a smartphone or tablet. These instructions were used to try to standardise the conditions under which participants completed the experiment as much as possible.

Participant exclusion. Comparable with other online studies (Hoerger, 2010), 96 (22.7%) participants were excluded due to failing to complete the entire experiment. Ten participants were excluded due to participating on a phone or tablet and 14 were excluded due to being identified as outliers (greater than 3 times the interquartile range from the upper quartile) for the total time taken on the

experiment, indicating that they took a lot longer than expected and were therefore likely not paying attention to the task. A further 28 participants were excluded because a manipulation check indicated that they had been searching for the wrong prospective memory cue. The final data analysis was conducted on 274 participants aged 18-71 (M = 29.68, SD = 11.70). There were 74 men and 200 women in the final sample.

A series of tests were conducted to see whether there were differences between those participants who were excluded and those who were included in the final analyses. Chi-square tests showed there was no relationship between participants' experimental condition and whether they were excluded from the analysis based on failing to complete the experiment, $\chi^2(5, N=422) = 6.72$, $p = .242$; completing it on a tablet or phone, $\chi^2(5, N=422) = 3.90$, $p = .564$; taking an excessive amount of time to complete the experiment, $\chi^2(5, N=422) = 5.78$, $p = .328$; or incorrectly identifying the cue, $\chi^2(5, N=422) = 4.23$, $p = .517$. Furthermore, excluded participants did not differ from non-excluded participants on age, $F(1, 324) = 1.32$, $p = .252$, or gender $\chi^2(1, N=422) = 0.31$, $p = .578$. Therefore excluded participants were evenly represented across conditions and representative of the sample as a whole. Table 3 presents details of the sample characteristics by condition.

Design

The experiment used a fully factorial 3x2 between-participants design. The independent variables were valence of the prospective memory cue (positive, neutral, negative) and instruction given at the start of the experiment (implementation

intentions, prospective memory instructions only). Each participant was randomly assigned to one of the six conditions via a server-side function of the software administering the experiment. The dependent variable was prospective memory performance measured by the number of prospective memory cues that participants detected correctly.

Table 3. *Sample Characteristics by Condition*.

	Condition					
Instruction	Implementation Intention			Standard Instructions		
Cue	Negative	Neutral	Positive	Negative	Neutral	Positive
N	41	43	50	49	45	46
M Age (*SD*)	29.5 (11.0)	27.5 (9.8)	28.9 (11.1)	31.5 (13.1)	29.9 (13.1)	30.6 (11.9)
N Male, Female	9, 32	10, 33	16, 34	9, 40	10, 35	20, 26
M Total time spent on experiment (s)	1135.39	1219.47	1104.88	1078.20	1098.53	1191.80

Materials

Ongoing task. An ongoing visual search task was employed in order to simulate the conditions of being engaged in another activity that could interfere with successful prospective memory performance. All participants had to count the number of occurrences of a specific symbol ('targets') within an array of other symbols ('distractors'). There were 60 trials in total, with each trial having between 1 and 13 (M = 6.43) targets to count. Each trial was presented on a separate page of

the online software used to administer the experiment. In each trial, the target was presented at the top of the screen under the heading "Symbol:" Below this the array was presented under the heading "Array:" Below this was an answer box with the instructions "How many times did the symbol appear in the array?" in which participants were instructed to type a number. Participants progressed to subsequent trials by clicking an arrow button at the bottom right of the page. Trials were presented in the same order for each participant in order to ensure that the difficulty of the trials between receiving the prospective memory instructions and the presentation of the prospective memory cues were the same for participants in all conditions.

Symbol arrays. Symbols were presented in arrays and were all black on white designs measuring approximately 60 *x* 60 pixels, and taken from the website http://getemoji.com. They were primarily a combination of inanimate objects such as office supplies, fruit and vegetables, food and sports equipment, and abstract shapes such as circles, crosses, and stars. These items were chosen as they represented stimuli that are unlikely to evoke an emotional reaction, unlike stimuli such as animals, faces, and eyes. The arrays were created using Adobe Photoshop and contained between 20 and 74 symbols (M = 45.32) in total, of which between 1 and 13 (M = 6.43) were targets, in order to vary the difficulty of each trial. The symbols in each array were deliberately placed close together and not aligned in grids in order to prevent the use of systematic search strategies for the targets. The frequency of individual distractor symbols also varied on each trial so that prospective memory cues did not stand out simply because they were less frequent. An example of a target and accompanying array can be found in Appendix B.

Prospective memory cues. The prospective memory cues were black on white symbols that were created to match the size and style of the other symbols used in the arrays. The positive prospective memory cue was a happy schematic face and the negative prospective memory cue was an unhappy schematic face, both of which have been shown to produce emotional reactions (Ohman, 2002). The neutral prospective memory cue was a percentage symbol inside a circle that resembled both the emotional cues (a line and two dots inside a circle) but did not resemble a face or convey any emotional information. The prospective memory cue appeared as one of the distractor symbols in the arrays on trials 37, 47 and 55. The position of the cue in each of these arrays was the same for all participants, but the cue itself varied depending on valence condition. The prospective memory cues did not appear as targets or distractors in the arrays on any of the other trials in the experiment. In order to avoid confusion, none of the symbols used as either targets or distractors in the rest of the experiment were faces or could easily be mistaken for the prospective memory cues.

Implementation intentions. Participants in the implementation intention condition were given the following instructions to form an implementation intention: "In order to help you remember to complete this secondary task, please repeat the following sentence to yourself three times in your head, and type it out word-for-word in the box below: *"If I see the symbol above, then I will remember to type a letter instead of a number!"*. An answer box was provided below this text in which participants were asked to type the implementation intention before they could proceed with the experiment. Typing anything other than the exact implementation intention meant that participants could not proceed with the experiment. This

ensured that all participants in the relevant conditions formed implementation intentions.

Procedure

The experiment was conducted online using Qualtrics survey software. After providing informed consent, participants were first presented with the instructions for the prospective memory task. All participants were told that in addition to the "primary symbol counting task" (the ongoing task), they had a "secondary task" (the prospective memory task). This secondary task was to look out for a particular symbol and to indicate if they detected it by withholding the normal response they would give as part of the ongoing symbol counting task, and instead to give a different response. A picture of the prospective memory cue for their condition was displayed along with the following instructions: "At any time during the questionnaire after this page that you see the following symbol, please type a letter in the answer box on that page, instead of the number of symbols you are counting. It can be any letter you like." At this stage, participants in the implementation intention conditions were given the instructions to form the implementation intentions. All participants were told that the instructions for the secondary task would not be presented again, and that they should spend as long as they wanted reading them before continuing.

The following page presented the instructions for the ongoing visual counting task. An example of a symbol, array and correct answer were presented to aid comprehension of the task. Participants were told that they should try to complete the visual counting task as quickly and as accurately as possible, and that they should

proceed to the subsequent trials by clicking the arrow button on the page when they had provided an answer for the trial. They were told that after each set of 20 trials there would be a 'rest page' where they could rest their eyes for 20 seconds before continuing. The rest pages ended and progressed automatically to the next set of trials after this time. Full details of the task instructions are presented in Appendix B.

Three blocks of 20 trials of the visual counting task, including two rest pages, followed the instructions. After this, participants were asked to provide basic demographic information and to identify their prospective memory cue from a list of 10 symbols before being debriefed. The entire experiment took approximately 20-30 minutes to complete.

Data Analysis Plan

The prospective memory instructions were for participants to type a letter instead of a number response to the ongoing task on the trials in which they detected the prospective memory cue. It emerged that four participants responded with a letter in addition to a number response to the ongoing task. Therefore it was clear that these participants had correctly detected the prospective memory cue, but did not suppress the correct response to the ongoing task, as per the instructions. As such, all analyses on prospective memory performance were conducted twice, once under 'strict' criteria in which responses with both a number and a letter were classed as incorrect, and once in which they were classed as correct. None of the results differed substantively between the two types of analyses, and so the present analyses are based under the 'strict' criteria in order to provide as rigorous a test as possible of our procedures. The number of false hits (prospective memory responses to trials

that did not include prospective memory cues) was also assessed, however only two false hits were detected, both coming from the same participant.

Randomization to conditions was assessed using an ANOVA for age and a chi-square test for gender proportion. The dependent variable of prospective memory performance - the number of prospective memory cues correctly responded to - was modelled using an ordinal regression model. Ongoing task performance and reaction times to the ongoing task trials were assessed using ANOVAs. Ongoing task performance was assessed by the percentage of trials in which the participant correctly counted the correct number of symbols, excluding the prospective memory trials.

Results

Randomization Check

A 2 (instruction) x 3 (emotion) way ANOVA found no differences in age between instruction conditions, $F(1, 268) = 2.07$, $p = .152$ or emotion conditions $F(2, 268) = 0.52$, $p = .598$. A Chi-Square test also showed there were no differences between conditions in proportion of gender, $\chi^2(5, N=274) = 10.18$, $p = .070$, indicating randomization to conditions was successful. There was also no difference between conditions in the total time taken on the experiment, $F(5, 268) = 1.14$, $p = .339$.

Prospective Memory Performance

An ordinal regression model was used to fit the data. The assumptions of multicollinearity and proportional odds necessary for the use of this model were met.

The overall model tested the instruction *x* emotion interaction, as well as the main effects of whether or not people formed implementation intentions ("instruction condition"), and were exposed to positive, neutral or negative cues ("emotion condition"). The overall model was shown to predict prospective memory performance over and above an intercept only model, $\chi^2(5, N=274)= 29.13$, $p < .001$, meaning that at least some of the variation in prospective memory performance was explained by the predictors.

The instruction x emotion interaction was nonsignificant, $\chi^2(2, N=274) = 1.18$, $p = .555$, as was the main effect of instruction, $\chi^2(1, N=274) = 0.30$, $p = .585$. As seen in Table 2, roughly equal numbers of participants in each instruction condition showed maximum (3/3) performance (implementation intentions: 49.6%, standard prospective memory instructions: 43.6%) and minimum (0/3) performance (implementation intentions: 29.6%, standard prospective memory instructions: 32.1%). However, there was a significant effect of cue emotionality, $\chi^2(2, N=274) = 26.13$, $p < .001$. Table 4 shows that more participants responded correctly to all three prospective memory cues in the positive (51.5%) and negative (61.1%) conditions than the neutral condition (26.1%). In addition, more participants in the neutral condition failed to respond correctly to any of the prospective memory cues (50.0%) compared to the positive (22.7%) and negative (21.1%) conditions.

The use of emotional cues improved prospective memory performance compared to the use of neutral cues: The odds of better performance on the prospective memory task for participants exposed to the negative cue was 5.54 (95% CI [2.49, 12.31]) times higher than for those exposed to the neutral cue, which was statistically significant: Wald $\chi^2(1, N=274) = 17.67$, $p < .001$. Similarly, the odds of

better performance for participants presented with the positive cue was 3.12 (95% CI [1.43, 6.81]) times higher than for those who were presented with a neutral cue, which was also statistically significant: Wald $\chi^2(1, N=274) = 8.21$, $p < .01$. A repeated regression with condition re-coded showed that the odds of a difference in performance confirmed no significant differences between positive and negative cues , $\chi^2(1, N=274) = 2.07$, $p = .150$.

Table 4. *Number of Prospective Memory Cues Responded to by Condition*

	Emotion condition			Total
Instruction condition	Negative	Neutral	Positive	
Implementation Intention	*N* = 41	*N* = 43	*N* = 50	135
3 correct targets	24 (58.5%)	14 (32.6%)	28 (56.0%)	66 (49.6%)
2	4 (9.8%)	5 (11.6%)	5 (10.0%)	14 (10.4%)
1	4 (9.8%)	4 (9.3%)	6 (12.0%)	14 (10.4%)
0	9 (22.0%)	20 (46.5%)	11(22.0%)	40 (29.6%)
Standard Only	*N* = 49	*N* = 45	*N* = 46	140
3 correct targets	31 (63.3%)	9 (20.0%)	21 (45.7%)	61 (43.6%)
2	7 (14.3%)	9 (20.0%)	10 (21.7%)	26 (18.6%)
1	1 (2.0%)	3 (6.7%)	4 (8.7%)	8 (5.7%)
0	10 (20.4%)	24 (53.3%)	11 (23.9%)	45 (32.1%)
Total	90	88	96	274

Ongoing Task Performance

Performance and reaction times to the ongoing visual search task were also assessed. There were no significant differences in performance between instruction

conditions $F(1, 268) = 0.001$, $p = .974$, $d = 0.01$ and no significant interaction between instruction and emotion $F(2, 268) = 0.203$, $p = .817$, However, there was a significant effect of emotion $F(2, 268) = 3.552$, $p = .030$. Main effect contrasts revealed that performance on the ongoing task was slightly higher for participants in the positive cue condition ($M = 87.6\%$ of trials correct) than for participants in the negative cue condition ($M = 83.5\%$ correct), Adj. sig $p = .026$, $d = 0.36$. However, as there was no significant difference between the positive and negative conditions on prospective memory task performance, the reason for these results is unclear. The absolute difference in performance between the positive and negative conditions on the ongoing task was 49.9 to 47.6 trials correct, meaning that participants in the positive condition only got on average 2.3 extra trails correct. Due to the minimal real world nature of this difference (in comparison to the large difference in prospective memory performance between emotional and neutral cues) these results are not discussed further. There were no significant differences in ongoing task performance between the positive cue and neutral cue conditions (Adj. sig $p = 1.00$, $d = 0.18$) or negative and neutral cue conditions (Adj. sig $p = .300$, $d = 0.23$). Although the present experiment did not employ accurate reaction time measures, average response time for the ongoing task was calculated for each participant based on the number of seconds they spent on each trial as recorded by the survey software. There were no significant differences in average response time between instruction conditions $F(1, 268) = 1.144$, $p = .286$; emotion conditions $F(2, 268) = 0.556$, $p = .574$; or an interaction between instruction and emotion $F(2, 268) = 1.359$, $p = .259$.

Discussion

Prospective memory performance has been shown to be improved by both implementation intentions (X. J. Chen et al., 2015) and the emotionality of critical cues (Meta-analyses, Chapter 3) individually. The present research used a fully factorial design to test for the first time whether both strategies could be used to improve prospective memory performance simultaneously in a novel visual search task. The results showed that participants primed to respond to an emotional symbol cue showed significantly better prospective memory performance than those primed to respond to a neutral cue. In contrast, implementation intention formation did not affect prospective memory performance. The following discussion considers the theoretical and applied implications of the present findings.

The finding that emotional cues improved prospective memory performance is consistent with a growing body of research demonstrating a superiority for emotional prospective memory cues compared to neutral cues (Altgassen et al., 2010; May et al., 2015; Schnitzspahn et al., 2012) and is consistent more generally with research showing preferential processing of emotional compared to neutral stimuli (Okon-Singer et al., 2013). In the present research, both positively- and negatively-valenced cues boosted prospective memory performance. The effect of valence has previously been shown to be inconsistent, with some studies showing only a benefit of positive stimuli and not negative stimuli (Altgassen et al., 2011; Rendell et al., 2011). These inconsistencies may be due to idiosyncrasies associated with the words and photographs used as stimuli in previous research. Prospective memory processes such as perception and memory can be influenced by variables such as the spatial frequency of photos (Delplanque, N'diaye, Scherer, & Grandjean,

2007) and the imageability of words (Fliessbach, Weis, Klaver, Elger, & Weber, 2006). To mitigate these issues, the present research employed a novel set of symbol cues that shared extremely similar perceptual features, meaning that differences in detection of the cues were likely to come from differences in emotional valence rather than from inherent perceptual variations.

Contrary to predictions, there was no observed benefit of implementation intentions, which contradicts a recent systematic review that concluded that implementation intentions augmented prospective memory performance (X. J. Chen et al., 2015). One possible explanation for this is the specificity of the prospective memory response, i.e. the 'then' portion of the implementation intention. Participants were instructed to type a letter instead of a number when they detected the prospective memory cue. However, the response was relatively vague as participants were not directed to type a particular letter, but rather "any letter they liked". In previous prospective memory studies, participants have typically been given a specific response (e.g. "When I see *corn* or *dancer* during the category decision task, I will press the 'Z' key"; McDaniel & Scullin, 2010). Research has shown that implementation intentions with non-specific responses are less effective (van Osch, Lechner, Reubsaet, & De Vries, 2010), which may explain the lack of an effect for implementation intentions in the present study. Theoretically, it may be more difficult to form a strong cue-response link when the response is vague, thus limiting the effectiveness of the strategy.

An alternative or contributing explanation may be the use of an online methodology. Although some studies have shown that implementation intentions formed online can be effective at influencing behaviour (Craciun, Schüz, Lippke &

Schwarzer, 2011; Sniehotta, Araújo-Soares & Dombrowski, 2007), several others have failed to find a benefit (de Nooijer, Jansen & van Assema, 2012; Hagger, Lonsdale & Chatzisarantis, 2012; Prestwich, 2003; Skår, Sniehotta, Molloy, Prestwich & Araújo-Soares, 2011). The online delivery of the intervention means that there was less control over participant's attention to instructions than in a traditional laboratory experiment. It is possible that some participants were concurrently engaged in other activities on their computer, and therefore did not fully commit to forming the implementation intention. This is despite the fact that several control measures were employed to try to minimise this possibility. For example, participants were forced to type out the implementation intention before being allowed to progress to the rest of the experiment, and any participants who took an excessive amount of time to complete the experiment were excluded as it was deemed they would likely have been distracted from the task. Nevertheless, one limitation with internet-based methodologies is that there is no way of knowing what participants are doing concurrently whilst participating in the experiment. Traditional laboratory experiments require participants to make the effort to come to the laboratory, whilst internet experiments can be completed from anywhere at any time, for example during a lunch break, when participants may have other thoughts on their mind, or tasks to complete. Thus in the present research participants may not have processed the implementation intention instructions deeply enough to activate the mechanisms of enhanced cue accessibility and a strengthened cue-response link thought to underlie the benefits of this strategy. This suggestion, if correct, highlights the importance of attending to implementation intentions whilst forming them to ensure their effectiveness.

One limitation of the methodology that needs to be acknowledged is the confounding issue of the implementation intention instructions. Participants in the implementation intention condition received instructions to form an 'if-then' plan in addition to the standard prospective memory task instructions, however participants in the control condition received no additional instructions. Therefore, participants in the implementation intention condition spent longer thinking about the prospective memory task and how to complete it, which could confound any effects of the specific strategy of forming implementation intentions. As there was no effect of implementation intentions observed in the current study, this limitation appears not to be relevant to the results, however it should be considered by researchers who may wish to replicate the methodology of this experiment. In future, participants in the control condition should also be given instructions to think about the prospective memory task for a suitable amount of time. This will ensure that any differences in prospective memory performance between the conditions can be attributed to the strategy of forming implementation intentions, and not just a difference in the amount of time spent thinking about the task.

A second limitation of the methodology is that the number of prospective memory cues that occurred during the ongoing task for participants to detect was low. Only three cues were presented during the 60 trials of the task (5% of trials). This number was chosen to prevent the prospective memory task remaining in participant's consciousness, which can occur when a large number of cues are presented during the detection phase (Uttl, 2008). In these cases, the task may measure vigilance rather than prospective memory. However, just as a small number of items on a scale is associated with lower reliability, a small number of prospective

memory cues embedded in an ongoing task is also linked to lower reliability (Kelemen et al., 2006). Future research should attempt to replicate the task in order to assess its reliability and to confirm the findings of this experiment.

In regards to the investigation into the effectiveness of emotional cues, another limitation of the present study and the prospective memory literature more generally is the artificial nature of the prospective memory task used. The present study employed a novel visual search task in which participants had to detect prospective memory cues embedded in symbol arrays. This expands our knowledge of the conditions under which emotional cues are likely to be effective, as previous research on the effectiveness of emotional cues had employed only a small range of tasks, principally lexical decision tasks (e.g., May et al., 2015). However, as with the tasks used in previous research, the prospective memory task to type a letter in response to the prospective memory cue and the ongoing visual search task were computer-based and not particularly representative of either the types of intentions that people make in everyday life or the types of ongoing activities that they might be engaged in. As such, further research is necessary to explore whether emotional prospective memory cues can improve intention realisation in situations in which the prospective memory response is a real life behaviour that requires more dedicated effort than merely pressing a button on a keyboard, and the ongoing is also more naturalistic than a computer-based task.

Conclusion

The present study shows that emotional cues can enhance prospective memory performance, even in tasks in which the cue does not have to be attended to

as a requirement to complete the ongoing task. The use of emotional cues may therefore be beneficial in situations where one has to remember to do something, but where attention is likely to be directed at a different task one is completing. No benefit was found for implementation intentions; however the results help to stimulate discussion about the limitations of this strategy. It is possible that the lack of effectiveness of the implementation intentions strategy was due to the nature of the prospective memory response, or the online delivery of the intervention. Future research should seek to explore these possibilities further.

Chapter Five: An Experiment To Explore the Effect of Using Both Implementation Intentions and Emotional Cues to Enhance the Naturalistic Behaviour of Handwashing.

The experiment presented in the previous chapter was the first to test the use of emotional cues within implementation intentions at improving prospective memory. However, further evidence is necessary to determine whether these strategies can be used together to improve intention realisation. In addition, and as noted in the discussion of the limitations of the previous experiment, the evidence underpinning the effect of the emotional content of cues on prospective memory has thus far been restricted to laboratory experiments in which the overall goal is to press a key in response to a stimulus on a screen. Therefore, there is a need to study the effect of emotional content of cues in applied settings to see if the benefit of emotion observed in prospective memory studies is transferable to more ecologically valid outcomes. This would represent a valuable step towards determining whether emotional cues can be used in interventions to change real-world behaviour. The present experiment sought to fill this gap in the literature by testing whether the strategies are effective in a more naturalistic task. Handwashing was chosen as the behavioural intention to examine for this purpose. There were multiple justifications for this choice as will become clear in the following section.

Hand hygiene behaviours, including handwashing, are the "best and most cost effective way to prevent infection and illness" (Babeluk, Jutz, Mertlitz, Matiasek, & Klaus, 2014, p.6) and have been shown to be important in healthcare (World Health Organisation, 2009), food service (Pellegrino, Crandall, O'Bryan, & Seo, 2015) as well as in home and community settings (Bloomfield, Aiello,

Cookson, O'Boyle, & Larson, 2007). Despite the importance of handwashing, adherence to guidelines is generally poor. A review by the World Health Organisation (2009) reported average compliance rates of only 38.7% amongst healthcare workers. In the food industry, adherence to appropriate hygiene standards has been described as "abysmal" (Pellegrino et al., 2015). Studies using observational methods have consistently shown "abysmal" to be a fair assessment, with rates of handwashing observed to be as low as 5% and no higher than 27% (do Prado et al., 2015; Green et al., 2006; Lubran et al., 2010).

Compliance with recommended guidelines in the general population is better, but less than optimal (Hubner, Hubner, & Kramer, 2013). A study by De Alwis, Pakirisamy, San, and Xiaofen (2012) found a significant increase in bacteria on students' hands after using the toilet, suggesting poor handwashing practice. The present study took the novel approach of priming pictorial cues using implementation intentions (Gollwitzer, 1999) to promote handwashing at the same time as seeing whether the emotional content of cues in the environment could boost the performance of implementation intention-based interventions.

Reasons for Failing to Wash Hands

Although there are numerous reasons that people cite when they do not wash their hands (World Health Organisation, 2009), the literature suggests that a lack of knowledge or motivation are not the primary causes. Research has shown that knowledge of correct hygiene procedures amongst food workers is high (Clayton, Griffith, Price, & Peters, 2002; Robertson, Boyer, Chapman, Eifert, & Franz, 2013) and a review by Larson and Kretzer (1995) found that non-compliance to

handwashing guidelines amongst healthcare professionals was not caused by a lack of knowledge. Lack of motivation to wash one's hands is also unlikely to be a reason for failure to engage in the behaviour: O'Boyle, Henly and Larson (2001) found that intention to perform handwashing behaviours among nurses was high and that they had positive attitudes and perceived social pressure to wash their hands. Relatedly, barriers to handwashing are more likely to be related to forgetting than not knowing how or when to wash one's hands (McLaughlin & Walsh, 2012; Strohbehn et al., 2014).

Overall, the literature suggests that failure to wash one's hands is not likely due to a lack of knowledge or motivation, but to struggles with implementing motivation or failures of a volitional nature. This finding is not unique to handwashing and has been observed in several other health behaviours: 47% of people who intend to engage in a health behaviour typically fail to do so (Sheeran, 2002). Encouraging people to form implementation intentions (Gollwitzer, 1993) represents one means of bridging this intention-behaviour gap.

Implementation Intentions and Handwashing

There exists a small number of studies that have looked at using implementation intentions to increase handwashing. Three field studies showed that implementation intentions can increase handwashing (Erasmus et al., 2010; Lhakhang, Lippke, Knoll, & Schwarzer, 2015; Zhou, Jiang, Knoll, & Schwarzer, 2015), although a third study did not (Fernandez, Lippke, Knoll, Moya, & Schwarzer, 2015). However, each of these studies has limitations that limit the extent to which valid conclusions can be drawn about the effectiveness of implementation

intentions at increasing handwashing. The study by Erasmus et al. (2010) did not employ a control condition against which to compare the effects of implementation intentions, meaning that the observed increase in handwashing may have been the result of a mere measurement effect. The studies by Lhakhang et al. (2015) and Zhou et al. (2015) utilised implementation intentions alongside other behaviour change techniques meaning that it is not possible to tell whether the observed benefits were due to the implementation intention component of the intervention. Only the study by Erasmus et al. (2010) measured handwashing objectively, and subjective measures of handwashing such as those employed in the studies by Fernandez et al. (2015), Lhakhang et al. (2015), and Zhou et al. (2015) have been demonstrated to be inaccurate (Contzen, De Pasquale, & Mosler, 2015). The present experiment addresses these issues by employing a rigorous control condition, using implementation intentions as the only behaviour change component of the intervention, and by measuring handwashing objectively. This design allows for a more valid assessment of the effectiveness of implementation intentions at increasing handwashing.

Another limitation of previous work with implementation intentions with respect to handwashing specifically, but also the literature more broadly, is that cues have typically been operationalized in terms of specific times and/or places. For example, according to World Health Organisation (2009) guidelines, handwashing needs to be performed both before and after a variety of activities and in numerous diverse settings in the healthcare environment. An implementation intention that specifies handwashing in response to only one of these particular settings (e.g. "before touching a patient") would only be expected to trigger handwashing in that

situation, and not promote handwashing in other necessary situations (e.g. "after body fluid exposure risk"). Concurrently, and as discussed in detail in Chapter 2, forming multiple implementation intentions that specify a range of situational cues has been shown to be less effective than a single implementation intention with a single cue (Verhoeven et al., 2013). The implication is that forming an implementation intention that specifies a single cue that is not tied to a specific time or location is most likely to encourage handwashing. Thus, encouraging people to form implementation intentions that specify a pictorial cue that could be placed in multiple contexts may be effective at reminding people to wash their hands or any behaviour that needs to be performed independent of time or place. Chapter 4 presented the results of an experiment that used implementation intentions with basic visual cues, although the implementation intentions were not effective at improving intention realisation. However, it is thought that this might be due to the formulation of the prospective memory response, and as such did not provide a suitable test of implementation intentions with pictorial cues. Previous research by McCrea et al. (2015) has shown that implementation intentions can be responsive to basic visual cues in computer-based lab experiments, however there remains an open question as to whether pictorial cues can trigger implementation intentions in more naturalistic settings. The present study is the first to test the efficacy of using pictorial cues to trigger appropriate responses in a field experiment.

Emotion and Implementation Intentions in a Naturalistic Behaviour

Chapter 4 presented evidence that emotional cues can improve intention realisation in comparison to neutral cues. This corroborated the results of the meta-analysis in Chapter 3 that showed that overall emotional cues were an effective

strategy for improving intention realisation. The previous experiment in Chapter 4 was unable to determine whether implementation intentions could be successfully combined with emotional cues, due to the lack of effectiveness of implementation intentions in general, possibly due to the nature of the prospective memory response. However, there remains a strong theoretical basis that combining the strategies of emotional cues and implementation intentions can improve intention realisation (Webb & Sheeran, 2008). The present study therefore sought to address this question again, and to expand on the previous experiment by using the naturalistic behaviour of handwashing. This helps fill the gap in the literature of the use of emotional cues in a real-world environment and to promote a real-world behaviour. The use of pictorial cues in the present experiment are particularly suitable for emotional manipulation, due to the ease in which emotionality can be manipulated yet other variables be controlled for. Using a unique image allowed control over the exposure of the cue to participants.

The present experiment employed three conditions: an emotional cue implementation intentions condition, a neutral cue implementation intention condition, and a control condition. The meta-analyses presented in Chapter 3 and the experiment presented in Chapter 4 found that both positive and negative cues were shown to be effective when the emotional cues were presented at both encoding and detection. However, the meta-analyses also showed that overall regardless of the timing of the manipulation, positive cues had a greater effect than negative cues. Within the literature generally, positive cues have consistently been shown to improve prospective memory (Altgassen et al., 2010; May et al., 2012; Rendell et al., 2011). Therefore, due to the equivalent effectiveness of both positive and negative

cues, but the more consistent effectiveness of positive cues, a positively-valenced image was chosen for the emotional cue in the present study.

The Present Research

The aims of the present research were to investigate: (a) whether implementation intentions that specify pictorial cues can be used to promote handwashing; and (b) whether positive cues improve the effectiveness of implementation intentions in this behaviour. In doing so, the study addresses limitations in past literature on both implementation intentions and emotional cues. The hypotheses are: (1) participants who form an implementation intention are more likely to wash their hands than participants who do not form implementation intentions; (2) participants who form an implementation intention with a positive cue are more likely to wash their hands than participants who form an implementation intention with a neutral cue.

Method

Participants

Participants were (N=111) first year undergraduate psychology students from a UK university. They were aged 18-28 years (M=18.96, SD= 1.43) and participated in the experiment in exchange for partial course credit. There were 87 females and 23 males in the sample. One participant did not report their gender. The sample size of 37 participants in each condition gave a computed power of 82.9% to detect an effect size of d= 0.65 (Gollwitzer & Sheeran, 2006) (converted to Binomial Effect Size Display).

Design

The experiment used a between-participants design with the independent variable of *intervention* that had three levels: neutral cue implementation intention, positive cue implementation intention, and control condition, in which no implementation intention was formed. Handwashing was observed surreptitiously post-intervention by a researcher who was blind to condition. Participants were assigned to conditions using a random number generator.

Procedure

Phase 1. All participants were met by experimenter 1 and taken to the testing room, where they were told that they would be completing a task about creativity and self-reflection, and would be using clay to make a series of models. Participants were told that the modelling clay could leave an unwanted scent on their hands and so after the experiment they should go and wash their hands using a special antibacterial scented soap that had been placed in the psychology department kitchen, down the hallway from the testing room. Participants in the two experimental conditions were additionally told that in order to help them to remember to complete this task, they should form an implementation intention to assist them. Participants in the two experimental conditions were presented with the pictorial cue that was either neutral or positively valenced depending on the condition to which they had been randomly allocated, and formed the implementation intention "If I see this picture, then I will go and wash my hands in the psychology kitchen". Participants in the control condition did not receive any further instructions after being told of the location of the kitchen.

Phase 2. After phase 1, experimenter 1 was replaced with experimenter 2, to prevent participants using the presence of experimenter 1 as a reminder to wash their hands at the end of the experiment. Experimenter 2 (who was blind to participants' conditions) explained that the next task involved creating a set of models out of scented modelling clay, and rating them on a series of scales. This task took approximately 20 minutes, and participants were told they were free to leave when they had finished, without being reminded of the goal of washing their hands. For the neutral cue and positive cue conditions, the relevant pictorial cue was placed by experimenter 1 on the back of a closed door opposite the testing room, through which the participants had to exit. This placement ensured that all participants had the opportunity to see the cue upon leaving the experiment. In the control condition, no cue was placed on the door.

Phase 3. In order to fulfil the goal of washing their hands, participants had to walk down the hallway and go into a kitchen where there was a sink with soap. The most efficient route out of the building for participants would be down the stairs and would avoid the kitchen (see Figure 3). Therefore, walking down the hallway to wash their hands in the kitchen indicates that the participant specifically remembering to complete their goal, rather than responding to the cue of passing the kitchen. Experimenter 3 was sat in view of the kitchen in a cafe, and recorded whether each participant washed their hands or not. Experimenter 3 was informed of the physical appearance of the participant by experimenter 1 so they could correctly identify if participants washed their hands, but were blind to the participant's condition.

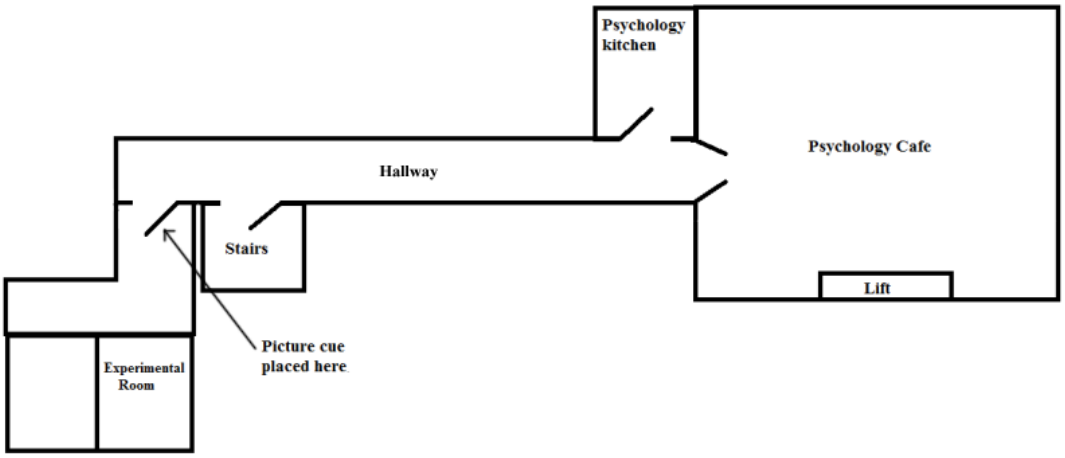

Figure 3. The Layout of the Department.

Materials

Modelling clay. The clay modelling task was used to simulate a situation in which a new goal takes priority and also as a motivation for participants to wash their hands, as completing the task left an odour on the hands. Participants were given a portion of scented modelling clay and asked to create a series of models from two lists of items. The items they were asked to create were chosen to be non-emotionally arousing (e.g. lily, toothbrush, apron). After they had created each set participants were asked to rate the quality of the models on a Likert scale, however these data were not analysed and the questions were used only to add to the credibility of the task.

Handwashing. The sink in which participants were instructed to wash their hands was located in a kitchen down the hallway from the experimental testing cubicle. By the sink was a dispenser of soap that was clearly labelled. The sink is visible from the adjacent café area where a condition-blind third experimenter recorded whether or not participants washed their hands.

Cues. The pictorial cue was a clip-art picture of a stylised cartoon sink, which was approximately 15cm square and printed in greyscale on a piece of A4 paper. For the positive cue, the eyes and mouth of a cartoon smiley face was superimposed onto the sink using Adobe Photoshop (see Appendix C). Faces have been demonstrated to be an emotional stimuli that triggers activity in the amygdala, provoking an affective response (Okon-Singer et al., 2013; Sergerie, Chochol, & Armony, 2008). For the neutral cue, the picture was unchanged. The cue was shown to participants as they formed their implementation intention and was subsequently placed on the back of the door through which they exited in order to expose them to it. The door was kept closed, ensuring that participants in the implementation intention conditions would see the cue, although their attention was not explicitly directed towards it.

Implementation intentions. Participants in the experimental conditions were additionally given the piece of paper with the picture of the relevant cue for their condition (positive sink versus neutral sink) and asked to read the phrase "If I see this picture, then I will go and wash my hands in the psychology kitchen" silently to themselves. Participants were then instructed to read the sentence aloud and also to write it down.

Analysis

Success of the randomisation procedure was checked using ANOVA for continuous variables and chi-square for categorical variables. The principal hypotheses were tested using binary logistic regression with handwashing as the dependent variable and condition as the categorical independent variable. Condition

was dummy coded with the control condition as the reference category to test the first hypothesis and with the neutral cue condition as the reference category to test the second hypothesis.

Results

Descriptive Statistics

One participant was excluded from the positive cue condition as they revealed that another participant had told them the nature of the deception. There were no significant differences between the conditions on either age $F(2,107) = 1.32$, $p = .27$, or proportion of each gender $\chi^2(2, N = 110) = 3.99$, $p = .14$, suggesting that randomization was successful.

The overall binary logistic regression model with handwashing as the dependent variable and condition as the categorical independent variable was statistically significant $\chi^2 = 6.47$, $df = 2$, $p = .039$, indicating that the variable of experimental condition was a reliable predictor of handwashing compared to the constant-only model. The model correctly predicted 66 of the 110 participants' handwashing (60.0%). The results of the model are presented in Table 5.

Table 5. *Results of Logistic Regression Analysis with the Control Condition as the Reference Category.*

Predictor	*B*	*S.E.*	*Wald's* χ^2	*df*	Sig.	e^B(odds ratio)	95% CI
Constant	-0.86	0.36	5.72	1	.017	0.42	
Condition			8.41	2	.047		
Neutral	1.13	0.49	5.35	1	.021*	3.10	1.19 - 8.10
Emotional	.97	0.49	3.92	1	.048*	2.64	1.01 - 6.91

Note. $p < .05$*

Implementation Intentions and Handwashing

Eleven out of 37 (29.7%) participants in the control condition washed their hands whereas 21 out of 37 (56.8%) participants in the neutral cue condition, and 19 out of 36 (52.8%) participants in the positive cue condition washed their hands.

The results show that condition as a predictor was statistically significant (p = .047) and that the neutral cue and positive cue conditions were significantly different from the control condition (p's = .021 and .048 respectively). For neutral cue implementation intentions the odds of performing handwashing were 3.10 times that of the control condition, and for positive cue implementation intentions the odds of performing handwashing were 2.64 times that of the control condition.

Positive Versus Neutral Cues

Although it was clear from the descriptive statistics that implementation intentions with positive cues were not more effective than implementation intentions

with neutral cues, a second logistic regression was performed with the neutral cue condition as the reference category to assess whether rates of observed handwashing differed between conditions. The positive cue condition was not significantly different from the neutral cue condition (p= .733). The odds of handwashing for the neutral cue condition were slightly higher (1.17 times) than that of the positive cue condition.

Discussion

The present study investigated two novel research questions, namely: (a) whether implementation intentions utilising pictorial cues are effective at aiding the realisation of the intention of handwashing, and (b) whether the use of a positive cue in the implementation intention is more effective than a neutral cue for this behaviour. The results showed for the first time that specifying pictorial cues when forming implementation intentions were effective at increasing handwashing. Participants were much more likely to wash their hands after forming an implementation intention (54.8%) than control participants who did not form an implementation intention (29.7%). Contrary to predictions, however, the emotional valence of the cues did not affect the operation of implementation intentions. The following discussion considers the theoretical and public health implications of the findings.

Implementation Intentions and Handwashing

The results of the present research add further evidence to the growing literature showing that implementation intentions can help to promote a range of different behaviours (Gollwitzer & Sheeran, 2006). In regards to handwashing

specifically, the results corroborate those of previous research by Zhou et al. (2015) and Lhakhang et al. (2015) who demonstrated the effectiveness of implementation intentions at increasing handwashing behaviour, but extend these findings by employing an objective measure of handwashing, rather than self-report (Lhakhang et al., 2015; Zhou et al., 2015).

The present research further extends previous work by providing evidence that pictorial cues can be used as the critical situations designated in the 'if' part of the implementation intention. The use of such a cue, which can be placed in multiple situations, helps to alleviate one potential problem of the use of implementation intentions, namely, that only one critical situation at a time can be specified when forming an implementation intention. Consistent with many health behaviours, handwashing is a behaviour that needs to be performed in many different situations and contexts (World Health Organisation, 2009). Given that forming multiple implementation intentions with different cues has been shown to undermine their effectiveness (Verhoeven et al., 2013), the use of pictorial cues is potentially generalisable to multiple contexts. For example, a pictorial cue could be placed on both sides of a door, facilitating handwashing in the contexts of both entering and exiting a ward, without the need to form multiple implementation intentions. Further research that extends the present findings to reducing unwanted behaviours (as opposed to promoting desired behaviours) is required. For example, the use of implementation intentions with pictorial cues could be integrated within product packaging to help augment implementation intention-based interventions and so facilitate healthier consumer choices and behaviours (Armitage & Arden, in press).

The results were not consistent with the results of the experiment in Chapter 4, which found no benefit of implementation intentions at improving intention realisation. However, as previously discussed, a possible reason for the lack of benefit of implementation intentions in the previous experiment was due to the non-specific nature of the prospective memory response. In the present experiment, the response to "wash hands in the psychology kitchen" was more specific and utilised a 'when and where' formulation used successfully in previous studies (e.g. Holland, Aarts, & Langendam, 2006).

Emotional Cues

Contrary to predictions, implementation intentions formed using emotional pictorial cues were no more effective than neutral cues. There are multiple possible explanations for this. Firstly, it may be that the emotional cue used did not elicit sufficient emotional arousal in the viewer. The emotional cue used the same image as the neutral cue, but with the eyes and mouth of a smiley face superimposed over the top. Research has shown that faces are emotional stimuli, and trigger greater activity in the amygdala compared to non-facial pictures (Sergerie et al., 2008). However, it may be that the emotional stimulus was not sufficiently more emotional than the neutral cue to show any difference. Previous research that has found effects of emotion in prospective memory have commonly used words (May et al., 2012) from the Affective Norms for English Words database (ANEW; Bradley & Lang, 1999) and pictures (Rendell et al., 2011) from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) that have previously been validated to be emotionally arousing. Future research should seek to rate the emotionality of the cues to ensure that stimuli is sufficiently emotional.

An alternative explanation concerns the congruency between the emotional cue and the prospective memory response. The present research was the first to use emotional cues in a real-world environment to trigger a real-world behaviour, and one possible explanation for the null finding is that the nature of the target behaviour influenced the effectiveness of the emotional cue. Previous research on emotional cues have utilised prospective memory paradigms in which the response is to simply press a button on a keyboard (Altgassen et al., 2011; May et al., 2012; Experiment 1, this thesis). In contrast, handwashing is a complex behaviour that requires a dedicated effort to perform, and as such may be evaluated as being undesirable or arduous. Therefore, there may have been a lack of congruency between the positive emotional stimuli used and the negative handwashing response. This represents a confounding variable that has not been relevant in previous research, but may have in this instance moderated the effectiveness of the emotional cue. One limitation of the design of the present experiment is that there was no negative emotional cue condition. Only a positive emotional cue was tested, which was chosen as much of the previous prospective memory research, including the meta-analyses in Chapter 3 and the experiment in Chapter 4, has found a benefit for positive compared to neutral stimuli (e.g., Altgassen et al., 2010; May et al., 2012) and many have also found a further benefit for positive compared to negative cues (Clark-Foos et al., 2009, experiments 1a-1c; Rendell et al., 2011). However, the use of a different emotional cue with stronger semantic links to the behaviour of handwashing may be more effective. Previous research has shown that the semantic relationship between the cue and the response can influence prospective memory (Pereira et al., 2012). In an experiment that employed a task in which prospective memory cue words had to be

responded to by stating a paired word, the authors found that semantically related cues and responses produced better prospective memory performance than unrelated words. Further research is necessary to determine whether there is a similar emotional congruency effect that echoes the semantic congruency effect demonstrated by Pereira et al. (2012).

Relevant to this suggestion is the discussion by Pellegrino et al. (2015) of the use of disgust as a cue in the promotion of hand hygiene behaviour. The emotion of disgust is universal and signals the threat of infection and disease (Curtis, Aunger, & Rabie, 2004), and should therefore represent an appropriate cue to prompt behaviour to minimise or reduce this threat. A study by Porzig-Drummond, Stevenson, Case, and Oaten (2009) successfully used an intervention triggering disgust using visual cues to promote hand hygiene behaviour. Posters placed in the toilets of a university library that elicited disgust were more effective at increasing hand washing behaviour than posters without the disgust-inducing element. Recent research by Pellegrino, Crandall, and Seo (2016) has tested the use of disgust-inducing stimuli in a prospective memory experiment and found that presentation of disgust-inducing visual, auditory and particularly odour cues were more effective than non-disgust inducing visual cues in helping participants remember to wash their hands. The implications are that augmenting a pictorial cue with a disgust-inducing emotional property that is more semantically congruent with the behaviour of handwashing may be more effective than neutrally-valenced pictorial cues or pictorial cues that have an incongruent valence.

Despite the encouraging findings that implementation intentions can be used to promote handwashing, there are limitations to the present research. One

methodological issue that limits the interpretation of the results is that in the control condition, no pictorial cue was placed on the back of the door that participants had to exit through at the end of the modelling clay task. Therefore, it is possible that the observed benefits of implementation intentions were due to the presence of the cue, rather than forming the implementation intention itself. The cue was a picture of a cartoon sink, and therefore whilst not an explicit reminder for participants to wash their hands in the kitchen, may still have been used as a happenstance cue to trigger the prospective memory response regardless of the formation of an implementation intention. A second limitation is that it is possible that some participants followed the instructions to wash their hands, but did so in an alternative location. Toilets with sinks were available close to the exit of the building on the floor below, and the student participants would have been aware of the location of these. Although participants were reminded of the location of the psychology kitchen when being given the task instructions, experimenters only recorded handwashing that took place in this location, any participants using an alternative location would have been recorded as not washing their hands. Therefore, this represents a potential confound for the validity of the dependent variable.

Third, the modelling clay task employed is unlikely to accurately reflect the hectic and fast paced environment of a busy kitchen or hospital ward, where workers may have many conflicting and rapidly changing goals. Implementation intentions are theorised to operate automatically without the need for conscious control and as such should still retain their effectiveness even in such situations. However, empirical support for this assumption is mixed. While a number of studies have demonstrated the effectiveness of implementation intentions under cognitive load

e.g. Brandstätter, Lengfelder, and Gollwitzer (2001); A.-L. Cohen and Gollwitzer (2008); Gallo and Gollwitzer (2007b) and McDaniel et al. (2008), some research has failed to find a benefit of implementation intentions in these conditions (McDaniel & Scullin, 2010) - though this is limited. In addition, the majority of these studies have used controlled lab-based tasks that are limited in ecological validity. In order to validly assess the effectiveness of implementation intentions in promoting hand washing behaviour in food service and healthcare environments, more realistic field studies are likely to be necessary. Fourth, although we were able to assess frequency of handwashing objectively for the first time in an experimental design, we were unable to address quality of handwashing, which is also important in reducing bacteria on hands (Bloomfield et al., 2007). Nevertheless, the findings suggest that further exploration of the use of pictorial cues to initiate behaviour change is warranted.

Conclusion

The present research is the first to provide robust, objective evidence that implementation intentions employing pictorial cues are effective at promoting handwashing. The use of unique pictorial cues in implementation intention formation may help to overcome the potential narrowing associated with specific 'when, where and how' plans. However, there was no observed benefit of positively-valenced cues over neutral cues. It is possible that the congruency between the valence of the emotional cues and the nature of the handwashing response moderated the effectiveness of the emotional cues and future research should seek to explore this suggestion further.

Chapter Six - General Discussion

The present programme of research had two main aims. The first aim was to expand our current knowledge of the role of emotion in intention realisation. This included meta-analyses to clarify whether emotional cues have a beneficial effect on prospective memory. The second aim was to investigate whether the combined use of emotional cues and implementation intentions were effective at helping people to remember to realise their intentions. This was achieved through two empirical studies.

The research sought to build on previous studies of the strategies used to help people to remember to act at an opportune moment. Whilst implementation intentions are an established strategy for improving prospective memory (X. J. Chen et al., 2015), the effectiveness of emotional cues is less certain. The systematic literature review and series of meta-analyses help to quantify the effect of emotional cues on prospective memory from the existing literature on the topic. Overall, the picture that emerges is that there is an advantage to using emotional cues compared to neutral cues under certain circumstances. Moderator analyses were used to reveal the conditions under which emotional cues are most likely to be effective at improving intention realisation, and also indicate possible reasons for the contradictory results present in the literature. The results highlight that the effect of emotional cues on prospective memory is not likely to be straightforward, but confirm that further empirical investigation involving both emotional cues and implementation intentions is a potentially positive line of enquiry.

These findings were used to help design two complementary studies to explore the use of implementation intentions and emotional cues together at improving prospective memory. The first study used an online experiment with a prospective memory dual-task paradigm (with novel task and cues) to test the effects of implementation intentions and emotional cues together in a fully factorial design. This allowed for the first time to see whether emotional cues and implementation intentions could concurrently improve prospective memory. Following this, a second experiment was conducted to test the combination of implementation intentions and emotional cues at improving prospective memory for the more naturalistic behaviour of handwashing.

Overall, the results show that the strategies of emotional cues and implementation intentions can improve intention realisation individually, but that their effectiveness is not reliable in all conditions. In Experiment 1, emotional cues were effective but implementation intentions were not. In Experiment 2, the opposite pattern was observed. There were no interaction effects observed for the use of emotional cues and implementation intentions together in either study.

With regards to the aim of the present research to determine whether the use of both strategies are effective together at improving prospective memory, it is clear that further work is necessary to tease apart the reasons for the contrasting findings of experiments 1 and 2. However, the present research represents the first attempt to address this issue and signpost important directions for future research. The discussion that follows covers the strengths and limitations of the research, and the implications and potential applications of the findings and the research area to everyday life.

There are several strengths to the methodologies employed in the present research that deserve highlighting. First, whilst the empirical experiments focused on different prospective memory intentions and were conducted in different settings, both employed modified versions of the dual-task paradigm developed by Einstein and McDaniel (1990). This is the dominant paradigm in the literature used for investigating prospective memory in the laboratory. It allows for a large degree of control over factors relating to the prospective memory intention, as well as the context in which it will be performed. This is important as variables such as the presentation of the prospective memory cue and the instructions given to participants can be isolated and manipulated. Variables such as the nature of the ongoing activities that participants were engaged in, the timing of the presentation of the cues, and the formulation of the intentions themselves were controlled for. Therefore, the effects observed in Experiments 1 and 2 can be reasonably put down to the manipulation of the emotional valence of the cues and the implementation intention task instructions. Highly-controlled laboratory studies can be accused of lacking ecological validity and of having little application to everyday life. However, Kvavilashvili and Ellis (2004) highlight the complementary nature of traditional laboratory research and more ecological work, and argue that both approaches investigate the same underlying processes, particularly in the field of cognitive psychology and memory. The present work is thus an important first step in determining the effectiveness of the strategies of implementation intentions and emotional cues, and supporting the theoretical basis underlying the suggestion of their use to improve prospective memory in everyday life.

Another strength of the research is the consistent use of visual cues to trigger prospective memory intentions. Whilst visual cues such as photographs have previously been employed in prospective memory research (Altgassen et al., 2010), the majority of applied implementation intentions work has used situational cues (e.g., Armitage, 2009; Chapman, Armitage, & Norman, 2009). Situational cues can be effective, however research has shown that forming multiple intentions with separate cues can have a detrimental effect on intention realisation (Einstein et al., 1992; Verhoeven et al., 2013). It is not uncommon that an intention - such as washing one's hands - needs to be realised in multiple different situations. In a practical sense, visual cues can overcome the issue of forming multiple intentions by linking the prospective memory response to a single visual representation, which can be placed in multiple situations. In addition, the findings of the meta-analysis in Chapter 3 illustrate the importance of making sure that the encoded cue matches the observed cue in order to maximise prospective memory performance. The results showed that when the emotional cues were observed during both the encoding and detection phases of prospective memory, performance on the prospective memory task was better than when the emotion of the cues was manipulated at only one of these phases. Visual cues also trump situational cues in this respect, as it may not always be possible to exactly imagine the situation that one will find oneself in at the point when the delayed intention needs to be realised. However, encoding a specific visual cue in advance that one can memorise and then place in a relevant situation means prospective memory performance is likely to be improved. Finally, the salience of visual cues can also be easily manipulated, particularly with regards to emotional salience. The use of basic visual cues in the present research with clear

emotional connotations (e.g., a happy smiley face in Experiment 1) means that there was little scope for ambiguity regarding the emotional valence of the observed cues, and a limit on the impact of other cue variables that may have influenced cue detection.

Despite the strengths of the present research, the conclusions and implications of the findings are necessarily tempered by the limitations of the specific studies carried out and the field of research into prospective memory and emotion in general. One limitation common to both empirical studies conducted concerns the nature of the sample of participants used. The handwashing experiment presented in Chapter 5 used a sample of undergraduate psychology students, as is common with much of the previous research on emotional cues and prospective memory (e.g. Clark-Foos et al., 2009; Graf & Yu, 2015; Rummel et al., 2012; Singh & Kashyap, 2016) and psychological research more generally (Henrich, Heine, & Norenzayan, 2010). The online experiment presented in Chapter 4 sampled from a University-wide email list, and so although the sample was more diverse than that used in the handwashing experiment (*M* age = 29.68, *SD* = 11.70), it still consisted of predominantly young and middle-aged adults. The limited demographic diversity of these samples restricts the extent to which the conclusions can be applied to other populations. Previous research has found age differences in both the effectiveness of emotional cues and implementation intentions, in particular a difference between young and older adults. For example, Schnitzspahn et al. (2012) found that emotional cues were more effective at improving prospective memory relative to neutral cues for older adults compared to young adults. Altgassen et al. (2010) observed a similar pattern of effects for older adults compared to young adults. In

order to explore these differences further, age was coded for as a moderator in the meta-analysis presented in Chapter 2 but no significant effects emerged. However, this may have been due to the influence of other potential moderator variables that can interact with both age and emotional processing, such as task complexity (d'Ydewalle, Bouckaert, & Brunfaut, 2001; Okon-Singer et al., 2013) that could not be coded for in the current analysis. Nevertheless, the age differences observed in previous research suggest that the effects of emotional cues observed in the present research (e.g. in the online study in Chapter 4) may be stronger for older adults.

Regarding implementation intentions, age differences have also been observed that influence the effectiveness of this strategy: Zimmerman and Meier (2010) observed a benefit of implementation intentions at improving prospective memory in older adults, but not adolescents or young adults. Schnitzspahn and Kliegel (2009) also found a benefit of implementation intentions for older adults, however the 'old-old' adults (*M* age = 81.5) in their study who formed implementation intentions actually showed impaired prospective memory performance, in comparison to the control condition. The implications of this are that whilst the findings of the present research regarding the effectiveness of implementation intentions (for example, at improving hand washing behaviour) may generalise to older adults, they may not hold for very old people. Further research is necessary to explore whether the combination of both implementation intentions and emotional cues together is effective at enhancing prospective memory in the population of very old adults.

A second limitation of the present research concerns the applicability of the findings to every day prospective memory. Whilst the need for controlled, lab-based

studies such as those used in the present research has already been highlighted, the generalisability of the findings to applied settings is a legitimate concern. For example, whilst the results of Experiment 2 were promising with regards to the use of implementation intentions to promote handwashing, further research is necessary in order to generalise this finding to real-life settings of hospitals and food service workplaces where compliance with handwashing guidelines is poor. The modelling clay task employed in the study is unlikely to capture the hectic environment and increased cognitive load of either of these naturalistic settings. Field studies are necessary in order to confirm whether the strategy of implementation intentions with pictorial cues is effective at increasing handwashing in these specific environments.

The prospective memory task employed in Experiment 1 is also limited by the lack of motivational salience found in real-world prospective memory intentions. The successful realisation of a prospective memory intention in the real world is often accompanied by some kind of reward, for example remembering to buy an item of clothing whilst it is in the sale results in a financial benefit. More commonly, the *failure* to realise an intention is accompanied by negative consequences, for example forgetting to buy a ticket for a concert before it sells out results in a missed social outing. The motivational salience, or perceived importance, of prospective memory tasks has been found to modulate prospective memory performance (Kliegel et al., 2004), a finding echoed in the implementation intention literature on the influence of the strength of goal intentions (Sheeran, Webb, & Gollwitzer, 2005). However, the intention given to participants in Experiment 1, as is common with most prospective memory tasks conducted in the laboratory, was lacking in either positive or negative consequences. The widespread neglect of the influence of

motivational salience in laboratory-based experimental research on prospective memory means that there is a lack of ecological validity in this research, which can limit the applicability of the findings to everyday life (Phillips, Henry, & Martin, 2012). Suggestions for methodological manipulations to overcome this issue are discussed in the future research section below.

One limitation common to the overall literature on emotional cues in prospective memory is the reliance on dimensional models of emotion and the classification of emotional stimuli into positive, negative and neutral. Although these models allow for the differentiation of emotional cues based on the dimensions of valence and arousal, they neglect the influence of basic emotions (Ekman, 1992) that may be caused by certain emotional stimuli. As was highlighted in the discussion of the findings of Experiment 2, it may be that certain emotional stimuli that elicit these basic emotions are particularly suited to triggering prospective memory for specific intentions. For example, the use of disgust-inducing cues to trigger hygiene-based intentions (Pellegrino et al., 2016). Furthermore, variables such as the 'emotional impact' of stimuli (F. C. Murphy et al., 2010) or their personal relevance to the observer (Purkis, Lester, & Field, 2011) can modulate the effect of emotional cues on attention, but have not yet been investigated in relation to prospective memory. The use of a single theoretical basis (the dimensional model of emotion) within the literature arguably accelerates our understanding of whether and how emotional cues can influence prospective memory, since research can easily build on the findings of previous studies. However, neglecting other variables or ways of classifying emotional stimuli may result in exciting and important insights being missed, so this is an area ripe for further research.

Despite these limitations, the present research is important in order to expand our knowledge of how prospective memory can be improved through the use of simple strategies. Prospective memory is an important ability in everyday life for independent living (by remembering to perform necessary household tasks at appropriate times), keeping healthy (by remembering to take medication and realise health behaviour intentions), and maintaining social relationships (by remembering to contact friends and family and attend social events). However, people often fail to realise their intentions (Crovitz et al., 1984; Unsworth et al., 2012). The present research adds to the existing literature that has investigated the use of the strategies of implementation intentions and emotional cues to improve prospective memory. Broadly speaking, the findings support the use of these strategies to improve prospective memory: Whilst not effective under all conditions, both emotional cues and implementation intentions were shown to help people remember to realise delayed intentions. These strategies are easy to use in everyday life by individuals looking to improve their everyday prospective memory. In addition, they may be employed by researchers designing interventions to promote behaviour change, particularly in situations where the volitional stage of action has been identified as being important, such as non-adherence to handwashing guidelines. Practitioners are encouraged to employ theory-based and evidence-based components in interventions (Michie & Prestwich, 2010), and the results of the present research help to provide more robust evidence of the effectiveness of implementation intentions at aiding intention realisation.

In order to maximise the chances of successfully realising an intention, an intention should be formed in the 'if[cue], then[response]' implementation intention

format, linking the exact response that people wish to achieve with a suitable cue to action. If a visual cue is chosen (for example, in order to overcome the drawbacks of forming multiple intentions for different situations), then a specific image should be chosen that the individual can observe when forming the intention. The cue should also be as salient as possible. This could be achieved through choosing a visually salient cue, for example, something large and brightly coloured; or a semantically salient cue, for example, a picture of something unusual. The present research also supports the suggestion that an emotionally salient cue, i.e. an image that triggers an emotional reaction in the observer such as a picture of a loved one or an unpleasant scene, may be more effective at triggering the prospective memory intention than a neutral cue.

In terms of the possibility of an enhanced boost to prospective memory from combining the two strategies - forming an implementation intention that specifies an emotional cue - the results of the present research were inconclusive. However, the lack of evidence for an interaction effect should not preclude future research from investigating this further. The lack of an effect of implementation intentions in Experiment 1 was thought to be due to the methodology employed, and Experiment 2 tested the use of a positive cue in a naturalistic intention for the first time. Therefore, the use of emotional cues to improve implementation intentions for other intentions cannot be ruled out. In general, implementation intentions are an effective strategy at enhancing intention realisation and there is a potentially beneficial synergy with emotional cues that warrants future research. However, by posing the question the present research has highlighted a potentially beneficial synergy between the two strategies which warrants further research.

Future Research

Throughout this discussion, potential directions for future research have been suggested to overcome the limitations of the present research and to investigate several research questions that have arisen as a result of the findings of the present research. These suggestions for future research are expanded upon below.

First, the results of the meta-analysis have generated several potential lines of enquiry with regards to how emotional cues may influence the separate processes of prospective memory. The results show that prospective memory performance is differentially affected based on whether negative cues are presented only during the encoding phase, the detection phase, or at both the encoding and detection phases. Theoretical reasons, such as the influence of emotion on the type of processing used at encoding (Kensinger, 2009) and the encoding specificity principle (Tulving & Thomson, 1973), were suggested that help to explain the different effects of manipulating emotional cues at the separate stages of prospective memory. However, Peters, de Bruin and Crutzen (2015) recommend that controlled experiments employing fully-factorial designs are necessary to specifically test moderator variables identified in meta-analyses. By using this approach, the parameters of effectiveness of interventions and strategies such as the use of emotional cues can be determined more accurately. In light of the findings of the present research, empirical experiments should focus on testing the moderating variable of the timing of the affective manipulation identified in the meta-analyses. Such an experiment could utilise the methodology of Hannon and Daneman (2007) who separately manipulated the salience of cues at encoding, detection, and both encoding and detection. In addition, empirical work is needed to explore the influence of

moderating variables that were unable to be coded for in the present meta-analyses, including task complexity.

A second suggestion for future research is to make sure that potentially influential variables that may affect prospective memory performance in the real world are taken into account in laboratory experiments. This is an argument previously articulated by other authors in the field (e.g. Hertzog, 2012; Phillips et al., 2012), but some practical suggestions are made explicit here. In Experiment 2, there was no observed benefit for emotional cues. The suggested explanation for this - a lack of congruency between the valence of the positive emotional cue and the emotional evaluation of the handwashing response - is speculative and requires further research. However, this suggestion highlights the paucity of the use of real-world prospective memory responses in prospective memory experiments, i.e., responses that require more thought and effort than just pressing a button or writing a word. This is a limitation common to a large proportion of the prospective memory literature. Future research should aim to vary the complexity and emotional valence of prospective memory responses in order to investigate whether this is a moderating factor in prospective memory performance. For example, future research could employ prospective memory responses such as passing a message to someone, remembering to take an important item, or performing a household chore. These types of responses are more representative of tasks that people are likely to complete in everyday life, and thus their use in experiments will increase the generalisability of the findings. In particular, it is possible that the valence of the prospective memory response (i.e. whether the task is desirable to perform or not) may moderate the influence of the emotional valence of cues, and this should be explored further.

Another variable that has been overlooked in much of the laboratory-based prospective memory research is the influence of the motivational salience of the prospective memory intention. This refers to whether the participant is motivated to perform the intention. In the implementation intention literature, it is theorised that if the participant does not have a strong goal intention - i.e. that they are not motivated to achieve the overarching goal that the intention is related to, then the use of strategies such as implementation intentions will be ineffective (Sheeran et al., 2005). Despite this, motivational salience is not routinely manipulated or induced in prospective memory paradigms. One way of overcoming this may be to offer small rewards to participants based on their completion of prospective memory tasks, or to remove expected rewards for failure to complete the tasks. Research would be required to determine the appropriate size of these rewards or punishments, as it is likely that giving participants too large a reward or punishment would alter the balance of the relationship between the prospective memory task and the ongoing task. In the real world, even important prospective memory tasks with meaningful consequences may need to take second priority behind more mundane but complex ongoing tasks, such as driving. However, introducing some kind of motivational salience related to the completion or non-completion of prospective memory tasks would improve the ecological validity of the tasks and take into account an important influence of real-world prospective memory that has been missing from laboratory-based work.

The suggestions for future research mentioned above both relate to the aim of ensuring that the findings of future laboratory-based prospective memory research are generalisable to real-world settings. This can be achieved by controlling for the

influence of variables that are likely to influence prospective memory performance in the real world – namely the complexity of the prospective memory response and the motivational salience of the intention – but are not commonly manipulated or controlled for in laboratory-based research. Another approach to improving the generalisability of findings is to conduct applied research in naturalistic settings to test whether the manipulations in the lab still have the same effect. This suggestion is particularly applicable to the findings of Experiment 2, the handwashing study. One limitation of this study is that the modelling clay task may not accurately reflect the hectic real world nature of the hospitals and food outlets in which handwashing compliance is low. Although the experiment showed that implementation intentions can be effective at helping people to remember to wash their hands after being distracted with another task, field studies within healthcare and food service workplaces are necessary to determine whether the strategy is effective as a real world intervention. Such studies must ensure that the limitations of previous field studies, such as the inclusion of multiple behaviour change components (Lhakhang et al., 2015; Zhou et al., 2015) or significant baseline differences in handwashing behaviour (Fernandez et al., 2015) are eliminated. The intervention itself could involve placing emotional visual cues in key handwashing locations around the ward, or kitchen. Employees in the workplace would be randomly assigned to either form implementation intentions specifying handwashing in response to seeing the visual cue, or a control condition involving a non-planning intervention, for example reflecting about the importance of handwashing. The behaviour of handwashing could then be surreptitiously recorded using observational methods that have previously been successfully employed in such environments (e.g. Erasmus et al.,

2010). This design would overcome not only the limitation of the handwashing study conducted in the present research, namely the lack of visual cues provided to the control condition, but also the limitation of Experiment 1 in which participants in the implementation intention condition spent more time thinking about the intention than those in the control condition.

A third option for conducting more ecologically-valid tests of prospective memory is be to employ a video-based methodology developed by Titov and Knight (2001). This method can be seen as a cross between the traditional laboratory tests of prospective memory and those conducted in naturalistic environments. In this methodology, participants view a video segment of movement through a real-world environment, such as a shopping centre. They are given a list of prospective memory responses to be completed when certain locations are encountered during the video (e.g. "Ask about the opening hours of the State Insurance Company"), and must write down the correct response when the prospective memory cue is detected. In comparison to the traditional dual task paradigm, the context of the prospective memory tasks used in this methodology are more representative of everyday intentions. However, the researcher retains a large degree of control over the presentation of prospective memory cues and other relevant variables. The methodology has been demonstrated to have high criterion validity (Titov & Knight, 2001), meaning that performance on the task correlates well with real-world prospective memory performance. A similar methodology has been used to replicate the beneficial perceptual saliency effect for prospective memory cues (Trawley, Law, Brown, Niven, & Logie, 2014), and could be used to test the effects of emotionally salient cues and implementation intentions. Such an experiment could

involve creating a video of a journey through a participant's familiar environment, for example a walk around a university campus if testing undergraduate students. Prospective memory tasks can then be devised that employ emotional or neutral cues that are placed within the video at specific locations. Using a fully-factorial design, the effectiveness of emotional cues (compared to neutral) and forming implementation intentions (compared to an active control condition employing a non-planning related intervention) could be tested. With the recent advances in virtual reality technology and its application in psychological research (Wilson, C. J. & Soranzo, 2015), this type of methodology has the potential to increase the ecological validity of laboratory-based prospective memory research whilst retaining a high degree of control over variables pertinent to prospective memory performance.

Conclusion

The present research has addressed questions relating to helping people to remember to realise their intentions. As Chapter 2 highlighted, this is a field of enquiry that has attracted a lot of interest from researchers over the last 20 years. Two of the leading lines of enquiry are the social cognitive approach (using implementation intentions) and the cognitive approach (prospective memory). These two approaches have generally been investigated separately, however the present research sought to expand a small body of recent research that has attempted to integrate the findings and theories of the two approaches. More specifically, the present research tested for the first time whether the strategies of implementation intentions and emotional cues, drawn from the different approaches, could be used effectively together. The meta-analyses are a particularly important feature of the

work reported here, since they contributed a sound basis for the design of the experimental studies. They indicate that the use of emotional cues to aid intention realisation under certain conditions could be effective and thus a productive possibility to explore further. This was a necessary first step that preceded the investigation of whether emotional cues and implementation intentions could be combined together to aid intention realisation. When the efficacy of the combination of emotional cues and implementations intentions was explored in the experiments reported in Chapters 4 and 5, no interaction between these two strategies was observed. As explained in those chapters, this may have been due to factors that prevented one of the components from having an effect, namely the specificity of the button-pressing response (Experiment 1) and the affective nature of the handwashing response (Experiment 2). Nevertheless, the experiments produced interesting and positive results and did not rule out the possibility of a beneficial synergy when using these strategies in combination. The results should therefore be taken as a whole as a contribution to a large body of findings working towards a clearer and more nuanced understanding of the extent to which these strategies are effective. By exploring the use of emotional cues and implementation intentions outside the typical experimental paradigms utilised in prospective memory research, the present studies have revealed multiple factors that may moderate the effectiveness of these strategies. One of the important contributions of the present research is the identification of these factors - such as the specificity and the real world nature of prospective memory responses - as influential to the operation of emotional cues and implementation intentions. From these findings, clear directions for future research in this area have been determined. Overall, the present research makes a substantive

contribution to our understanding of the role of emotion in intention realisation, and has highlights new insights and directions for future research in the area.

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Appendix A – Calculations for Effect Sizes Used in Meta-Analyses (Chapter 3)

Effect sizes for within-subjects studies were calculated using the following equation from Cumming (2012):

$$d_{unb} = \left(1 - \frac{3}{4(n_1 + n_2) - 9}\right)\left(\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{SD_1^2 + SD_2^2}{2}}}\right)$$

Effect sizes for between-subjects studies were calculated using the following equation from Cumming (2012):

$$d_{unb} = \left(1 - \frac{3}{4(n_1 + n_2) - 9}\right)\left(\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}{n_1 + n_2 - 2}}}\right)$$

Where n_1 is the number of participants in one of the emotional conditions, n_2 is the number of participants in the comparison condition, $\bar{X}_1$ is the mean prospective memory ability score for one of the emotional conditions, $\bar{X}_2$ is the mean prospective memory ability score for the comparison condition, and SD_1 and SD_2 are the respective standard deviations associated with the means.

Appendix B – Task Instructions and Stimuli Used in Experiment (Chapter 4)

The below image is a screenshot of the instructions given to participants in the negative cue, implementation intention condition:

Thank you for agreeing to participate. Please read these instructions carefully.

In this study we are interested in people's ability to perform visual counting tasks. In each trial, you will have to search for and count the number of occurrences of a specific symbol in an array. The instructions for this task will be explained in more detail on the following page.

In addition to the symbol counting task, you also have a secondary task. **The instructions for this task will not be repeated again, so please make sure you understand them before proceeding.**

The secondary task is as follows: At any time during the questionnaire after this page that you see the following symbol, please type a letter in the answer box on that page, instead of the number of symbols you are counting. It can be any letter you like.

In order to help you remember to complete this secondary task, please repeat the following sentence to yourself three times in your head, and type it out word-for-word in the box below:

If I see the symbol above, then I will remember to type a letter instead of a number!

Please proceed to the next page when you are happy that you know how to complete the secondary task.

The image of the cue displayed depended on the participant's condition. In the example above, the unhappy face is displayed as the participant is in the negative cue condition. Participants in the control condition received exactly the same instructions as above, except that the instructions to form an implementation intention ("in order to help you remember…") and the text box to do so in were not present.

On the subsequent page, all participants received the following instructions for the ongoing visual counting task:

The visual counting task will begin on the next page. Please read these instructions carefully before proceeding.

Each trial of the task will be on a separate page of the survey. In each trial, there will be an array of symbols. You will be asked to count the number of occurrences of a particular symbol and type this number in a box.

After typing the number in, please proceed to the next trial by clicking on the arrow button at the bottom of the page. Please work through the trials as **quickly and accurately** as you can. After each set of 20 trials there will be a 'rest page' that you can spend as long as you like on to take a break from working through the trials quickly and accurately.

Please note that especially if you have a slow internet connection it may take a few seconds for the images to load. Please try to complete the task as quickly and accurately as possible after the images have loaded.

You can see an example of a trial below:

Please count the number of times the following symbol appears in the array below and type the answer into the answer box. When you have done this please move on to the next question by clicking the arrow at the bottom right of this page.
Symbol:

Array:

In this example, the correct answer would be *4*

Before proceeding to the next page, **please make your internet browser full-screen if possible (press F11)**. When you have done this, please click on the arrow in the bottom right hand corner of this page to start the first set of trials.

On the next page, the first of the 60 trials of the ongoing visual counting task was presented. Below is an example of one of the trials containing the positive prospective memory cue:

Symbol:

Array:

How many times did the symbol appear in the array?

In this case, as the prospective memory cue is present in the array, the correct answer is to type a letter, rather than the number of times the symbol occurs (3).

Appendix C – Stimuli Used in Experiment (Chapter 5)

Emotional sink cue:

Neutral sink cue: