

**AN INVESTIGATION OF EPISODIC FUTURE THINKING,
EPISODIC FORESIGHT AND PROSPECTIVE MEMORY IN
CHILDREN WITH AUTISM SPECTRUM DISORDER**

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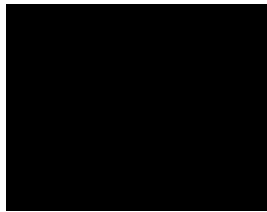
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Declaration of Authorship and Sources

This thesis contains no material that has been extracted in whole or in part from a thesis that I have submitted towards the award of any other degree or diploma in any other tertiary institution. No other person's work has been used without due acknowledgment in the main text of the thesis. All research procedures reported in the thesis received the approval of the relevant Ethics Committees (where required).

Signed:



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“Every good and perfect gift is from above, coming down from the Father of the heavenly lights, who does not change like shifting shadows.” – James 1:17

Abstract

Background and Objectives: The overall objective of the current thesis was to investigate three forms of prospection in children with autism spectrum disorder (ASD), namely episodic future thinking, episodic foresight and prospective memory (PM), using three empirical studies. While few past studies have found ASD-related impairments in episodic future thinking, there is limited understanding of the mechanisms that might underpin these impairments in this clinical group. The aim of the first empirical study was therefore to investigate whether difficulties in two potential cognitive mechanisms, specifically scene construction and self-projection through time, might contribute to episodic future thinking deficits in children with ASD. In addition, no studies to date have examined the practical application of episodic future thinking, which involves taking steps in the present in light of imaginations of the future (referred to as episodic foresight in the current thesis), in individuals with ASD. Thus, the second empirical study aimed to investigate whether episodic foresight might be compromised in children with ASD, and possible cognitive factors that might underpin any identified episodic foresight deficits. Furthermore, while time-based PM has consistently been shown to be impaired in ASD, findings on event-based PM have been mixed in the literature. The cognitive contributors to impairments in PM also remain unclear. Hence, the aim of the third empirical study was to investigate event-based and time-based PM, as well as their potential contributing factors, in children with ASD. Lastly, given the importance of episodic foresight and PM on daily functioning argued in the literature, the current thesis also explored the relationships between these forms of prospection and functional capacity in children with ASD.

Method and Results: Children with high-functioning ASD (i.e., IQ > 80) aged 8 to 12 years and age- and IQ-matched healthy controls were recruited for the current research project. Study 1 ($n = 37$ ASD, 60 controls) showed that impairments in episodic future thinking were linked to difficulties in scene construction, rather than self-projection through time. In addition, Study 2 ($n = 40$ ASD, 55 controls) provided novel evidence of an intact capacity to take appropriate steps in the present in anticipation of potential future problems in the ASD group. However, children with the disorder demonstrated an impaired capacity to subsequently implement actions at specific future points that allowed successful problem resolutions, therefore result in a failure in episodic foresight. The impairments in implementing actions at appropriate future points were not attributable to retrospective memory or executive functioning deficits. Study 3 ($n = 32$ ASD, 42 controls) revealed pervasive deficits in both event-based and time-based PM in children with ASD, and indicated that these deficits were related to difficulties in executive functioning and retrospective memory for PM task content. Finally, episodic foresight and PM were not found to be associated with functional capacity in the ASD group.

Conclusions: The current thesis provided novel insights into the unique profile of impairments across different forms of prospection in children with ASD. Further investigations will be needed to clarify how and why specific impairments in these forms of prospection are apparent in children with ASD, specifically whether these impairments may be attributable to common underlying deficits. Future research in this area will be beneficial in contributing to the development of targeted interventions that aim to improve daily functioning in this clinical population.

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List of Abbreviations

ABAS-II	Adaptive Behavior Assessment System, Second Edition
ADHD	Attention-Deficit/Hyperactivity Disorder
ADI-R	Autism Diagnostic Interview – Revised
AI	Adapted Autobiographical Interview
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
ASD	Autism Spectrum Disorder
D-KEFS	Delis-Kaplan Executive Function System
DSM-IV-TR	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision
DSM-5	Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition
FSIQ	Full Scale IQ
ODD	Oppositional Defiant Disorder
PDD-NOS	Pervasive Developmental Disorder – Not Otherwise Specified
PM	Prospective Memory
PRI	Perceptual Reasoning Index
SCQ	Social Communication Questionnaire
VCI	Verbal Comprehension Index
VW-Foresight	Virtual Week – Foresight
VW-PM	Virtual Week – Prospective Memory
WASI-II	Wechsler Abbreviated Scale of Intelligence, Second Edition
WISC-V	Wechsler Intelligence Scale for Children, Fifth Edition

Chapter 1: Thesis Introduction and Overview

1.1 Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a lifelong pervasive neurodevelopmental disorder characterised by impairments in social reciprocity and social communication, as well as restricted and repetitive patterns of behaviour (American Psychiatric Association, 2013). The disorder has previously encompassed a range of diagnostic labels including autistic disorder, Asperger's syndrome and pervasive developmental disorder not otherwise specified in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000). However, these diagnoses have been subsumed under one broad diagnostic category of ASD in the latest Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition (DSM-5; American Psychiatric Association, 2013). As a result, the diagnosis of ASD now includes individuals who fall on a wide spectrum of symptom severity and show considerably varied levels of language and intellectual abilities (American Psychiatric Association, 2013; Gonzalez-Gadea et al., 2014). As such, ASD is considered a highly heterogenous disorder. Regardless of the differences in these diagnostic features, all individuals with ASD present with poor adaptive functioning and often struggle to acquire independent living skills throughout life (American Psychiatric Association, 2013).

There is generally a global rise in the number of people being diagnosed with ASD, with population prevalence rates estimated to be 1.5% in developed countries (Lyall et al., 2017; Özerk, 2016). In Australia, there has been a 42.1% increase in ASD diagnoses from 2012 to 2015, with the overall prevalence rate estimated to be 1 in 150 people (Australian

Bureau of Statistics, 2015; Australian Institute of Health and Welfare, 2017). Statistical reports from the Australian Bureau of Statistics (2015) further revealed that 83.7% of individuals with ASD between 5 and 20 years of age experienced significant difficulties within the educational domain. For adults with ASD, unemployment rates were reported to be as high as 31.6%, which was three times more than the rate for individuals with other disabilities and six times more than the rate for those without a disability (Australian Bureau of Statistics, 2015). The substantial increase in the number of individuals diagnosed with ASD is alarming, considering the challenges for these individuals and the potential burden on families and society more broadly as a consequence. In fact, findings in recent studies illustrated that ASD is associated with high lifetime costs across multiple domains, due to these individuals' needs for lifelong care and support (Roddy & O'Neill, 2019; Rogge & Janssen, 2019). Clearly, the high prevalence of ASD and high degree of associated impairment underscores the importance of increasing current understanding regarding the possible contributors to the poor functional outcomes in life associated with the disorder.

In the research literature, individuals with ASD have generally been categorised as either low-functioning or high-functioning (Jaarsma & Welin, 2012; Pineda, Friedrich, & LaMarca, 2014; Thomeer, McDonald, Rodgers, & Lopata, 2019). Individuals with low-functioning ASD are usually those with a comorbid intellectual disability and language delay, whereas those who are high-functioning have an average to above average IQ, as in the former diagnosis of Asperger's syndrome (American Psychiatric Association, 2000; Zimmerman, Owsnsworth, O'Donovan, Roberts, & Gullo, 2018). Due to the normal general cognitive ability of the high-functioning group, these individuals are often overlooked in

terms of receiving support in their daily living activities. For instance, one of the common issues with children who are identified as high-functioning is that they are often placed in mainstream schools where limited support is provided, despite their ongoing behavioural and academic difficulties in the classroom (Thomeer et al., 2019). Daily challenges such as time management and task organisation are also frequently experienced by children with high-functioning ASD, which often in turn impose heightened stress levels for their parents (Bonis, 2016; Thomeer et al., 2019). Research on high-functioning children with ASD is therefore invaluable as it provides further insights into ASD-related deficits which will contribute to understanding of the specific support that these children require to adaptively function in different settings. For the current research project, children with high-functioning ASD were recruited as the population of interest.

1.2 Introduction to Cognitive Functioning in ASD

Despite the average to high levels of intellectual functioning in a proportion of individuals with ASD, deficits in various areas of cognitive functioning have been shown in a wealth of past studies in these individuals. For example, there is well-established evidence of impairments in theory of mind (Baron-Cohen, Leslie, & Frith, 1985; Baron-Cohen, O'riordan, Stone, Jones, & Plaisted, 1999; Baron-Cohen, Tager-Flusberg, & Cohen, 1994; Happé, 1994; Kimhi, 2014; Mathersul, McDonald, & Rushby, 2013), episodic memory (Boucher, Mayes, & Bigham, 2012; Lind, 2010; Lind & Bowler, 2008; Tanweer, Rathbone, & Souchay, 2010), relational memory (Bowler, Gaigg, & Gardiner, 2014; Bowler, Gaigg, & Lind, 2011), retrospective memory measured on verbal recall tasks (Bowler et al., 2011; Jones et al., 2011), and central coherence (Booth & Happé, 2018;

Brunsdon et al., 2015; Fitch, Fein, & Eigsti, 2015; Lind, Bowler, & Raber, 2014; Pellicano, 2011) across all age groups. In addition, attenuated performances across a range of executive function tasks have been shown in individuals with high-functioning ASD, including tasks measuring cognitive flexibility (Sinzig, Morsch, Bruning, Schmidt, & Lehmkuhl, 2008; Van Eylen et al., 2011; Yeung, Han, Sze, & Chan, 2016), inhibition (Sanders, Johnson, Garavan, Gill, & Gallagher, 2008; Xiao et al., 2012), working memory (Fried et al., 2016; Lai et al., 2017; Landa & Goldberg, 2005), and verbal fluency (Lai et al., 2017; Spek, Schatorjé, Scholte, & van Berckelaer-Onnes, 2009). Deficits in these areas have been found to contribute to the behavioural symptoms of ASD (Berenguer, Miranda, Colomer, Baixauli, & Roselló, 2017; Jones et al., 2018; Lind, Williams, Raber, Peel, & Bowler, 2013; Oberman & Ramachandran, 2007; Zalla & Korman, 2018), as well as functional difficulties in daily life (Bennett et al., 2013; John, Dawson, & Estes, 2018; Kenny, Cribb, & Pellicano, 2019). One area of cognition that has largely been neglected in the field, however, is the capacity for prospection, which could possibly be an additional contributing factor to the reduced adaptive skills in individuals with ASD.

1.3 Introduction to Prospection

Prospection is a broad future-oriented cognitive construct that encompasses all forms of thinking related to the future, such as planning, spatial navigation, implementation intentions and semantic future thinking (Baumeister, Vohs, & Oettingen, 2016; Gilbert & Wilson, 2007; Szpunar, 2010; Szpunar, Spreng, & Schacter, 2014). Episodic future thinking, episodic foresight and prospective memory (PM) are three forms of prospection that have received increased research attention in the last two decades and will be the focus

in the current thesis. Episodic future thinking refers to the capacity to imagine oneself pre-experiencing events that might happen in a particular future time period (Atance & O'Neill, 2001; Schacter, Benoit, & Szpunar, 2017). A number of researchers in recent years have extended this concept by highlighting the adaptive function of imagining the future, which includes the ability to apply imaginations of hypothetical future scenarios to guide actions in the present in order to secure future benefits (Baumeister et al., 2016; Suddendorf & Moore, 2011). For example, a person who imagines themselves possibly getting wet in the rain on the way home from work then chooses to bring an umbrella with them before leaving the house in the morning. This practical capacity has been labelled 'episodic foresight' (Suddendorf & Moore, 2011) and will be a term that is used in the current thesis to specifically refer to the adaptive application of imagining the future. To date, most past studies have focused on investigating the capacity to mentally simulate future scenarios (i.e., episodic future thinking), whereas the adaptive application of such capacity (i.e., episodic foresight) has attracted less empirical attention. The third form of prospection focused on in the current thesis is PM, which refers to the ability to remember to perform intentions associated with the future such as remembering to call a friend at 8 p.m. or remembering to turn off the lights before leaving the house (Einstein & McDaniel, 1990; Ellis & Kvavilashvili, 2000). Relative to the investigation of episodic future thinking and episodic foresight, PM is a topic that has a longer history of research, particularly in relation to aging populations (e.g., Henry, MacLeod, Phillips, & Crawford, 2004; Phillips, Henry, & Martin, 2008; Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010). By contrast, research on PM in children has rapidly increased only in recent years (Kvavilashvili, KyLe, & Messer, 2008; Mahy, Mazachowsky, & Pagobo, 2018; Mahy, Kliegel, & Marcovitch,

2014). The importance of episodic future thinking, episodic foresight and PM for successful daily functioning has continually been emphasised throughout the literature (Brunette, Calamia, Black, & Tranel, 2018; Henry, Addis, Suddendorf, & Rendell, 2016; Hering, Kliegel, Rendell, Craik, & Rose, 2018; Raskin, 2018), with increasing evidence showing impairments in these capacities in clinical populations that have well-established difficulties with adaptive functioning such as adults with schizophrenia (D'Argembeau, Raffard, & Van der Linden, 2008; Henry, Rendell, Kliegel, & Altgassen, 2007), individuals with depression (Addis, Hach, & Tippett, 2016; Altgassen, Kliegel, & Martin, 2009) and older adults with Parkinson's disease (de Vito et al., 2012; Foster, Rose, McDaniel, & Rendell, 2013). Given that poor adaptive functioning is commonly observed in children with ASD, an investigation into episodic future thinking, episodic foresight and PM is warranted to gain a better understanding of why functional difficulties may be present in this clinical population.

1.4 Objectives of the Current Project

The overall objective of the current research project was to investigate prospection in children with ASD, with a specific focus on episodic future thinking, episodic foresight and PM. Three empirical studies were conducted to address research questions related to episodic future thinking, episodic foresight and PM in this clinical group, and these studies were written in three separate chapters in the current thesis (Chapters 5, 6 and 7).

1.4.1 Study 1

Given that there is emerging evidence of an impairment in episodic future thinking in children with ASD (e.g., Ciaramelli et al., 2018; Terrett et al., 2013), the first empirical

study was designed to further explore possible mechanisms that might underpin these impairments. Two of the mechanisms argued to be important for episodic future thinking are self-projection through time and scene construction (Buckner & Carroll, 2007; Hassabis & Maguire, 2007). As such, the aim of the first empirical study was:

- To investigate whether difficulties in scene construction and/or self-projection through time might underpin the impairments in episodic future thinking in children with ASD.

1.4.2 Study 2

To date, past studies on children with ASD have predominantly examined the experiential component of imagining the future while the adaptive application of this capacity remains largely unexplored. As a result, there is currently very limited understanding of the capacity to adaptively apply episodic future thinking (i.e., episodic foresight) in this clinical group. The second empirical study thus aimed:

- To extend previous findings of an impairment in the capacity to pre-experience future events in imaginations in children with ASD by investigating whether episodic foresight might also be impaired in children with the disorder, using a novel behavioural measure called Virtual Week-Foresight.
- To identify the extent to which any deficits in episodic foresight in children with ASD might be contributed to by difficulties in retrospective memory and/or executive functions.

- To examine whether any deficits in episodic foresight in children with ASD might be related to poor adaptive functioning.

1.4.3 Study 3

The third empirical study was conducted to investigate PM abilities in children with ASD. Two main types of PM tasks were examined, namely event-based and time-based PM. To date, relatively few studies have investigated both event-based and time-based PM in the same sample of children with ASD. In addition, Study 3 addressed the potential role of retrospective memory and executive functions in any identified PM deficits in this clinical group as this remains unclear in the existing literature. The extent to which PM might be related to adaptive functioning in this clinical group has also been under-researched to date and was investigated in this study. Thus, the aims of the third study were:

- To examine patterns of performance on event-based and time-based PM tasks in children with ASD using a reliable measure called Virtual Week-Prospective Memory.
- To explore whether any identified PM impairments might be related to difficulties in retrospective memory and/or executive functions in children with ASD.
- To examine whether deficits in PM performance might be associated with poor adaptive functioning in children with ASD.

1.5 Thesis Structure

The current thesis comprises eight chapters. This chapter (Chapter 1) provides an overview of the area of interest (i.e., prospection in children with ASD), as well as the rationale and aims of the research project. Chapters 2 and 3 respectively provide two critical reviews on episodic future thinking and episodic foresight, and PM, covering definitions, proposed cognitive underpinnings of these cognitive abilities, and assessment methods that have been employed thus far in the literature. These two chapters also include discussions of the research to date regarding episodic future thinking, episodic foresight and PM in individuals with ASD and conclude with summaries of the gaps in the current ASD literature. Chapter 4 is a methodology chapter which provides details of the recruitment process, sample characteristics and measures used in the three empirical studies. Chapters 5, 6 and 7 are the empirical studies undertaken to address the research questions in the current project. These chapters are written as three standalone empirical papers and therefore necessarily contain some repetition of information from previous chapters. In the write-up of the first empirical study in Chapter 5, mechanisms underlying episodic future thinking in children with ASD are addressed. This is followed by Chapter 6 reporting the second empirical study which investigated the adaptive form of episodic future thinking (i.e., episodic foresight) and its contributors in this clinical group. Chapter 7 then explores PM in children with ASD and discusses the possible contributors of other cognitive abilities to PM. Finally, the thesis concludes in Chapter 8 with a general discussion of the findings from the three empirical studies and the implications of these findings for children with ASD. Strengths and limitations of the current project and future research directions are also highlighted in this chapter.

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Chapter 2: A Review of Episodic Future Thinking and Episodic Foresight and Their Relations to Autism Spectrum Disorder

Preamble

Episodic future thinking and episodic foresight are complex constructs of prospection and will be the focus of discussion in this chapter. The chapter will start by defining episodic future thinking and episodic foresight, followed by a review of the proposed cognitive mechanisms that might underpin these abilities. In addition, various methods of assessment that have been used to index episodic future thinking and episodic foresight will be reviewed, including a critical discussion of the limitations of existing measures. Finally, the chapter will critically analyse studies that have investigated episodic future thinking in adults and children with ASD and will identify the current gaps in research on episodic future thinking and episodic foresight in this clinical population.

2.1 Mental Time Travel into the Past and Future

Mental time travel is a unique human cognitive faculty that enables individuals to mentally experience personal events in subjective time (Suddendorf & Corballis, 1997, 2007; Tulving, 2002). One form of mental time travel, labelled episodic memory, is the ability to mentally project backwards in time to re-experience *past* events, and has been the focus of research attention for many years (Tulving, 2002, 2005). By contrast, research into the ability to mentally travel forwards in time to pre-experience hypothetical *future* events has only begun to flourish in the past decade. This rapidly growing interest in mental time travel into the future appears to have been motivated by increased recognition of the tremendous survival value of this ability (Atance & O'Neill, 2001; Suddendorf & Corballis, 2007; Szpunar, 2010). Specifically, mentally pre-experiencing future events allows humans to examine and compare multiple plausible future scenarios in their minds. Such consideration of possible future outcomes can in turn guide and shape actions in the present that might help secure future benefits and prepare for potential threats (Baumeister et al., 2016; Suddendorf, 2017; Suddendorf & Corballis, 2007). Many of the activities of daily living require mental time travel into the future, and range from trivial matters such as deciding what to wear to work tomorrow to making major life decisions such as getting married and buying a house (Bulley, Redshaw, & Suddendorf, in press; Henry et al., 2016; Suddendorf & Henry, 2013). As such, the ability to mentally simulate future scenarios is thought to have considerable impact on individuals' capacity to flexibly adapt to various life circumstances, which in turn promotes independent living (Suddendorf, Addis, & Corballis, 2009; Suddendorf & Corballis, 2007).

2.2 Definition of Episodic Future Thinking

The capacity to mentally project oneself into the future to simulate hypothetical scenarios has been referred to as ‘episodic future thinking’ by a number of researchers (Atance & O’Neill, 2001; Atance & O’Neill, 2005; Schacter et al., 2017; Schacter, Devitt, & Addis, 2019). The key characteristic that defines episodic future thinking has been proposed to be the subjective feeling of ‘pre-living’ an event that might happen in the near or distant future (Suddendorf & Corballis, 1997, 2007). For example, a person might imagine themselves going to the beach on their next summer holiday or giving a speech at their friend’s 50th birthday party in 20 years’ time. This sense of pre-experiencing future scenarios is what differentiates episodic future thinking from semantic future thinking, which refers to general knowledge of future events (e.g., who might be the next prime minister of Australia; Atance & O’Neill, 2001; Szpunar et al., 2014). A further distinction between episodic and semantic future thinking has been argued to be the involvement of different forms of consciousness (Atance & O’Neill, 2005; Szpunar, 2010). While semantic future thinking requires noetic consciousness (i.e., the sense of knowing general information in the absence of pre-experiencing personal events), episodic future thinking is the manifestation of auto-noetic consciousness, which is the awareness of one’s own existence that extends across time (Suddendorf & Corballis, 1997; Szpunar, 2010; Tulving, 1985). Auto-noetic consciousness has been argued to be the hallmark of episodic future thinking, without which it has been claimed that humans are deprived of the ability to experience events in subjective time (Suddendorf & Corballis, 2007; Tulving, 2002).

The ability to imagine specific future episodes that are *plausible* is another key property of episodic future thinking (Atance, 2015; Szpunar, 2010). Whilst engaging in

episodic future thinking allows one to entertain endless possibilities of the future, the imagination of hypothetical future events is often not given free reign. Rather, episodic future thinking is constrained to reality and a person's current life circumstances (Atance & O'Neill, 2001; Atance & O'Neill, 2005; Szpunar, 2010). For instance, it would be implausible for someone who has never skied before to imagine themselves winning a gold medal at the upcoming Olympics games or for an 8-year-old child to envisage himself driving to his friend's birthday party on Saturday. Thus, the plausibility of an event is one key element that distinguishes episodic future thinking from broader concepts of imagination or daydreaming (Szpunar, 2010).

2.2.1 Functional aspect of episodic future thinking

As previously mentioned, episodic future thinking has considerable adaptive value in everyday life because the primary function of imagining what might happen in the future is arguably to inform current behaviours that might influence future outcomes (Baumeister et al., 2016; Suddendorf, 2017). This functional aspect of episodic future thinking will be labelled 'episodic foresight' in the current thesis. It has been suggested that episodic foresight not only encompasses the ability to mentally simulate future scenarios (i.e., episodic future thinking), but also involves the practical capacity to adjust behaviours in the present in light of the imagined future (Suddendorf & Moore, 2011). To illustrate episodic foresight in daily life, consider the possibility that I have a job interview next week and I imagine myself sitting in the interview room with the interviewer. As I continue to imagine myself answering each question that might be asked in the interview, I realise there is one question I do not know the answer to. This then prompts me to search for the answer in the present so that I can be better prepared for the upcoming interview and in turn may increase

likelihood of getting the job. This example demonstrates that episodic foresight may draw on processes that support the imagination of the future scene as well as those that are required to organise future-directed behaviours (Suddendorf & Moore, 2011).

Theoretical arguments thus far in the literature have mostly focused on possible processes that might be involved in mentally pre-experiencing future events, while much less has been discussed about mechanisms that might underpin the practical capacity for episodic foresight. However, given that episodic future thinking is considered an essential component of episodic foresight (Suddendorf & Moore, 2011; Suddendorf & Redshaw, 2013), it may be argued that processes that support episodic future thinking may also be involved in episodic foresight. The next section will cover theories and empirical evidence of potential cognitive abilities that have been suggested to be related to episodic future thinking and episodic foresight. For simplicity, the term ‘episodic future thinking’ will mainly be used in this next section. This partly reflects the increased research attention that episodic future thinking has received to date, compared to the dearth of knowledge about episodic foresight in the current field.

2.3 Processes Involved in Episodic Future Thinking

Episodic future thinking is a sophisticated cognitive faculty that has been argued to rely on a host of underlying cognitive mechanisms for its successful execution in real life (Suddendorf & Corballis, 2007; Suddendorf & Redshaw, 2013). In particular, the capacity to imagine hypothetical future scenarios requires a person to temporarily suspend attention to the present surroundings, perceive imagined events from a future perspective and create a mental space in which the future episode can be represented and imagined. In addition,

the construction of novel future scenarios in our imagination draws on the capacity to flexibly combine elements that are extracted from various cognitive systems and inhibit tendencies to simply project a past episode into the imagined future (Buckner & Carroll, 2007; D'argembeau & Mathy, 2011; Hassabis & Maguire, 2007; Schacter & Addis, 2007; Schacter et al., 2017; Suddendorf, 2017; Szpunar, 2010; Wang & Koh, 2015). As such, it is apparent that episodic future thinking potentially imposes demands on a range of cognitive abilities including episodic memory (Schacter, Addis, & Buckner, 2008; Schacter et al., 2017; Suddendorf, 2010a), semantic memory (Irish, 2016; Irish & Piguet, 2013; Martin-Ordas, Atance, & Louw, 2012), relational binding (Wiebels et al., 2019), theory of mind (Buckner & Carroll, 2007; Suddendorf & Corballis, 2007), and executive functions (Suddendorf & Corballis, 1997, 2007; Suddendorf & Redshaw, 2013), although the specific roles of these mechanisms in episodic future thinking remain a source of debate in the field. Executive functions and episodic memory are two of the cognitive abilities that have received increased empirical investigation in relation to episodic future thinking in recent years.

2.3.1 The role of executive functions in episodic future thinking

Executive functions refer to a set of higher-order cognitive processes that govern the regulation of behaviours for successful problem solving and goal attainment, and include cognitive flexibility, inhibition and working memory (Kenworthy, Yerys, Anthony, & Wallace, 2008). Executive functions are argued to be involved in episodic future thinking because the mental simulation of hypothetical future scenarios, as mentioned, requires the ability to flexibly combine disparate elements from past experiences, inhibit the retrieval of irrelevant information and switch between examining multiple alternatives for the most

desirable outcome (Schacter & Addis, 2007; Suddendorf, 2010a; Suddendorf & Corballis, 1997, 2007).

In terms of empirical evidence regarding the contribution of executive functions to episodic future thinking, findings to date have been mixed. For example, one study found episodic future thinking imposed the highest demands on executive functions (indexed by performance on verbal fluency tasks), relative to other cognitive processes such as visual-spatial processing and verbal relational memory, in a group of young adults (D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010). The authors thus posited that executive functions may be required to support the retrieval of autobiographical knowledge, and to support the search and selection of the most appropriate spatiotemporal context within which hypothetical future events may be simulated (D'Argembeau et al., 2010). These findings were supported in some subsequent studies that also found executive functions to be related to episodic future thinking (Atance & Jackson, 2009; Cole, Morrison, & Conway, 2013; Mercuri et al., 2018; Terrett, Lyons, et al., 2016; Ünal & Hohenberger, 2017). However, a number of other studies have demonstrated no associations between executive functions and episodic future thinking (Cole et al., 2013; Gott & Lah, 2014; Hanson, Atance, & Paluck, 2014; Lyons, Henry, Rendell, Corballis, & Suddendorf, 2014; Lyons, Henry, Rendell, Robinson, & Suddendorf, 2015; Lyons, Henry, Robinson, Rendell, & Suddendorf, 2019; Mercuri et al., 2015). The contribution of executive functions to episodic future thinking therefore remains unclear in the current literature.

It should, however, be noted that past studies addressing the relationship between executive functions and episodic future thinking differed in the ways episodic future thinking was indexed. For example, some studies assessed the phenomenological

experiences of imagining future scenarios. In particular, one study by Mercuri et al. (2015) investigated episodic future thinking in long-term opiate users by asking them to imagine and describe hypothetical future scenarios in response to a series of cue words. The capacity for episodic future thinking was determined by the level of episodic details provided (i.e., temporal and contextual details relevant to the described event). These authors found that executive functions were not significantly associated with the ability to mentally simulate future scenarios for controls or for opiate users. By contrast, other studies examined the practical capacity to secure items for future use. For instance, Terrett, Lyons, et al. (2016) used a behavioural measure to investigate the functional aspect of episodic future thinking (i.e., episodic foresight) by assessing participants' ability to take actions in the present in anticipation of potential future problems. Episodic foresight was indexed using two measures: the ability to acquire items for future use and the ability to use items to solve problems at a future time point. Their results showed that executive functions were associated with item acquisition, but not item use, for both controls and long-term opiate users. The authors thus argued that episodic foresight may impose greater demands on executive functions than imagining and describing hypothetical future events (Terrett, Lyons, et al., 2016). Hence, it is possible that varying levels of executive functions are required for different aspects of episodic future thinking, which may partly explain the inconsistent pattern of findings across the literature. However, given that empirical studies on episodic future thinking, episodic foresight and executive functioning remain scarce, firm conclusions about the involvement of executive functioning in different aspects of episodic future thinking cannot yet be drawn.

2.3.2 The role of episodic memory in episodic future thinking

In contrast to the mixed findings on executive functions, a relationship between episodic memory and episodic future thinking has consistently been demonstrated in past studies across various areas of research (see Suddendorf, 2010a, for a review). For example, there has been behavioural evidence of a concurrent emergence of episodic memory and episodic future thinking in young children around the ages of 4 to 5 years (e.g., Busby & Suddendorf, 2005; Hayne, Gross, McNamee, Fitzgibbon, & Tustin, 2011; Suddendorf, 2010b; Suddendorf & Busby, 2005; Ünal & Hohenberger, 2017), a parallel decline in both abilities associated with healthy aging (e.g., Addis, Wong, & Schacter, 2008; Gaesser, Sacchetti, Addis, & Schacter, 2011; Madore, Gaesser, & Schacter, 2014; Schacter, Gaesser, & Addis, 2013), and concurrent impairments in both abilities in a range of clinical groups (e.g., Addis, Sacchetti, Ally, Budson, & Schacter, 2009; D'Argembeau et al., 2008; El Haj, Antoine, & Kapogiannis, 2015; Gamboz et al., 2010; Rasmussen et al., 2017; Rasmussen & Berntsen, 2018). In addition, neuroimaging studies have provided further evidence of a link between episodic memory and episodic future thinking by revealing significant overlaps in the activation of several brain regions when past personal events were recalled and when future personal events were imagined (e.g., Addis, Wong, & Schacter, 2007; Okuda et al., 2003; Schacter et al., 2012; Szpunar, Watson, & McDermott, 2007).

Several explanations as to why episodic future thinking might be closely linked to episodic memory have been offered in the literature. One of the most prominent theories is the constructive episodic simulation hypothesis proposed by Schacter and Addis (2007). Given that imagined future events are often novel rather than an exact replication of a

specific past episode, this hypothesis stated that episodic future thinking is a constructive process that requires multiple elements to be drawn from past experiences to mentally create hypothetical future scenarios in our imagination. In other words, separate pieces of information from past memories are extracted, integrated and used as basic building blocks for the mental construction of novel future events (Schacter et al., 2008; Schacter et al., 2012). As such, the primary function of episodic memory has been argued to support episodic future thinking, and thus has been recognised as a highly adaptive cognitive system (Schacter et al., 2008; Suddendorf, 2010a). However, recent views have shifted to place more emphasis on the processes that support and link episodic memory and episodic future thinking. More specifically, the constructive episodic simulation hypothesis now argues that episodic memory and episodic future thinking involve the same simulation process where schemas, episodic and semantic content are activated, integrated and encoded to construct event representations of the past or future (Addis, 2018).

Similar lines of arguments about the link between episodic memory and episodic future thinking have also emerged in the literature. For example, they both depend on the same broader underlying processes (Buckner & Carroll, 2007; Hassabis & Maguire, 2007). This hypothesis is based on neuroimaging data that suggest episodic memory and episodic future thinking share similar neurocognitive resources, thus indicating the presence of more general mechanisms that may underpin various cognitive abilities, including episodic memory and episodic future thinking (Buckner & Carroll, 2007; Hassabis & Maguire, 2007, 2009). Reflecting this perspective, two prominent theories have been proposed in the literature: one is the self-projection theory and the other is the scene construction theory.

2.3.3 The self-projection and scene construction theories

Buckner and Carroll (2007) identified a range of cognitive abilities, including episodic memory and episodic future thinking, as well as theory of mind and spatial navigation, that similarly activated the default mode network in the brain. These authors subsequently hypothesised that this activation of shared brain regions may reflect a common reliance on an underlying process they referred to as ‘self-projection’. Self-projection is defined as the ability to shift perspective from the immediate environment to alternative perspectives, such as different mental, spatial or temporal perspectives (Buckner & Carroll, 2007). However, the self-projection theory has been criticised for being rather vague and appearing to refer to a process that is somewhat similar to the broader capacity of ‘thinking’ (Hassabis & Maguire, 2007; Lind & Williams, 2012). This then led to the suggestion embedded in Suddendorf and Corballis’s (1997) idea of mental time travel which places particular emphasis on the temporal aspect of self-projection. In other words, they suggest that re-experiencing past events and pre-experiencing future events both involve the projection of the self *through time* (Suddendorf & Corballis, 1997, 2007).

On the other hand, some researchers have argued the process of scene construction as an alternative to the focus on self-projection as a key factor that underlies episodic memory and episodic future thinking. More specifically, while Hassabis and Maguire (2007) recognised the importance of self-projection through time in episodic memory and episodic future thinking, they proposed that it is only an addition to the fundamental process of scene construction. Unlike visual imagery where single objects are visualised, scene construction involves the complex process of mentally generating and binding elements including visual details, sounds, smells, thoughts, people and objects to create a coherent

spatial representation in the mind (Hassabis & Maguire, 2007, 2009). Hassabis and Maguire (2007) argued that the process of scene construction is not restricted to episodic memory and episodic future thinking but also underpins other cognitive abilities such as spatial navigation. As such, the process of scene construction is arguably atemporal (Hassabis, Kumaran, & Maguire, 2007; Hassabis & Maguire, 2009). Moreover, the scene construction theory may be argued to somewhat overlap with the constructive episodic simulation hypothesis in that both suggest the process of re-experiencing past events and pre-experiencing future events to be constructive in nature. However, the emphasis of the constructive episodic simulation hypothesis is on the process of constructing simulations of past or future experiences (Addis, 2018), whereas the scene construction theory focuses on the process of constructing scenes or spatial representations within which past or future events may be simulated (Hassabis & Maguire, 2007).

To date, the theories of self-projection through time and scene construction have been supported in a limited number of studies in the literature. For example, a neuroimaging study revealed specific neural substrates that are differentially involved in these processes (Hassabis, Kumaran, & Maguire, 2007). In particular, the hippocampus, which is the part of the brain that has long been known to process memory and spatial information (Bird & Burgess, 2008; Ergorul & Eichenbaum, 2004), has been identified to primarily support the process of scene construction (Hassabis, Kumaran, & Maguire, 2007; Maguire, Intraub, & Mullally, 2016). By contrast, the anterior medial prefrontal cortex, posterior cingulate cortex and precuneus are regions of the brain that have been associated with self-projection through time (Hassabis, Kumaran, & Maguire, 2007). Further evidence for the scene construction theory has been shown in a recent study by Clark, Hotchin, et al.

(2019) who found that scene construction, episodic memory and episodic future thinking loaded onto the same factor using principal component analysis. Additional analysis in this study revealed that the association between episodic memory and episodic future thinking was in fact fully mediated by scene construction, suggesting that scene construction may be an essential mechanism underpinning episodic memory and episodic future thinking.

Moreover, past studies in clinical populations have suggested that difficulties in either the self-projection through time or scene construction process could lead to impairments in episodic memory and episodic future thinking. For example, some studies have found impairments in episodic future thinking to be associated with difficulties in self-projection through time in older adults (Jarvis & Miller, 2017; Rendell et al., 2012) and in opiate users (Mercuri et al., 2016), while other studies have linked deficits in episodic future thinking to compromised scene construction ability in individuals with schizophrenia (Raffard, D'Argembeau, Bayard, Boulenger, & Van der Linden, 2010), hippocampal amnesia (Hassabis, Kumaran, Vaan, & Maguire, 2007), developmental amnesia (Maguire, Vargha-Khadem, & Hassabis, 2010), and Alzheimer's disease (Irish et al., 2015). Taken together, findings in the current literature highlight the importance of the functional integrity of the processes of scene construction and self-projection through time that appear to be required to support higher-order cognitive abilities such as episodic future thinking.

2.4 Assessment of Episodic Future Thinking and Episodic Foresight

As demonstrated thus far in this chapter, episodic future thinking appears to be a complex multifaceted construct, which consequently poses a variety of challenges for the development of appropriate methods of assessment. While a range of approaches have been

adopted in the literature, measures of episodic future thinking to date have most often involved analysis and scoring of extended verbal descriptions of imagined future experiences. Such measures include word-cueing paradigms where participants are asked to imagine and describe hypothetical future scenarios in response to cue words (e.g., “imagine a specific event in the future that the word ‘*birthday*’ makes you think of”; Addis et al., 2008), and paradigms that require participants to construct scenes in their minds in response to scenario cues (e.g., “imagine something you will be doing this weekend, but just give me one event”; Hassabis, Kumaran, Vaan, et al., 2007). Different scoring methods have also been employed across studies in the literature. For example, some studies have categorised obtained verbal descriptions of future events into either internal details (i.e., episodic details including specific information related to time and place) or external details (i.e., irrelevant details including semantic details, errors and repetitions). In these studies, internal details are used as an indicator of episodic future thinking, with higher levels of internal details argued to represent better episodic future thinking (e.g., Gaesser et al., 2011; Gott & Lah, 2014; Mercuri et al., 2015; Mercuri et al., 2018; Miloyan, McFarlane, & Echeverría, 2019; Rasmussen & Berntsen, 2018; Terrett et al., 2019; Wang, Capous, Koh, & Hou, 2014). Other studies have assessed episodic specificity of the future events described, with episodic future thinking indexed by the capacity to provide specific information such as the time or place of an imagined future episode (e.g., Busby & Suddendorf, 2005; Coughlin, Lyons, & Ghetti, 2014; Quon & Atance, 2010; Suddendorf, 2010b; Weiler, Suchan, & Daum, 2010a, 2010b; see Williams & Broadbent, 1986, for scoring of episodic specificity originally used in memory research). Similar verbal paradigms have also been used to assess underlying mechanisms of episodic future thinking, specifically scene construction

and self-projection through time. For example, in one of these paradigms, participants are asked to mentally construct and describe fictitious atemporal scenes that have been argued to primarily impose demands on scene construction (e.g., “imagine you’re sitting having a drink in a pub”; Hassabis, Kumaran, & Maguire, 2007; Hassabis & Maguire, 2009). In addition, participants are asked to imagine and describe temporal self-relevant scenes (e.g., “imagine how you will spend next Christmas”), which require both scene construction and self-projection through time (Hassabis, Kumaran, Vaan, et al., 2007; Mercuri et al., 2016). Participants’ relative performances on these tasks are then compared and used to disentangle the underpinning processes of scene construction and self-projection through time (e.g., Mercuri et al., 2016; Rendell et al., 2012). While such approaches in previous research have provided some understanding of episodic future thinking and its underlying mechanisms, it should be noted that these types of assessment have largely tapped the experiential component of this construct. By contrast, the practical application of imagining the future (i.e., episodic foresight) is not addressed in these verbal paradigms (Miloyan & McFarlane, 2018; Miloyan, McFarlane, & Suddendorf, 2019).

Some recent investigations have employed measures that place more emphasis on the practical application of imagining the future. One such measure that has been used in the literature, especially in studies with children, is the Picture Book Trip task (Atance & Meltzoff, 2005; Ferretti, Adornetti, et al., 2018; Ferretti, Chiera, et al., 2018; Hanson & Atance, 2014; Marini et al., 2019). In the Picture Book Trip task, participants are presented with pictures of different locations and they are told to imagine going on a trip to these locations (e.g., a desert with a long road). Pictures of items that might or might not be useful for these future trips are then shown to the participants and they are asked to choose

one appropriate item to bring with them on the trip (e.g., an appropriate choice of item would be ‘water’ rather than ‘present’ or ‘plant’ in anticipation of thirst when walking in a desert). In addition, participants are asked to explain their choices as a means of probing whether their behaviours are indeed motivated by imagination of possible future scenarios (Atance & Meltzoff, 2005). While this task appears to involve some degree of episodic foresight because it requires the selection of items that might be beneficial in the future, it has been suggested that these behavioural choices may not necessarily reflect the application of episodic foresight. Rather, such future-directed actions could be driven by other factors such as behavioural predispositions, learned histories and chance (Suddendorf & Busby, 2005; Suddendorf, Nielsen, & von Gehlen, 2011). To eliminate such alternative reasons for observed future-directed behaviours in empirical investigations of episodic foresight, Suddendorf and Corballis (2010) proposed four stringent criteria for the development of episodic foresight measures. These criteria are: “(1) the use of single trials to avoid repeated exposure to the same stimulus-reward relationships; (2) the use of novel problems to avoid the influence of potential innate response tendencies as well as potentially relevant individual learning histories; (3) the use of clear temporal-spatial separation between the future-directed action and its consequence to avoid any potential cuing; and (4) the use of problems from a range of domains to avoid innate behavioural predispositions that drive the action and to demonstrate the flexibility that is characteristic of human foresight” (Suddendorf & Corballis, 2010, p. 296). The Picture Book Trip task does not appear to adhere to all of these criteria (e.g., violates criterion three), and as such, it may be argued that this task has some limitations as a measure of episodic foresight.

The first behavioural measure of episodic foresight that was developed according to Suddendorf and Corballis's (2010) four criteria is the two-rooms task (Suddendorf et al., 2011). In this task, participants are asked to solve novel problems which require the application of episodic foresight. For example, participants are first shown a box with a square key hole that cannot be opened with a triangular key that is initially presented to them. After a 15-minute delay involving unrelated activities in another room, participants are asked to choose among three different keys (circle, star and square) to take back with them to the first room. It is suggested that participants who are able to anticipate a return to the previously encountered problem in the first room (i.e., the inability to open the box with the triangular shaped key) will more likely select the square key which fits the square key hole. Therefore, success on this task is argued to reflect the capacity to apply episodic foresight because it necessitates the ability to link a specific past episode with an anticipated future scenario to subsequently guide appropriate decisions in the present (Redshaw & Suddendorf, 2013; Suddendorf, 2017). To date, the two-rooms task has only been used in two past studies, both of which involved typically developing preschool children (Redshaw & Suddendorf, 2013; Suddendorf et al., 2011).

A recent behavioural measure based on the two-rooms task that has been developed for use in adults is the Virtual Week-Foresight (VW-Foresight; Lyons et al., 2014). The VW-Foresight measure is a computerised board game that presents a range of problem-solving tasks that draw on episodic foresight for successful task resolution. These tasks require participants to independently identify and resolve problems without overt prompts, thus resembling the way in which episodic foresight is exercised in everyday life contexts. VW-Foresight consists of ten episodic foresight tasks, all of which involve the resolution of

novel problems across various domains. This is an important aspect of the measure because the inclusion of multiple tasks can enhance reliability estimates, which permits greater confidence in the conclusions made based on obtained findings. The value of these positive features of the VW-Foresight measure is reflected in its increasing use in studies of different adult populations, including older adults (Lyons et al., 2014), adults with schizophrenia (Lyons et al., 2015), opiate users (Terrett, Lyons, et al., 2016), and stroke patients (Lyons et al., 2019). To date, however, there appears to be no behavioural measure of episodic foresight for use with primary school-aged children or adolescents in the published literature that has been developed according to the four criteria proposed by Suddendorf and Corballis (2010). An adaptation of the VW-Foresight measure for use with children and adolescents may therefore be a valuable tool for measuring episodic foresight in these younger populations.

2.5 Episodic Future Thinking and Episodic Foresight in ASD

Given the importance of episodic future thinking and episodic foresight for successful daily living, investigation of these abilities in individuals with ASD is crucial, as findings may shed light on the functional difficulties experienced by these individuals. In turn, effective interventions may be developed and implemented to improve independent functioning in this clinical population. The following section will review this topic in both adults and children with ASD. The term ‘episodic future thinking’ will be used throughout this section considering most past studies have utilised verbal measures to capture possible deficits in this ability. In addition, no studies to date have used a measure of episodic

foresight that adhered to the four criteria proposed by Suddendorf and Corballis (2010), thereby limiting current understanding of episodic foresight in individuals with ASD.

2.5.1 Evidence of impairments in episodic future thinking in ASD

It has been argued that individuals with ASD are vulnerable to deficits in episodic future thinking given that some of the core mechanisms that have been theorised to be important for this cognitive ability, such as executive functions and episodic memory, have been found to be compromised in this clinical population (Lind, 2010; Lind & Williams, 2012; McCrimmon, Matchullis, Altomare, & Smith-Demers, 2016; Suddendorf & Corballis, 1997, 2007). In addition, there have been suggestions that the restricted and rigid repertoires of behaviour often observed in individuals with the disorder may partly be explained by an impairment in episodic future thinking (Lind & Bowler, 2010). This is because a reduced capacity to mentally simulate plausible events in the future is likely to limit a person's ability to flexibly modify behaviours in the present to accommodate future needs (Suddendorf & Corballis, 1997; Terrett et al., 2013). Surprisingly, however, empirical studies investigating this issue are scarce in the current ASD literature.

For example, investigations of episodic future thinking in adults with ASD are currently limited to three empirical studies, with two of these studies showing impairments in this clinical group. Specifically, Lind and Bowler (2010) found that adults with ASD described significantly fewer specific personally experienced future events across different time periods (e.g., 'tomorrow' or 'in 10 years') than controls. Consistent with these findings, Lind, Williams, Bowler, and Peel (2014) also found significantly poorer episodic quality in the verbal descriptions of imagined future scenarios for adults with ASD compared to controls. By contrast, a study by Crane, Lind, and Bowler (2013) reported no

significant difference between the ASD and control groups on an online sentence completion task used to index episodic future thinking. In this task, participants were required to respond in written form to a series of sentence stems related to the future (e.g., “Next year...”). The capacity for episodic future thinking was measured by the level of specificity in their responses (i.e., descriptions of a single unique event that lasts less than a day). However, because specific future events were not explicitly probed, it has been suggested that this task design may have led participants in the control group to produce more general information about their described future events compared to controls in past studies that explicitly asked participants to describe specific future events (e.g., Lind & Bowler, 2010). Hence, the lack of group differences shown in this study may be explained by lower levels of response specificity in controls, rather than greater specific future event details produced by participants with ASD (Crane et al., 2013). In fact, the validity of sentence completion tasks as a measure of episodic future thinking has been questioned, as this approach appears to largely tap semantic knowledge while the mental simulation of future scenarios may not be required to complete the task (Miloyan & McFarlane, 2018). Overall, then, it appears that there are preliminary findings that suggest the presence of an impairment in episodic future thinking in adults with ASD, although research on this topic remains scarce.

Similar to the adult ASD literature, there has been limited investigation of episodic future thinking in children with ASD. There are currently only eight studies that have examined episodic future thinking in this clinical group, with findings in most of these suggesting that this cognitive ability is impaired. For example, Lind, Bowler, et al. (2014) showed that children with ASD not only produced less specific future events, but were also

more likely to generate future events that were implausible when asked to describe specific future events (e.g., breakfast or evening meals). In addition, when compared to controls, the capacity to imagine and describe hypothetical future scenarios was found to be attenuated in children with ASD aged 8 to 12 years (Terrett et al., 2013), and in children and adolescents with ASD aged 7 to 15 years (Ciaramelli et al., 2018) as indicated by significantly less internal details being produced by these ASD groups. Another study by Marini et al. (2016) assessed episodic future thinking in children with ASD and controls using an approach originally developed by Jackson and Atance (2008). This approach involved presenting the children with two types of tasks: self-based tasks which required the mental simulation of future situations to solve problems (e.g., choosing whether the head or the body of an ant-costume is the most appropriate to put on first), and mechanical-based tasks which involved the prediction of mechanical outcomes (e.g., choosing between a small and big ball when deciding what would fit into both wide and narrow tubes). The results revealed significantly poorer performance on both the self-based and mechanical-based tasks in the ASD group relative to controls, thus providing evidence for diminished episodic future thinking capacity in children with ASD. Similar conclusions were also reported in two recent studies that utilised the Picture Book Trip task (Ferretti, Adornetti, et al., 2018; Marini et al., 2019), both of which showed that children in the ASD group performed significantly worse than controls.

In contrast to these previous findings, however, one study obtained results that provided mixed evidence of impairments in episodic future thinking in children with ASD. Specifically, Hanson and Atance (2014) investigated episodic future thinking in preschool children with ASD across five different tasks, and found that the ASD group performed

significantly worse than typically developing controls on only two of the five episodic future thinking tasks assessed. However, the authors suggested that the employment of insensitive measures, and exposure to intervention programs for children in the ASD group, may have partially contributed to the lack of group differences found on three of the tasks (Hanson & Atance, 2014). Another possible explanation for the discrepant findings relative to past studies may relate to differences in the samples included in these studies. For instance, Hanson and Atance (2014) tested young preschool children while other studies examined primary school-aged children (e.g., Ferretti, Adornetti, et al., 2018; Lind, Bowler, et al., 2014; Terrett et al., 2013). As episodic future thinking typically emerges in the preschool years, around the ages of 4 to 5 (see Atance & Mahy, 2016, for a review), it is possible that this ability may not yet have fully developed in the typically developing control group in Hanson and Atance's (2014) study, hence limiting the capacity to detect significant group differences. Taken together, then, evidence from the current literature, albeit limited, appears to suggest some degree of impairment in episodic future thinking amongst individuals with ASD.

2.5.2 Cognitive contributors to episodic future thinking impairments in ASD

A key question raised by the findings of the aforementioned studies in ASD relates to the issue of what might underpin deficits in episodic future thinking in this clinical population. As previously noted, there are a number of processes that have been proposed to be important for episodic future thinking including scene construction, self-projection, episodic memory and executive functioning (Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Schacter et al., 2008; Schacter et al., 2017; Suddendorf & Redshaw, 2013). However, empirical evidence of such processes underlying episodic future thinking

impairments in individuals with ASD remains scarce. For example, there are only three studies to date that have attempted to investigate the roles of scene construction and self-projection in explaining ASD-related deficits in episodic future thinking, but each of these studies have varied in their conclusions. In the first, Marini et al. (2016) concluded that episodic future thinking impairments in children with ASD appeared to reflect underlying difficulties in both scene construction and self-projection into the future, but that self-projection into the future was more severely compromised in this clinical group. This is consistent with the conclusion reached by Jackson and Atance (2008) which showed that the ability to project oneself into future scenarios is impaired in children with ASD. By contrast, Ciaramelli et al. (2018) concluded that a diminished capacity for scene construction, but not self-projection, appears to underpin episodic future thinking impairments in children with ASD. In line with Ciaramelli et al.'s (2018) findings, another study on adults with ASD showed that deficits in episodic future thinking were linked to difficulties in scene construction, and that any difficulty in self-projection through time did not contribute to impairments in episodic future thinking over and above the difficulties in scene construction (Lind, Williams, et al., 2014).

In relation to the relationship between episodic memory and episodic future thinking in individuals with ASD, there is one study that has demonstrated episodic memory to be a significant contributor to episodic future thinking in children with ASD (Terrett et al., 2013) while three other studies have failed to find an association between episodic memory and episodic future thinking in children (Lind, Bowler, et al., 2014) and adults with the disorder (Crane et al., 2013; Lind & Bowler, 2010). It has been proposed that the lack of associations revealed in the latter studies might reflect a tendency for

individuals with ASD to draw more heavily on semantic memory, rather than episodic memory, to envisage personal future events (Lind & Bowler, 2010; Lind, Bowler, et al., 2014). However, given that there have only been four studies that explored the relationship between episodic memory and episodic future thinking in ASD, the role of episodic memory in episodic future thinking remains somewhat unclear in this clinical population.

Regarding the contribution of executive functioning to episodic future thinking, Hanson and Atance (2014) showed that children with ASD who performed worse on episodic future thinking tasks had poorer executive functioning, suggesting that poorer episodic future thinking ability may be linked to executive dysfunction. However, the relationship between these two cognitive capacities was not directly assessed in this study. Terrett et al.'s (2013) study is thus far the only study that has directly examined executive functioning as a potential contributing factor to episodic future thinking in children with ASD. The results showed that executive functioning, specifically cognitive flexibility, did not significantly contribute to episodic future thinking in this clinical group. However, the authors noted that because only cognitive flexibility was explored in this study, it is possible that other aspects of executive functioning may be more involved in episodic future thinking, such as verbal fluency (Terrett et al., 2013). Overall, it is apparent that there is currently limited understanding of the underlying mechanisms that might explain episodic future thinking deficits in individuals with ASD.

2.5.3 Gaps in the current ASD literature

There is growing research on episodic future thinking in individuals with ASD, with emerging evidence showing persistent deficits in this capacity from early childhood years through to adulthood. However, a limitation in the current literature that should be

highlighted is that past studies of individuals with ASD have predominantly tapped the experiential component of episodic future thinking. More specifically, most studies have focused on the investigation of how well individuals with ASD are able to mentally simulate future scenarios based on their verbal responses. Consequently, there is currently little understanding of the functional aspect of episodic future thinking (i.e., episodic foresight) in this clinical population. It may be argued that findings in some previous studies of children with ASD have provided initial insights into their capacity to apply imaginations of the future, as demonstrated by the capacity to choose which piece of a costume to put on first in the self-based tasks (Jackson & Atance, 2008; Marini et al., 2016) or selection of an appropriate item in anticipation of future states of self in the Picture Book Trip task (Ferretti, Adornetti, et al., 2018; Hanson & Atance, 2014; Marini et al., 2019). However, the Picture Book Trip task and self-based tasks do not adhere to the four proposed criteria for a valid behavioural measure of episodic foresight (Suddendorf & Busby, 2005; Suddendorf & Corballis, 2010). It is thus difficult to determine whether future-directed behaviours demonstrated by children with ASD specifically reflected episodic foresight ability in these past studies. In addition, another current gap in the literature relates to the limited understanding of what might underpin the identified deficits in episodic future thinking and the anticipated deficits in episodic foresight in this clinical population. A better understanding of the capacity for episodic future thinking and episodic foresight, as well as the processes that drive any impairments will be important for the development of tailored supports that can help promote functional independence in individuals with ASD in everyday life.

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Chapter 3: A Review of Prospective Memory and Its Relation to Autism Spectrum Disorder

Preamble

This chapter provides a review of another form of prospection, namely prospective memory (PM). The chapter will begin with defining PM and will then discuss the proposed underlying cognitive mechanisms that may drive successful performance on PM tasks. Moreover, a range of assessment methods that have been employed thus far in the literature and their limitations will be covered before finally providing a critical analysis of past studies on PM abilities in the ASD population. The current gaps in the ASD literature in relation to PM, and potential future research directions, will be highlighted.

3.1 Definition of Prospective Memory

PM refers to the ability to remember to carry out an intention at the appropriate moment in the future (Einstein & McDaniel, 1990). Daily life examples include remembering to attend a meeting at 10 a.m. tomorrow, remembering to return a book when you walk past the library, or remembering to meet a friend for a movie on Saturday night. PM failures in everyday living are common but in some cases these failures could lead to disastrous consequences. For instance, forgetting to turn off the stove before you leave the house for work in the morning or forgetting to pick up your child from school in the afternoon. As such, PM has been argued to be a cognitive ability that has important implications for an individual's well-being, safety, social relationships, daily functioning and autonomy (Henry et al., 2014; Hering et al., 2018; Raskin, 2018; Woods et al., 2015).

There are several phases involved in the successful performance of PM tasks. Firstly, individuals must form and encode an intended action that needs to be carried out in the future and must retain this intention in memory. The intention must then later be retrieved when the target cue appears, and finally the intended action needs to be executed and evaluated at the specified moment (Ellis, 1996; Ellis & Freeman, 2008; McDaniel & Einstein, 2000). PM tasks are thus typically characterised by: (1) a delayed interval between the initial formation of the intention and the execution of the intention at a later point (which can range from minutes to days); (2) self-initiation of the execution with an absence of explicit directions to perform the intention at the appropriate moment; and (3) a temporary suspension of one's current activity to perform the delayed intention (Ellis & Kvavilashvili, 2000).

3.1.1 Retrospective and prospective components of prospective memory

Given that PM tasks involve delayed retrieval of the intention and execution at a particular future point, it is apparent that these tasks comprise two critical components: a retrospective component and a prospective component (Einstein & McDaniel, 1990; Ellis, 1996; Graf & Utzl, 2001). The retrospective component involves the ability to remember the specific content of the PM tasks, that is, individuals are required to remember the details of the tasks that need to be done and the circumstances under which these tasks need to be carried out. By contrast, the prospective component refers to the ability to remember to retrieve details of, and execute, the intention at the appropriate point (Ellis & Kvavilashvili, 2000; McDaniel & Einstein, 2007). The retrospective and prospective components of PM tasks have been argued to be independent, although difficulties in either can result in failures to successfully perform PM tasks (Graf & Utzl, 2001; McDaniel & Einstein, 2007). In other words, it is possible for a person to remember the content of a PM task (retrospective component) while forgetting to carry it out at the appropriate moment in the future (prospective component). Alternatively, one may remember that a task needs to be performed (prospective component) but fail to recall what the task is or when to perform it (retrospective component). It is thus widely accepted that both components are necessary for the successful completion of PM tasks (Einstein & McDaniel, 1996; Ellis, 1996; Ellis & Kvavilashvili, 2000). While there is a general consensus that remembering the content of PM tasks relies on successful encoding and storage of specific information related to the PM intentions (i.e., retrospective component; Bugg, McDaniel, & Einstein, 2013; Ellis & Freeman, 2008; Zöllig, Martin, & Kliegel, 2010), there has been increased debate regarding the retrieval processes that support the execution of PM tasks (i.e., prospective component).

Several theories have been proposed, with the multiprocess framework being the most influential theory to date (see Bugg et al., 2013; McDaniel & Einstein, 2007).

3.1.2 Multiprocess framework

According to the multiprocess framework (McDaniel & Einstein, 2000), there are two distinct processes that can support the retrieval of PM tasks: spontaneous processing and strategic monitoring processes. Spontaneous processing usually occurs when salient or unusual target cues appear within the environment, which subsequently trigger retrieval of the PM tasks that need to be performed (Einstein & McDaniel, 2005; Hicks, Marsh, & Cook, 2005; McDaniel & Einstein, 2000, 2007). By contrast, strategic monitoring processes are used when the performance of PM tasks relies on the detection of subtle target cues in the environment (McDaniel & Einstein, 2007). As such, these strategic processes are argued to impose more demands on executive resources because target cues are constantly monitored and evaluated in the environment for the appropriate moment to perform the intention (Smith, 2003; Smith & Bayen, 2004). McDaniel and Einstein's (2000) multiprocess framework further emphasises that these two processes are flexibly used at varying degrees in different situations. The activation of either of these processes is largely dependent on the demands of the ongoing activity, the distinctiveness of the PM tasks and the type of cue available to complete the PM tasks (McDaniel & Einstein, 2000, 2007).

3.1.3 Types of prospective memory

The two most common types of PM investigated in the literature are event-based PM and time-based PM. Event-based PM is the ability to carry out intentions in response to

a target event cue such as remembering to take out the cake from the fridge (intention) when your friends arrive at your house (event cue). On the other hand, time-based PM is the ability to perform intentions at the appropriate time in the future, either at a specified time point or after a specific time interval (Einstein & McDaniel, 1990). For example, remembering to attend class (intention) at 2 p.m. tomorrow (time cue) or remembering to take the boiled eggs out of the pot (intention) after three minutes (time cue). In relation to the multiprocess framework, it has been suggested that event-based PM relies more on spontaneous processing of target cues for task completion. This is because the appearance of external event cues is often sufficient to trigger the retrieval of the PM tasks that need to be carried out (Hicks et al., 2005; McDaniel & Einstein, 2000, 2007). By contrast, time-based tasks tend to involve self-initiated and effortful monitoring processes. More specifically, unlike event-based tasks where there is an inherent environmental event cue, the completion of time-based tasks at the appropriate time require individuals to monitor the time elapsed while engaging in their ongoing activities (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). As such, time-based PM tasks are arguably more difficult to successfully complete as they impose more cognitive demands than event-based PM tasks (Einstein & McDaniel, 1990, 1996).

3.2 Processes Involved in Prospective Memory

A number of cognitive processes have been theorised to be involved in the completion of PM tasks, including retrospective memory and executive functions abilities. These cognitive abilities have been argued to support performance at various stages of PM (Foster et al., 2013; Mahy, Moses, & Kliegel, 2014; Zöllig et al., 2010). In particular,

retrospective memory is thought to play a crucial role during the encoding and retention stages as the intention must first be properly encoded and retained in memory so that it may be retrieved at the appropriate point later (Ellis & Freeman, 2008; Zöllig et al., 2010). Furthermore, to successfully complete PM tasks, individuals are required to monitor the environment for PM cues, flexibly alternate between an ongoing task and the PM task, and inhibit any irrelevant response that might hinder the successful completion of the PM task at the appropriate moment (Altgassen, Vetter, Phillips, Akgün, & Kliegel, 2014; Kliegel, Mackinlay, & Jäger, 2008). As such, it has been proposed that executive functions such as working memory, cognitive flexibility and inhibition may also be critical to the performance of PM tasks (Mahy, Moses, et al., 2014; Yi et al., 2014). However, the extent to which these cognitive abilities are involved in PM may be dependent on the demands required to complete different types of PM tasks. For example, as previously noted, time-based PM tasks are argued to be more cognitive demanding than event-based PM tasks and therefore potentially require greater executive function resources (Einstein & McDaniel, 1990).

Empirically, it has been shown that retrospective memory is associated with PM task performances in children (Mahy et al., 2018; Mattli, Schnitzspahn, Studerus-Germann, Brehmer, & Zöllig, 2014; Terrett et al., 2019; Wang, Kliegel, Liu, & Yang, 2008) and adults (Cavuoto, Ong, Pike, Nicholas, & Kinsella, 2017; Foster et al., 2013; Mattli et al., 2014; Yang, Wang, Lin, Zheng, & Chan, 2013). For example, Terrett et al. (2019) found strong correlations between retrospective memory for PM task content and PM task performances in typically developing children aged 8 to 12 years. In addition, the results revealed that retrospective memory was the strongest predictor of PM performances in this

study. A similar pattern of findings has also been demonstrated in adult clinical populations. In one study by Henry and colleagues, retrospective memory was assessed using a verbal learning and delayed recall task and results showed that poorer retrospective memory was significantly related to poorer ability to carry out PM tasks in adults with schizophrenia (Henry et al., 2007). These findings thus reinforce the importance of retrospective memory in the completion of PM intentions.

On the other hand, the empirical evidence regarding the role of executive functions in PM has been mixed, with some studies showing that working memory, cognitive flexibility and inhibition were related to event-based PM (e.g., Spiess, Meier, & Roebbers, 2016; Wang et al., 2008) and time-based PM (e.g., Kerns, 2000; Voigt et al., 2014). Conversely, other studies have failed to find significant associations between event-based PM and inhibition (Cottini, Basso, & Palladino, 2018), or between time-based PM and inhibition (Kretschmer, Voigt, Friedrich, Pfeiffer, & Kliegel, 2014), working memory (Mackinlay, Kliegel, & Mäntylä, 2009) and cognitive flexibility (Mäntylä, Carelli, & Forman, 2007). Therefore, it appears that the relationship between executive functions and PM performance remains somewhat unclear in the current literature. One possible reason for the conflicting results may be because of the varying PM task complexity in each study which imposed different levels of demands on executive functioning. For instance, Shum, Cross, Ford, and Ownsworth (2008) found that working memory, inhibition and cognitive flexibility were significant contributors to event-based PM in typically developing children. Event-based PM was assessed by asking participants to substitute the name 'Henry' with 'Tom' or the word 'lower' with 'upper' each time they came across this name or word in the text of stories they were given to read. In another study by Mahy and Moses (2011),

working memory but not inhibition significantly predicted event-based PM performance when age was controlled for. The PM task in this study required children to name objects on a stack of cards and every time they came across an animal card, they were required to place it in a box. A proportion of children were additionally asked to place cards depicting a car in a separate box. Because these two types of event-based PM tasks appear to vary in terms of task difficulty, the precise executive functions that might be required to complete these tasks may consequently differ, which could partially explain the inconsistent findings.

One way to investigate the extent to which executive function demands differ across various PM tasks is to examine whether working memory, inhibition and cognitive flexibility might be related to event-based and time-based PM in a single sample of participants. Adopting this approach, a recent investigation with 6- to 11-year-old children by Zuber, Mahy, and Kliegel (2019) illustrated that time-based PM task performance was significantly predicted by working memory but not inhibition and cognitive flexibility. Event-based PM tasks were further investigated as two subtypes that are commonly distinguished in the literature: *focal* (i.e., when the defining features of PM cues largely overlap with the information relevant to the ongoing task) and *non-focal* (i.e., when the PM cues are present in the environment but not part of the ongoing task information processing; Einstein & McDaniel, 2005). Results showed that working memory and inhibition, but not cognitive flexibility, were significant predictors of *focal* event-based PM task performance. By contrast, working memory, inhibition and cognitive flexibility significantly contributed to *non-focal* event-based PM task performance. The authors argued that because *focal* tasks involved more spontaneous processing while *non-focal* tasks required increased strategic monitoring for target cues, the latter would additionally draw on cognitive resources that

allow one to switch between completing the ongoing task and monitoring for task cues. In addition, it was suggested that whilst cognitive flexibility may be involved in other phases of time-based PM task completion, working memory may be primarily required in actually carrying out the task (Zuber et al., 2019). These findings have therefore provided valuable insights into the specific contributions of different executive functions to event-based and time-based PM. While further research into these relationships within the same cohort of participants are needed, there is nevertheless growing evidence demonstrating that executive functions are involved in the completion of PM tasks, although the nature and extent may vary as a function of PM task demands.

3.3 Assessment of Prospective Memory

Many of the early studies of PM relied on naturalistic paradigms which included asking participants to remember to call the experimenter on a specific day, or for children to remind their parents to buy milk (Harris, 1984; Somerville, Wellman, & Cultice, 1983). However, such paradigms have been criticised for their lack of experimental control including experimenters' inability to assess or manipulate the use of external supports such as calendars that might aid PM task performance (Einstein & McDaniel, 1990, 2005). Consequently, the reliability as well as the internal validity of findings from such studies may be questioned. By contrast, laboratory-based methods such as the dual-task paradigm have been extensively used in the PM literature across different clinical populations and age groups (e.g., Altgassen, Schmitz-Hubsch, & Kliegel, 2010; Mäntylä et al., 2007; Phillips et al., 2018; Schnitzspahn, Stahl, Zeintl, Kaller, & Kliegel, 2013; Williams, Jarrold, Grainger, & Lind, 2014; Zinke et al., 2010). In the dual-task paradigm, participants are

asked to perform a prescribed intention at particular points in the experiment by pressing specific keys on a keyboard while engaging in an unrelated ongoing activity on a laboratory-based computer (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). The benefit of the dual-task paradigm is the inclusion of all three key features that characterise PM tasks (Ellis & Freeman, 2008; Ellis & Kvavilashvili, 2000), as mentioned earlier, allowing PM ability to be reliably assessed in controlled laboratory settings.

Several criticisms have, however, been raised in the literature regarding the use of such laboratory-based paradigms. Firstly, there is low ecological validity because the PM and ongoing tasks included often fail to reflect those that are typically performed in real life (Altgassen, Koban, & Kliegel, 2012; Mahy, Moses, et al., 2014). More specifically, pressing keys in response to target cues may have limited value in improving understanding of the ability to perform PM intentions in real-world settings. Moreover, laboratory-based tasks may fail to capture important aspects of PM, as PM tasks in everyday life tend to be more complex and less structured in comparison (Altgassen et al., 2010; Ellis & Kvavilashvili, 2000). Secondly, the reliability of such paradigms has been questioned as past studies have mostly assessed only one or two PM tasks that are performed over multiple trials (Kelemen, Weinberg, Alford, Mulvey, & Kaeochinda, 2006; McDaniel & Einstein, 2007; Rendell & Henry, 2009). In addition, the assessment of PM is usually limited to either event-based or time-based tasks thus restricting our understanding of PM ability across tasks types within the same sample. Finally, and perhaps the most important issue to consider in regards to investigations of PM in children is that, adult laboratory-based paradigms are generally not suitable for the assessment of PM ability in paediatric populations (Kvavilashvili et al., 2008). In particular, Kvavilashvili et al. (2008) asserted

that using adult laboratory-based paradigms with children raises issues regarding motivation and sustained engagement in task completion. Although various adaptations of these adult paradigms have been made to be more appropriate for children to overcome these issues (e.g., Guajardo & Best, 2000; Kvavilashvili, Messer, & Ebdon, 2001; Walsh, Martin, & Courage, 2014), the varying capacities to complete an ongoing task while carrying out PM tasks in different age groups across childhood remains a problem. This is because the cognitive resources allocated to perform the ongoing task versus PM tasks are likely to be different depending on age and therefore could impact PM performance. For example, younger children may need greater cognitive resources to complete an ongoing task such as a working memory task compared to older children due to their less well-developed working memory ability. Consequently, there may be less cognitive resources allocated to carrying out PM tasks for younger children (Kvavilashvili et al., 2008). To minimise the impacts of age on performances across the ongoing task and PM tasks, it has been suggested that asking children to watch cartoons or play video games as the ongoing activity is useful in equating the ongoing task difficulty so that PM abilities across different age groups may be reliably assessed (Kerns, 2000; Kvavilashvili et al., 2008).

One measure of PM that accounts for the limitations of naturalistic and laboratory-based paradigms is Virtual Week (VW-PM; Rendell & Craik, 2000). VW-PM is a computerised board game that attempts to simulate daily life-like PM tasks while also ensuring that a certain level of experimental control is maintained within a laboratory-based setting. Moreover, it assesses both event-based and time-based PM within the one measure, therefore allowing the systematic investigation of these two PM task types (Rendell & Craik, 2000; Rendell & Henry, 2009). In addition, the adult version of the measure has

been shown to have good psychometric properties (e.g., Henry et al., 2007; Mioni, Rendell, Stablum, Gamberini, & Bisiacchi, 2015; Mioni, Stablum, Biernacki, & Rendell, 2017) as has the recently developed children's version (e.g., Henry et al., 2014; Terrett et al., 2019). The VW-PM has also been shown to be a sensitive measure in various clinical populations (e.g., Henry et al., 2007; Mioni, Rendell, Henry, Cantagallo, & Stablum, 2013; Terrett et al., 2014). Hence, VW-PM has been increasingly recognised as a valuable measure of PM.

3.4 Evidence of Impairments in Prospective Memory in ASD

Individuals with ASD have been argued to be susceptible to impairments in PM considering that retrospective memory and executive processes that support PM performance have commonly been found to be compromised in this clinical group (Boucher et al., 2012; Bowler et al., 2011; Kenworthy et al., 2008). The following sections will present a critical review of the current literature on event-based and time-based PM in individuals with ASD across all age groups. Studies on adults with ASD will first be presented, followed by findings in children and adolescents with ASD. The current gaps in the literature as well as suggestions for future research will be highlighted.

3.4.1 Prospective memory in adults with ASD

There is a growing number of studies on PM in individuals with ASD. In general, time-based PM has consistently been shown to be impaired, while findings on event-based PM have somewhat been mixed (see Landsiedel, Williams, & Abbot-Smith, 2017; Sheppard, Bruineberg, Kretschmer-Trendowicz, & Altgassen, 2018). For example, Williams et al. (2014) revealed significantly poorer performance on time-based PM tasks in adults with ASD compared to controls, but found no significant group difference in

performance on event-based PM tasks using the typical laboratory-based PM paradigm. Employing the same method of assessment, Altgassen and Koch (2014) also found that event-based PM was not impaired in adults with ASD relative to controls, independent of inhibition load during PM task performance. However, two other studies, while they replicated the results of an impairment in time-based PM ability, also demonstrated deficits in event-based PM in adults with ASD (Altgassen et al., 2012; Kretschmer, Altgassen, Rendell, & Bölte, 2014). It should be noted though that the latter two studies assessed more plausible everyday life PM tasks such as preparing breakfast in a laboratory-based setting (Altgassen et al., 2012) or completing daily life-like tasks on the VW-PM (Kretschmer, Altgassen, et al., 2014) as opposed to completing the typical laboratory-based paradigm used in the former two studies (Altgassen & Koch, 2014; Williams et al., 2014). Consequently, it could be argued that the more life-like event-based tasks in Altgassen et al.'s (2012) and Kretschmer, Altgassen, et al.'s (2014) studies are more complex and thus may have required increased cognitive resources than the tasks in Altgassen and Koch's (2014) and Williams et al.'s (2014) studies. Thus, it is possible that differences in the cognitive demands needed to complete event-based tasks in these past studies may explain the discrepant findings on this aspect of PM in this clinical group.

3.4.2 Prospective memory in children and adolescents with ASD

The same pattern of findings reported above for adults with ASD is also observed in studies of children and adolescents with the disorder, whereby time-based PM has consistently been shown to be impaired while the capacity for event-based task performance remains unclear. For example, early studies by Altgassen, Williams, Bolte, and Kliegel (2009) and Altgassen et al. (2010) of children and adolescents with ASD

respectively revealed compromised task performance on time-based PM but comparable performances on event-based PM tasks relative to age- and IQ-matched controls. These findings were supported by two subsequent studies that examined both types of PM using different measures, specifically, the typical laboratory-based paradigm (Williams, Boucher, Lind, & Jarrold, 2013) and the VW-PM measure (Henry et al., 2014). By contrast, other studies have found that event-based PM ability was significantly poorer in children and adolescents with ASD than controls (Brandimonte, Filippello, Coluccia, Altgassen, & Kliegel, 2011; Jones et al., 2011; Sheppard, Kvavilashvili, & Ryder, 2016; Yi et al., 2014). The methods of assessment also varied in the studies that showed impaired event-based PM, with two of these studies employing laboratory-based paradigms (Brandimonte et al., 2011; Yi et al., 2014) and two others assessing responses to pre-planned events during the experiment (e.g., clapping your hands when you hear the music; Jones et al., 2011; Sheppard et al., 2016). Therefore, unlike the pattern of differences observed in the adult population as discussed above, there appears to be no systematic pattern of results associated with specific assessment methods that could explain the conflicting findings in event-based PM in children and adolescents with ASD.

However, several other factors including variability in age and cognitive abilities (e.g., retrospective memory and executive functions), as well as heterogeneity of the disorder may have contributed to the inconsistent findings in children and adolescents with ASD. Firstly, the age ranges included in past studies have varied considerably where some studies have examined both young pre-schoolers and primary school-aged children (e.g., Sheppard et al., 2016; Yi et al., 2014), while others included primary school-aged children and adolescents within the same sample (e.g., Altgassen et al., 2010; Altgassen, Williams,

et al., 2009). Because PM abilities undergo significant developmental changes from pre-school to adolescence years (Mattli et al., 2014; Voigt et al., 2014), the inclusion of such wide age ranges in different studies may increase sample variability and consequently makes comparisons across studies challenging. Secondly, it is possible that variations in retrospective memory ability have contributed to the differences in the capacity to perform event-based tasks in this clinical group. More specifically, poor event-based PM task performance may be attributed to failures in retrospective memory for PM task content in some studies (e.g., Jones et al., 2011), while individuals with ASD who were able to remember PM task content showed intact event-based PM (e.g., Williams et al., 2013). Indeed, one study revealed impaired event-based PM in adolescents with ASD but when participants with difficulties remembering PM task content were excluded, comparable task performances relative to the controls were observed (Jones et al., 2011; Williams et al., 2013). It has therefore been argued that the assessment of retrospective memory is important when attempting to understand PM deficits in individuals with ASD (Landsiedel et al., 2017; Lind & Williams, 2012). Surprisingly, however, most past studies have failed to consider the role of retrospective memory in PM task performances. Thirdly, varying abilities in executive functions across different ASD samples may also have contributed to the inconsistent findings in event-based PM performances. For example, children with ASD who showed intact performances on executive functioning tasks also had intact event-based PM (e.g., Henry et al., 2014), while impaired event-based PM ability were observed in children with ASD who showed executive dysfunctions (e.g., Yi et al., 2014). As such, the capacity to perform event-based PM tasks may vary based on their executive functioning ability. However, there remains a paucity in current understanding of the influence of

executive functions on event-based PM performance given the scarce research on these factors in the ASD literature. Finally, most past studies have investigated only one type of PM, which has been argued to be problematic considering that ASD is a heterogeneous disorder so the clinical presentations of the participants in each sample may markedly differ (Henry et al., 2014). Therefore, differences in sample characteristics rather than variations in the capacity to perform different types of PM tasks may partly explain the inconsistent findings in the current literature.

3.4.3 Gaps in the current ASD literature

Overall, there is converging evidence showing time-based PM to be compromised in individuals with ASD across all age groups. However, the capacity to carry out event-based PM tasks currently remains unclear in the ASD literature. Further investigation is needed to clarify this picture in this clinical population with careful considerations given to the methods of assessment and the inclusion of specific age ranges especially in children. Moreover, the assessment of retrospective memory and executive functions have largely been neglected in past studies with children in this clinical population, despite the suggested importance of these abilities in PM task performance in the wider literature. Future research should thus consider these factors when designing studies that aim to understand PM ability in individuals with ASD.

Chapter 4: Methodology for Empirical Studies

Preamble

In light of the current gaps in the literature for children with ASD, three empirical studies were designed to address the key research questions outlined in Chapter 1. The purpose of this chapter is to describe the methodology of these three empirical studies. A comprehensive overview of the data collection process will be provided, followed by detailed descriptions of the measures used in this research project. The development of measures designed to examine episodic foresight and prospective memory (PM) in Studies 2 and 3 will also be discussed.

4.1 Participant Groups

Two participant groups were included in the three empirical studies conducted: children with ASD and healthy controls. Participants in each group were screened with reference to inclusion and exclusion criteria as outlined below.

4.1.1 Eligibility criteria for healthy controls

To be included in the healthy control group, participants were required to meet the following inclusion criteria:

- a) aged between 8 and 12 years
- b) fluent English speakers
- c) had an IQ score of above 80

Participants were excluded if they met one of the following criteria:

- d) had an existing diagnosis of a developmental or mental health disorder
- e) had an existing neurological disorder
- f) had significant visual impairment or hearing loss

4.1.2 Eligibility criteria for children with ASD

Children with ASD were screened for the following inclusion criteria:

- a) aged between 8 and 12 years
- b) fluent English speakers
- c) had an IQ score of above 80
- d) had an existing formal diagnosis of high-functioning autism or Asperger's syndrome based on the DSM-IV-TR or autism spectrum disorder based on the

DSM-5 as provided by a qualified health professional (e.g., psychologist, paediatrician, psychiatrist)

Participants were excluded from the ASD group if they met any of the following criteria:

- e) had a comorbid diagnosis of another developmental disorder
- f) had a comorbid diagnosis of a mental health disorder
- g) had an existing neurological disorder
- h) had significant visual impairment or hearing loss

4.1.3 Participant recruitment

An existing database of 19 participants with ASD and 42 healthy controls formed part of the sample for Study 1. These participants were exposed to a similar testing protocol in a previous research project to the one implemented in the current thesis. The remaining participants for Study 1 (18 ASD, 18 healthy controls), and all participants in Studies 2 and 3 were recruited and tested by the research candidate. Healthy controls were recruited through independent schools and personal contacts, whereas participants with ASD were recruited via local communities, independent schools, ASD organisations (e.g., AMAZE), local events (e.g., Melbourne Autism Expo), psychology clinics, and Facebook pages. Figure 4.1. presents a flow diagram of the recruitment process, detailing the number of children recruited and tested for each group in each session.

As previously noted, for Study 1 an additional 18 participants with ASD and 18 healthy controls were included to form a total sample of 37 participants with ASD and 60 healthy controls. These additional participants also completed measures for Studies 2 and 3. Study 2 comprised 40 participants with ASD and 55 healthy controls. A subset of

participants in Study 2 (32 participants with ASD and 42 healthy controls) took part in Study 3 as they completed the extended test battery which included key measures such as the PM measure for Study 3 (see Figure 4.2.).

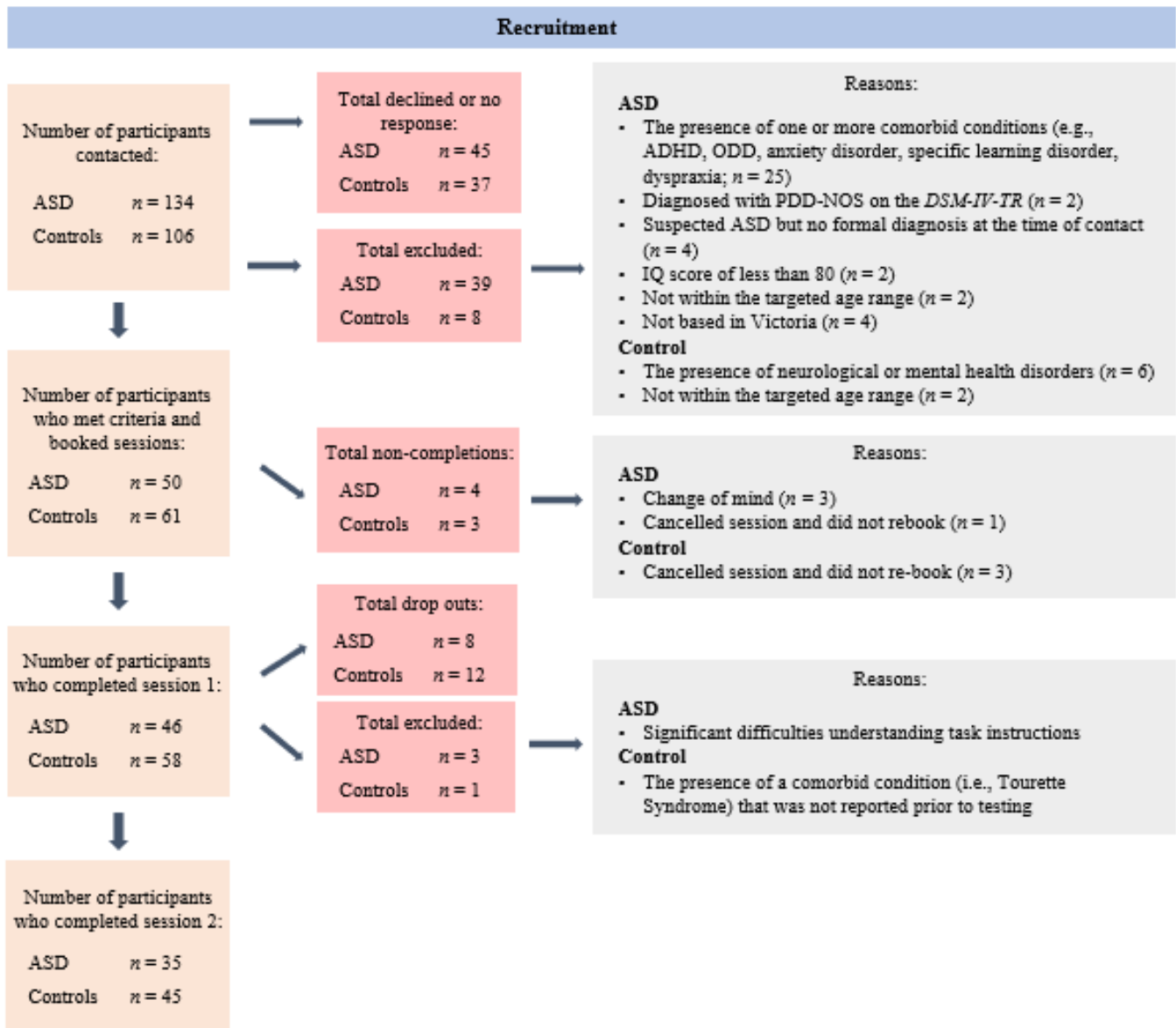


Figure 4.1. Recruitment process for Studies 1, 2 and 3

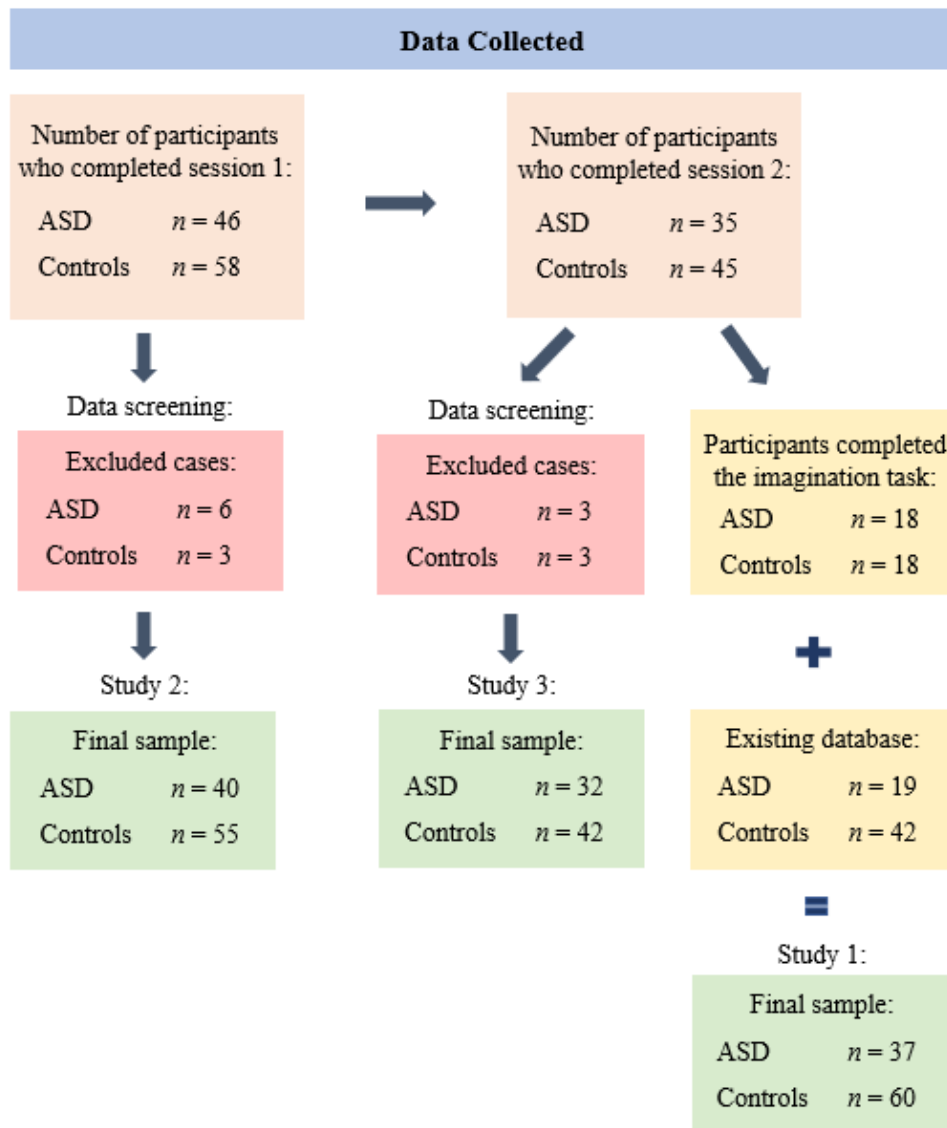


Figure 4.2. Total number of participants with autism spectrum disorder (ASD) and healthy controls tested and included in the final samples of Studies 1, 2 and 3

4.2 Background Measures

Participants who were recruited and tested for the studies completed a range of tasks across two testing sessions, one-on-one with the research candidate. The durations of the sessions were 2 to 2.5 hours for session 1, and 1 to 1.5 hours for session 2. Parents were also asked to complete three questionnaires about their child. These measures are described in detailed in the following section.

4.2.1 Background questionnaire

The background questionnaire gathers basic information about the child participants such as their name, gender, date of birth, first language spoken at home and the number of siblings. It also contains questions about their recent physical health, the presence of speech and behavioural issues or other mental health disorders such as anxiety, depression and attention-deficit/hyperactivity disorder.

4.2.2 Screener for ASD

The Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2008) is a screening measure for ASD that is based on the Autism Diagnostic Interview – Revised (ADI-R; Rutter, LeCouteur, & Lord, 2003). There are two forms: Lifetime Form and Current Form. The Lifetime Form was used to support the diagnosis of ASD in the clinical group, and to screen for symptoms of ASD in healthy controls. It comprises 40 parent-report forced-choice items (i.e., responses are either “yes” or “no”) that assess social reciprocity and verbal/nonverbal communication skills across a child’s developmental history. A score of above 15 indicates poor social and communication skills, which are the

core impairments in ASD. The SCQ shows good internal consistency with Cronbach's alpha ranging from .81 to .92 for children with and without ASD (Rutter et al., 2008).

4.2.3 Intellectual functioning

The Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II; Wechsler, 2011) was used to obtain an estimate of participants' intellectual functioning. It is an abbreviated version of other Wechsler intelligence tests (e.g., Wechsler Intelligence Scale for Children – Fourth Edition; Wechsler, 2003) and is designed for individuals aged 6 to 90 years. It consists of four subtests: Block Design, Vocabulary, Matrix Reasoning, and Similarities. Scores on these four subtests are combined to provide a Full Scale IQ score. In addition, the combination of scores on the Vocabulary and Similarities subtests form the Verbal Comprehension Index score, and scores on the Block Design and Matrix Reasoning subtests together form the Perceptual Reasoning Index score. Higher scores indicate higher levels of intellectual functioning. The WASI-II has internal consistency ranging from .92 to .96, and test-retest reliability ranging from .79 to .95 for children aged 6 to 16 years. It also shows good concurrent validity (Wechsler, 2011).

4.2.4 Executive functioning

4.2.4.1 *Cognitive flexibility*

The Trail Making Test from the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) was used to assess cognitive flexibility. The subtest has five conditions: visual scanning, number sequencing, letter sequencing, number-letter switching and motor speed. Cognitive flexibility is measured in the fourth condition, namely the number-letter switching condition. In this condition, participants are asked to

draw lines and switch between connecting numbers and letters in a sequential order as fast as possible without making mistakes. Participants' performances are timed and the completion time is recorded as a raw score. Higher scores indicate poorer cognitive flexibility ability. The D-KEFS Trail Making Test has internal consistency ranging from .57 to .78 for children aged 8 to 12 years, and test-retest reliability ranging from .20 to .82 for children and adolescents aged 8 to 19 years (Delis et al., 2001).

4.2.4.2 *Inhibition*

The Color-Word Interference Test from the D-KEFS (Delis et al., 2001) was used to assess inhibition. The subtest has four conditions: colour naming, word reading, inhibition and inhibition/switching. Inhibition is measured in the third condition, namely the inhibition condition. In this condition, names of colours are presented in a different coloured ink, and participants are required to name the ink colour and not read the colour words, as fast as possible without making mistakes. Performance is timed and the completion time is recorded as a raw score. Higher scores indicate poorer ability to inhibit automatic responses. The D-KEFS Color-Word Interference Test has internal consistency ranging from .72 to .79 for children aged 8 to 12 years, and test-retest reliability ranging from .77 to .90 for children and adolescents aged 8 to 19 years (Delis et al., 2001).

4.2.4.3 *Working memory*

The Letter Number Sequencing subtest of the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V; Wechsler, 2016) was used as an index of working memory. On this subtest, participants are verbally presented with a combination of letters and numbers on each trial at the speed of one second per letter or number. Participants are

then required to recall the numbers first, in order, starting with the smallest number, then the letters in alphabetical order. Each item consists of three trials and each trial is presented until participants obtain three incorrect trials within the same item. The sum of scores on all items form a total raw score, with higher scores indicating better ability to mentally hold and manipulate verbal information. The Letter Number Sequencing has an internal consistency of .86 (Wechsler, 2016).

4.2.5 Retrospective memory

The List Memory Delayed of the NEPSY-II (Korkman, Kirk, & Kemp, 2007) was used to assess retrospective memory. The List Memory Delayed is part of the List Memory and List Memory Delayed subtest where participants are first read a list of 15 words and then asked to recall the words in any order over five separate trials. Following this, an interference list of 15 new words is presented and participants are asked to recall the new list. Immediately after this trial, participants are instructed to recall the first list they previously learned without the experimenter repeating the list of words prior to recall. After an interval of approximately 25 to 35 minutes, the List Memory Delayed is administered where participants are asked to recall the first list of words with only the first word on the list provided as a cue. The raw score of List Memory Delayed was used as an index of retrospective memory. Higher scores indicate better retrospective memory ability. Internal consistency for the List Memory and List Memory Delayed subtest is .91 and test-retest reliability is .75 for children aged 7 to 10 years (Korkman et al., 2007).

4.2.6 Functional capacity

The Parent Form of the Adaptive Behavior Assessment System – Second Edition (ABAS-II; Harrison & Oakland, 2003) assesses adaptive functioning in everyday life. It is a parent-rated questionnaire designed for ages 5 to 21 years and consists of items that are categorised into 10 skill areas. The Self-Direction scale is particularly of interest in Studies 2 and 3 as it assesses daily living skills that are mostly likely dependent on future-oriented thinking abilities (i.e., episodic foresight and PM). For example, this scale assesses the ability to follow instructions, stick to time limits and adhere to daily routines, all of which are skills associated with independence, responsibility and self-control. This scale requires parents to rate how frequent their children displays the behaviours (e.g., “Routinely arrives at places on time”) on a 4-point Likert scale. The sum of these ratings provides a total raw score for the subscale. Higher scores indicate higher levels of self-direction and functional independence. The Self-Direction scale has internal consistency ranging from .91 to .94 for children aged 8 to 12 years and inter-rater reliability of .84 for individuals aged 5 to 21 years (Harrison & Oakland, 2003).

4.3 Key Measures

4.3.1 Imagination task

An imagination task was used to investigate the underlying component processes of episodic future thinking. This task is an adaptation of the Adapted Autobiographical Interview (AI; Addis et al., 2008), which is a semi-structured interview that assesses episodic and non-episodic details of past and future events. As Study 1 required a measure of episodic future thinking (but not episodic memory), only the *future* condition of the AI

was included. The *future* condition requires participants to imagine and describe a self-relevant, plausible event that might happen in their next summer holiday. The imagination task also has two additional conditions, namely *atemporal* and *narrative*. The *atemporal* condition involves participants mentally creating a novel, fictitious scene in a familiar context, specifically imagining sitting at a café and having a drink. The *narrative* condition requires participants to describe their experience of climbing to a tower in a medieval castle (see Table 4.1. for the provided verbal cues). These latter two conditions were derived from a task originally developed by Hassabis, Kumaran, Vaan, et al. (2007).

On the imagination task, all three conditions require the basic process of scene construction. The *atemporal* and *future* conditions have similar scene construction demands because both scenarios are required to be self-generated. However, these demands are substantially reduced in the *narrative* condition because a story structure to set the scene is provided (Hassabis & Maguire, 2009). In addition, the demands on self-projection are differentiated for each condition in the task. The *atemporal* and *narrative* conditions impose similar demands on self-projection whereas the *future* condition has an additional temporal element thus requiring self-projection through time. Given that the demands of scene construction and self-projection are systematically varied in this task, the pattern of performance across all three scenarios allows the identification of which process may be specifically compromised.

Table 4.1.

Verbal Cues Provided in Each Condition on the Imagination Task

Conditions	Verbal Cues
Narrative	<i>Imagine you are standing in the middle of an entrance hall of a large medieval castle. There is tower somewhere in the castle and the top of the tower can be reached by climbing up a tall winding staircase. I want you to describe to me in as much detail as possible your way through the castle's many rooms and floors until you reach the top of the tower. Use all of your senses including what you see, feel, and do on the way to the tower.</i>
Atemporal	<i>Imagine you are sitting having a drink in a café. I want you to describe the experience and the surroundings in as much detail as possible using all your senses including what you can see, hear, and feel.</i>
Future	<i>Imagine something you will be doing on your next summer holidays, but just give me one event. I want you to describe that event and the surroundings in as much detail as possible using all your senses including what you can see, hear, and feel.</i>

4.3.1.1 Task administration

Participants are asked to imagine and describe each scenario in as much details as possible, providing details using all of their senses including what they see, hear, smell, and feel. Participants are specifically instructed to create new scenes in their minds and not just describe a past event. Prompts are given when participants' responses are short and vague (e.g., "I see people") to elicit more detailed descriptions of their imagined scenes. The experimenter is only allowed to provide the task's prescribed set of prompts where appropriate and is strictly prohibited from introducing any concept, idea, detail, or entity that participants have not already mentioned (e.g., "What do the people look/sound/smell like?"). The number of prompts provided to each participant may slightly vary, but all participants are given an approximately equal amount of time to describe each scenario

(i.e., two to three minutes per scenario). Prior to presenting the three test conditions, an example of a scenario is given to the participants (i.e., sitting on a bench at the park), with a sample response to ensure that participants understand the instructions of the task. All conditions were counterbalanced across participants in both groups to minimise possible order effects.

4.3.1.2 Scoring

Standardised scoring procedures for the imagination task were followed as outlined in the training manuals provided by Donna Rose Addis. For each transcribed scenario description, a central event is first identified and then details are segmented and categorised as either internal (episodic details specific to the central event) or external (semantic information, repetitions and errors). The number of internal details generated in each condition provides an index of the extent to which participants personally experience the event in their imagination.

For Study 1, two independent scorers who were blinded to the aims of the study and group membership scored all transcripts. Both scorers completed the training procedures where they were asked to segment 20 training events into internal and external details. Inter-rater reliability between each scorer and the scoring of these events provided in the training manuals were examined using two-way mixed-design analysis of variance (ANOVA) intraclass correlation analysis. The Cronbach alphas obtained for the scorers and those in the manual were .99 for internal details and .94 for external details.

4.3.2 Episodic foresight

The Virtual Week-Foresight task (VW-Foresight; Lyons et al., 2014) is a computerised board game that assesses an individual's ability to engage in episodic foresight in an everyday life context. It attempts to simulate real life situations where this cognitive capacity is demonstrated and flexibly used. For example, after hearing a forecast of rain later today, a person may imagine themselves getting caught in the rain on the way home from work and subsequently decide to pack an umbrella before leaving home for work in the morning. Behaviours as in this example are largely guided by episodic foresight, where current actions are implemented in light of an imagined future event in order to avoid potential future problems. The VW-Foresight task is designed to specifically capture the ability to apply episodic foresight in daily life. This measure was originally developed at the University of Queensland for use with adults. It has been employed in past studies with older adults (Lyons et al., 2014), adults with schizophrenia (Lyons et al., 2015), opiate users (Terrett, Lyons, et al., 2016) and stroke patients (Lyons et al., 2019). The VW-Foresight task was recently adapted at the Cognition and Emotion Research Centre at the Australian Catholic University to be appropriate for use in school-aged children. The adaptation involved changing wording, scenarios and pictures to be more age-appropriate for 8- to 12-year-olds. For instance, going to university in the adult version was changed to attending school in the children's version.

4.3.2.1 Features of the VW-Foresight task

On the VW-Foresight, participants are required to move a token around the board on the roll of a die. A circuit around the board represents one virtual day (see Figure 4.3. for the game's interface). As participants move around the board each day, they are

required to make decisions about daily activities and carry out tasks that draw on episodic foresight. Each episodic foresight task consists of three components: (1) A plausible everyday situation is presented in which a problem arises (problem); (2) A daily activity which subsequently occurs and presents an opportunity to select an item from five possible options that allows the problem to be solved (daily activity); and (3) A similar situation is presented in which the previous problem is still present and provides the opportunity to use the previously acquired item to solve the problem (resolution).

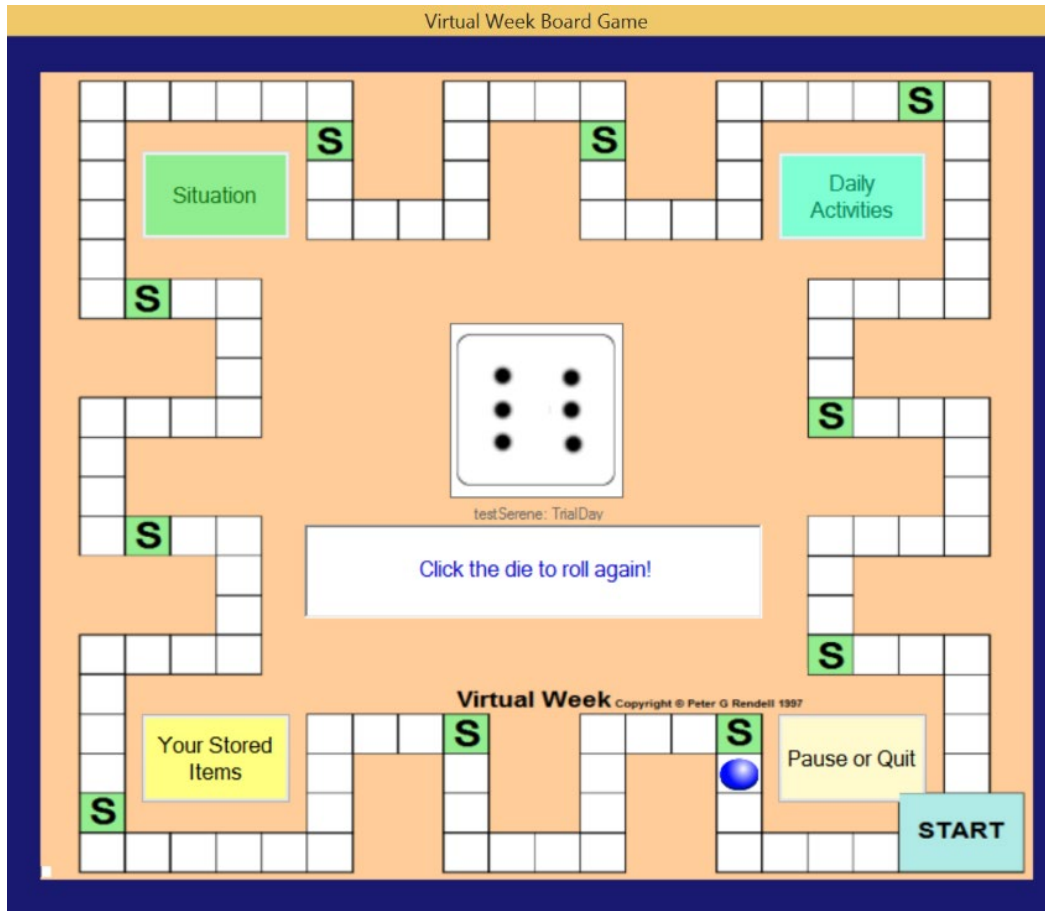


Figure 4.3. Children's version of the Virtual Week-Foresight game interface

During the game, participants pass a total of ten green ‘S’ squares on the board each virtual day. Every time they land on or pass an ‘S’ square, they are prompted to pick up a *Situation Card*. On each *Situation Card*, a realistic daily situation, such as eating breakfast, is presented. Participants are asked to choose one of the options on the card in response to the situation. Depending on the option the participants select, they are then prompted to roll a specific number on the die to continue moving around the board (e.g., roll a three, roll an even number or roll any number). Most of these *Situation Cards* are related to the episodic foresight tasks embedded within the game, that is, some *Situation Cards* consist of a problem which participants are required to independently identify (problem) and some *Situation Cards* present situations that provide the context for the problem to be resolved in (resolution). Other *Situation Cards* are not linked to any of the episodic foresight tasks but act as distractor situations.

In addition, participants are asked to pick up *Daily Activities Cards* on which five items are presented, and they are required choose one item. Some *Daily Activities Cards* contain an item on the list that allows participants to solve a problem previously encountered on a *Situation Card*. Other *Daily Activities Cards* are included as distractor activities where no items on these cards would help to solve a previous problem. Participants acquire an item from the list presented on the *Daily Activities Cards* by clicking on it, and it is then stored in a repository labelled *Your Stored Items* and can be retrieved later to solve a problem. The presentation of problem, resolution and distractor *Situation Cards* are interspersed throughout the day, with *Daily Activities Cards* presented in between the *Situation Cards*. On average, there are two intervening cards between problem presentation situations and acquisition of item opportunities. Two further

intervening cards are presented between item acquisition and problem resolution situations. Thus, participants encounter cards that are either (a) an initial problem presentation situation, (b) a problem resolution situation, (c) a distractor situation, (d) an opportunity to acquire a target item, or (e) a list of distractor items, as they move around the board. The purpose of including distractor situation cards, daily activities cards and distractor items throughout the game is to simulate problems related to episodic foresight that are typically encountered in everyday life, but which are commonly embedded among other ongoing activities.

The following is an example of an episodic foresight task to provide further understanding of the VW-Foresight game. Participants first encounter a situation in which a problem is required to be independently identified (e.g., “As you are rushing around to get ready for school you drop your glasses and one of the lenses breaks! You tell yourself that you will deal with it later because you can’t be late”). Problems such as this cannot be solved immediately so participants are asked to keep them in mind. At a later point during the game, participants are presented with an opportunity to acquire an item that would later allow the problem to be solved (e.g., acquire “your old pair of glasses”). The acquired item is ‘stored’ in *Your Stored Items* which is accessible via a button on the game board and on every *Situation Card*. Participants continue moving around the board until a different *Situation Card* is presented where a situation related to the same problem arises but is still unresolved (e.g., “After a long day, you look for a comfy spot to sit to watch your movie. You turn on your movie and realise it looks blurry!”). At this point, participants should retrieve and use the appropriate item (i.e., “your old pair of glasses”) from *Your Stored Items* to solve the problem (see Appendix A).

4.3.2.2 *Development of VW-Foresight 2-day version*

The first version of the children's VW-Foresight task adapted from the adult version consisted of ten episodic foresight tasks which were presented across three virtual days (Monday to Wednesday). However, a pilot study involving six healthy children indicated that the three-day version was extremely time consuming and led to a decline in motivation towards the end of the game. Therefore, it was decided that the game should be reduced to two virtual days. To develop the two-day version, all *Situation Cards* and *Daily Activities Cards* for the ten episodic foresight tasks were carefully assessed. It appeared that Monday had the least episodic foresight tasks to be solved, so Monday was removed from the game. Consequently, two episodic foresight tasks that were presented on Monday were omitted. Additionally, there were two foresight-related problems that were presented on Monday but items were not acquired and used until Tuesday. In order to retain as many episodic foresight tasks as possible, only one of these tasks was omitted. The *Daily Activities Card* to acquire the item to solve the problem for this omitted task was replaced with a distractor card on Tuesday. The *Situation Card* to use the item for this task on Tuesday was also replaced with the presentation of the other problem that had previously been presented on Monday. Tuesday and Wednesday in the three-day version were subsequently relabelled as Monday and Tuesday, respectively, in the two-day version (see Table 4.2. for summary changes). In sum, the two-day version consists of a total of seven episodic foresight tasks. There are 20 *Situation Cards*, 14 of which are related to episodic foresight tasks (i.e., seven *Situation Cards* present episodic foresight problems and seven *Situation Cards* provide the context in which these problems are solved). The remaining six *Situation Cards* are distractor situations.

Table 4.2.

Children Virtual Week-Foresight Summary Changes from Three-Day to Two-Day Version

Three-Day Version	Two-Day Version
Monday	Monday removed
<i>Scenario 1</i>	
Problem presented	
Item acquired	<i>Scenario 1</i> omitted
Item used	
<i>Scenario 2</i>	
Problem presented	
Item acquired	<i>Scenario 2</i> omitted
Item used	
<i>Scenario 3</i>	
Problem presented	<i>Scenario 3</i> omitted
<i>Scenario 4</i>	
Problem presented	<i>Scenario 4</i> moved to the following day
Tuesday	Relabelled as Monday
<i>Scenario 3</i>	<i>Scenario 3</i> omitted
Item acquired	<i>Daily Activities Card</i> to acquire item replaced with a distractor card
Item used	<i>Situation Card</i> to solve the problem was replaced by presenting the problem in Scenario 4
<i>Scenario 4*</i>	
Item acquired	No changes required
Item used	No changes required
Wednesday	Relabelled as Tuesday
<i>Scenarios 5 to 10*</i>	No changes required

*Scenarios 4 to 10 were presented throughout Monday and Tuesday on the two-day version which was moved from Tuesday and Wednesday, respectively, on the three-day version.

4.3.2.3 Administration of VW-Foresight

Participants are first taken through a Trial Day during which instructions on how to play the game are explained. When participants complete the Trial Day, they are then asked to complete the testing days. It is ensured that all participants understand the instructions of the game before proceeding to the test conditions because no further prompts are given after Trial Day. Two outcome measures are produced at the end of the game, namely *the number of correct items acquired* and *the number of correct items used*. The *number of correct items acquired* assesses the ability to secure future benefits in the present (i.e., obtain an appropriate item), whereas the *number of correct items used* assesses the ability to apply items to resolve a problem at the appropriate future time point. These two measures together assess the capacity to flexibly exercise episodic foresight in an everyday life context. All participants in Study 2 were tested on the two-day version of the children VW-Foresight.

4.3.3 Prospective memory

The Virtual Week (hereafter referred to as VW-PM; Rendell & Craik, 2000) is a computerised board game that has a similar interface to the VW-Foresight but involves different activities and places different cognitive demands on participants (see Figure 4.4. for the VW-PM game interface). On the VW-PM, participants roll a die and move a token around the board. Each circuit of the board represents a virtual day with the time of the virtual day displayed in the centre of the board. Fifteen virtual minutes go by for every two squares moved. Participants are prompted to pick up an *Event Card* each time they land on or pass an 'E' square. Each virtual day consists of ten *Event Cards* and each event card presents a different activity that relates to the point in the day when the card appears (e.g.,

an *Event Card* presented at the start of the day reads ‘This morning at school you sit next to your friend. You are both...’). Participants then choose from three options on these event cards (e.g., participating in the lesson actively, drawing a picture while listening, chatting a lot). In addition, participants carry out PM tasks that are embedded in the ongoing activity of rolling the die, moving the token, reading event cards, and making decisions in each event card.

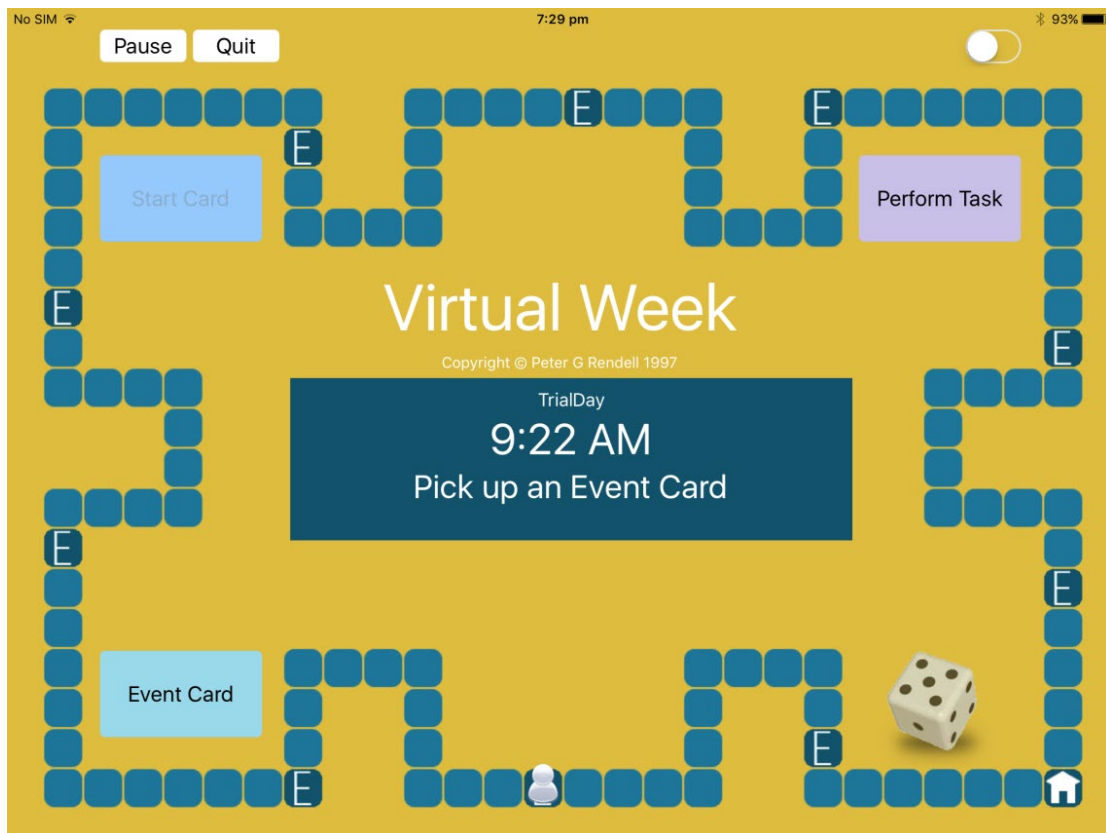


Figure 4.4. Children Virtual Week-Prospective Memory iPad version game interface

Participants encounter two types of PM tasks throughout the game: event-based and time-based tasks. Each virtual day has four event-based and four time-based PM tasks that

participants are asked to complete. Event-based tasks are required to be performed when the appropriate *Event Card* (e.g., buy some pencils at the event card of “Go Shopping”) is encountered, whereas time-based tasks are to be performed when the appropriate time is shown in the middle of the board (e.g., help set up the school hall when the virtual clock shows 10:30 a.m.). Four of the PM tasks (two event-based and two time-based) are the same each day and are expected to be carried out every day in the game. These tasks are presented on task cards with verbal and visual instructions provided once at the end of the Trial Day (i.e., a practice day around the board to familiarise participants with the features of the game board). The two event-based tasks involve taking antibiotics at breakfast and at dinner, and the two time-based tasks are to take an asthma inhaler at 11 a.m. and 9 p.m. Participants are asked to read these tasks out aloud twice, and then repeat them once while looking away from the iPad to ensure that the tasks are learned before proceeding to the first testing day. Two other PM tasks (one event-based and one time-based) are presented on *Start Cards* which are picked up at the start of each virtual day. Two additional PM tasks (one event-based and one time-based) are presented later as participants move around the board during each virtual day. These latter four event-based and time-based task cards display written instructions that are required to be read aloud. When participants are required to carry out a PM task (either in response to an event on an *Event Card* or at a particular time on the virtual clock), they are asked to press a ‘Perform Task’ button and select the appropriate task to perform.

At the completion of each virtual day, participants are also presented with *Task Review Cards* to assess retrospective memory for PM task content. This requires each PM task completed on the day (e.g., buy some pencils) to be matched with the corresponding

PM cue (e.g., when shopping). Four distractor tasks are also included on the *Task Review Cards* and participants are expected to indicate that these actions are ‘not required’. Tasks are individually presented on the screen and are automatically swiped to the next task once participants have responded to each task. This recognition task provides an index of the retrospective memory component of the PM tasks (see Appendix B).

Furthermore, it should be noted that the 2-day version of the VW-PM was used in Study 3. This version differs from longer versions (e.g., 3-day and 7-day versions) used in past studies in that the longer versions allow further differentiation of event-based and time-based tasks into *irregular* event-based and time-based tasks, and *regular* event-based and time-based tasks. Irregular event-based and time-based tasks are different each day and simulate tasks that occasionally need to be performed in everyday life. By contrast, regular event-based and time-based tasks are the same each day and are carried out daily in the game. This repetition is argued to lead to stronger encoding of task content and reduces the demands on retrospective memory, making the regular tasks less cognitively taxing than the irregular tasks. However, given the 2-day version of the game restricts the opportunity for the regular tasks to be overlearned due to the limited exposure in this shorter version of the game, the regular versus irregular task distinction was not addressed in Study 3.

4.3.3.1 Administration of VW-PM

Similar to the VW-Foresight task, participants are first taken through a Trial Day where instructions to play the game are explained before the commencement of the testing days. When participants complete the Trial Day and indicate that they understand the procedures of the game, two virtual days are administered: Monday and Tuesday.

Participants' responses are calculated as a percentage of the total number of PM tasks correctly performed, separately for event-based and time-based PM tasks.

4.3.3.2 *Development of VW-PM iPad version*

The VW-PM game was originally developed and administered on a computer. However, as all of the participants in Study 3 had previously completed the VW-Foresight task for Study 2, which was administered on a computer, an iPad version of the VW-PM was developed for Study 3 to reduce any possible practice effects. The iPad app was developed using HockeyApp and CloudKit Dashboard with the assistance of a computer programmer. In addition, any overlaps in content with the VW-Foresight measure were examined and addressed. Specifically, all birthday-related themes in the VW-PM were removed to avoid confusion with the storyline in the VW-Foresight (e.g., changed “send out invitations for your birthday party” to “send out invitations for your Halloween party”). Any images that were used in both VW-Foresight and VW-PM were also replaced with new images in the VW-PM. The VW-PM was also streamlined by reducing the amount of written instructions presented throughout the game and more explicitly flagging the time of day to avoid potential misunderstanding, especially in younger participants (e.g., changing “at 10:30 a.m. help set up the school hall” to “*in the morning* at 10:30 a.m. help set up the school hall”). The adaptations from the VW-PM computer version to the iPad version were relatively minor, and there were no major content changes. All participants in Study 3 completed the VW-PM on an iPad.

The children's version of the VW-PM has been employed with children with ASD and typically developing children in past studies (Henry et al., 2014; Terrett et al., 2019).

Reliability of the measure has been demonstrated to be relatively good in typically developing children and moderate in children with ASD, with Cronbach's alpha ranging from .78 to .84 and .57 to .58, respectively for the 3-day version (Henry et al., 2014).

4.4 Procedure

Parents of children with ASD or healthy controls who expressed interest in the study were contacted via phone or email and an interview was conducted to determine their child's eligibility to participate. A number of screening questions were asked, including the child's date of birth, diagnosis of ASD, and the presence of other mental health disorders or neurological disorders. A mutually convenient time and location for the first testing session was then arranged with eligible participants.

During the first testing session, written consent and written assent were obtained from all parents and child participants prior to the commencement of testing. Parents were then asked to complete three questionnaires while their child completed the first testing session. For both sessions, all child participants were tested individually in a room free of distractions. The first session took approximately 2 to 2.5 hours to complete while the second session took around 1 to 1.5 hours to complete, with regular small breaks incorporated between tasks in both sessions to reduce fatigue. The order of task administration for all participants in each session is outlined in Figure 4.5. However, participants who had completed a cognitive assessment in the past two years were exempt from completing the WASI-II in the first session as their previous assessment scores were still valid and were therefore used. As such, an alternative testing protocol was followed for these participants (see Figure 4.5.). The same number of participants in each group was

exposed to the alternative protocol. All participants were rewarded with a certificate of participation and reimbursed with one adult and one child movie voucher at the end of the second session. Collected data used for all studies in the current thesis were de-identified.

4.5 General Statistical Analyses

To ensure that all analyses in each study were sufficiently powered, G*Power 3.1.9.4 was used to calculate the minimum sample sizes required (see Table 4.3.). An alpha level of .05, power of .80 and effect sizes obtained from past studies with similar research designs were used in these calculations (Field, 2018; Tabachnick & Fidell, 2013). Overall, the sample sizes included in Studies 1, 2 and 3 were larger than the calculated sample sizes to perform analysis of variance (ANOVA) and thus the analyses would be sufficiently powered. By contrast, the included sample sizes in Studies 2 and 3 were smaller than the required sample sizes to run correlations and multiple regressions and therefore may lack statistical power to detect significance. However, given that Studies 2 and 3 were the first to investigate a range of cognitive contributors to episodic foresight and PM, obtained results will be considered exploratory in the current thesis. In addition, data collected in each study were cleaned prior to data analyses, and appropriate steps were taken to address outliers and violations of assumptions. Analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 25 for Windows (IBM Corp). Specific data screening and analyses are described within the method section of each empirical paper in Chapters 5, 6 and 7.

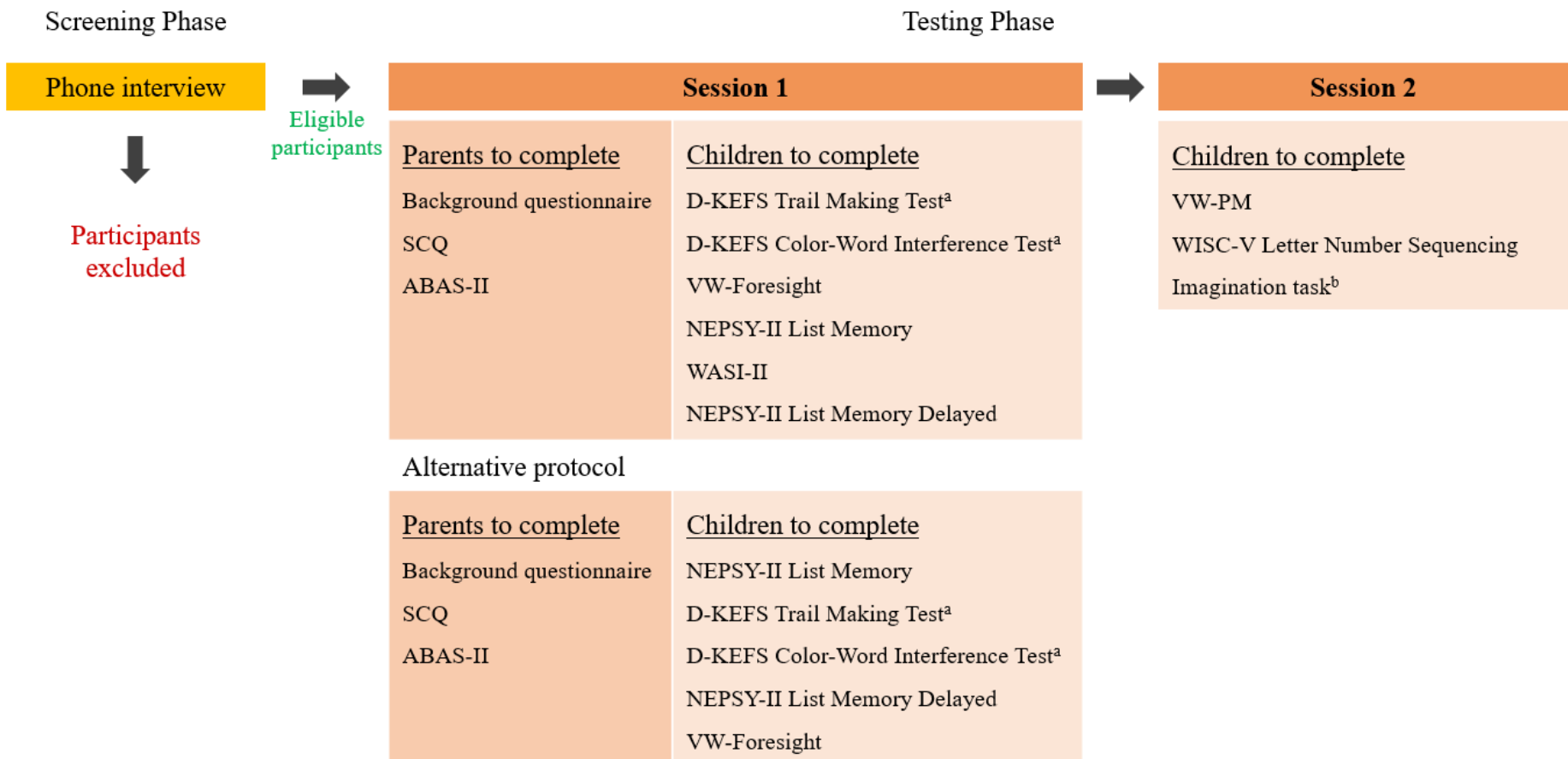


Figure 4.5. Procedure for the screening and testing phases

^aTasks were counterbalanced in each group to avoid order effects

^b18 participants with autism spectrum disorder (ASD) and 18 healthy controls were administered the imagination task to be included as part of the sample in Study 1

Table 4.3.

*Calculated Sample Sizes Required for Studies 1, 2 and 3 Using G*Power*

	Types of Analysis	Expected Effect Sizes	Required Sample Sizes	Included Sample Sizes
Study 1	ANOVA	Large effect (Terrett et al., 2013)	$N = 16$ ($n = 8$ in each group)	ASD ($n = 37$) Control ($n = 60$)
Study 2	ANOVA	Large effect (Terrett et al., 2013) Medium effect (Ferretti et al., 2018) Medium effect (Marini et al., 2019)	$N = 14$ ($n = 8$ in each group) $N = 60$ ($n = 30$ in each group) $N = 78$ ($n = 39$ in each group)	
	Correlation	Large effect for ASDs Medium to large effect for Controls (Terrett et al., 2013)	ASD $n = 25$ Control $n = 11$ to $n = 46$	ASD ($n = 40$) Control ($n = 55$)
	Multiple Regression	-	$n = 50$ in each group (Hair, Black, Babin, & Anderson, 2014) $n = 109$ in each group (Tabachnick & Fidell, 2013)	
Study 3	ANOVA	Medium effect (Henry et al., 2014)	$N = 48$ (24 in each group)	
	Correlation	Small effect for ASDs (Henry et al., 2014) Small to medium effect for Controls (Henry et al., 2014; Yi et al., 2014)	ASD $n = 159$ Control $n = 79$ to $n = 239$	ASD ($n = 32$) Controls ($n = 42$)

Note. ANOVA = Analysis of Variance, ASD = Autism Spectrum Disorder

Chapter 5: Deconstructing the Nature of Episodic Future Thinking Deficits in Children with Autism Spectrum Disorder: The Roles of Scene Construction and Self-Projection

Preamble

As reviewed in Chapter 2, several past studies have shown that episodic future thinking (i.e., the ability to mentally pre-experience hypothetical future events) is impaired in children with ASD. However, the underlying mechanisms that might be driving these deficits remain largely unknown. The current study aimed to shed light on why this form of prospection might be impaired in this clinical group, specifically by investigating the contributions of scene construction and self-projection through time. A task that is based on Hassabis, Kumaran, Vaan, et al. (2007) paradigm was employed to systematically disentangle these underlying processes in episodic future thinking.

5.1 Introduction

ASD is a lifelong neurodevelopmental disorder characterised by impairments in social and communication skills and the presence of repetitive and restricted repertoires of behaviour (American Psychiatric Association, 2013). While large research efforts have primarily been focused towards understanding factors that contribute to the social and communication deficits observed (Oberman & Ramachandran, 2007; Zalla & Korman, 2018), much less is known about what might explain the inflexible behaviours commonly seen in this clinical population. It has recently been suggested that these behaviours may relate to a compromised ability to mentally pre-experience hypothetical future events, known as episodic future thinking (Atance & O'Neill, 2001; Lind & Bowler, 2010; Terrett et al., 2013). Episodic future thinking is thought to have considerable adaptive value as it allows one to imagine and evaluate plausible future scenarios without actually engaging in the behaviours. This ability is argued to lead to increased behavioural flexibility and promote functional independence in everyday living (Henry et al., 2016; Suddendorf et al., 2009). Indeed, several clinical groups who display poor functional skills have been found to have difficulty imagining themselves experiencing future situations, including individuals with generalised anxiety disorder (Wu, Szpunar, Godovich, Schacter, & Hofmann, 2015) and long-term opiate users (Mercuri et al., 2015).

In the context of ASD, evidence now shows that deficits in episodic future thinking are apparent in both children (e.g., Ciaramelli et al., 2018; Terrett et al., 2013) and adults (e.g., Lind & Bowler, 2010) with this disorder. What is currently unclear, however, are the mechanisms underpinning this impairment. Given the potential value for this type of research to inform early intervention programs, the aim of the current study was therefore

to investigate the underlying basis of episodic future thinking deficits in children with ASD.

Episodic future thinking is a complex cognitive capacity that has been argued to involve a range of underlying processes (D'Argembeau et al., 2010; Schacter & Addis, 2007; Suddendorf & Corballis, 2007; Suddendorf & Redshaw, 2013). For example, it has been proposed that scene construction – the ability to mentally generate and bind multiple elements to create coherent scenes – is a basic necessary process that underpins episodic future thinking (Hassabis & Maguire, 2007). This proposal appears to somewhat overlap with the prominent constructive episodic simulation hypothesis, which argues that episodic future thinking is a constructive process whereby schematic, episodic and semantic information is retrieved and used to create novel hypothetical future scenarios in our imaginations (Addis, 2018). Episodic future thinking has also been argued to require the ability to mentally travel forward in time and “pre-live” an event that is anticipated to happen in one’s future (Suddendorf & Corballis, 2007; Tulving, 2002). Given this, it has also been suggested that episodic future thinking involves self-projection, which refers to the ability to shift the self from an immediate environment to an alternative perspective, such as a different mental or spatial perspective (Buckner & Carroll, 2007). This general ability to shift perspectives has been suggested to underpin various cognitive abilities including theory of mind and spatial navigation. In the case of episodic future thinking, self-projection has been argued to specifically involve adopting a different temporal (i.e., future) perspective which in turn enables pre-experiences of hypothetical future scenarios through subjective time (Buckner & Carroll, 2007; Suddendorf & Corballis, 2007; Tulving, 2002).

Given that both scene construction and self-projection *through time* have been suggested to play key roles in episodic future thinking, disruptions in either process could lead to a breakdown in this capacity. In relation to potential disruptions in scene construction ability, individuals with ASD may be vulnerable to such an impairment for a variety of reasons. For example, difficulties in scene construction may stem from a diminished capacity for relational binding, with several studies showing that individuals with ASD tend to focus on individual elements of an experience while struggling to identify and combine relevant features among these elements to form coherent episodes (Bowler et al., 2014; Bowler et al., 2011; Gaigg, Gardiner, & Bowler, 2008). Moreover, the hippocampus is argued to be the part of the brain that plays a vital role in supporting processes of binding separate elements within a coherent spatial context (Hassabis, Kumaran, Vaan, et al., 2007; Maguire et al., 2016). Individuals with ASD have often been found to show hippocampal abnormalities which may limit their ability to bind and construct mental experiences as required in scene construction (Nicolson et al., 2006; Sussman et al., 2015).

In terms of possible difficulties with self-projection through time, this may be linked to reduced self-awareness through time which had been reported among individuals with ASD (see Lind, 2010; Lind & Bowler, 2008 for comprehensive reviews). If these individuals lack self-awareness through time, then the process of projecting oneself into an imagined future scenario is likely to be disrupted given that awareness of the continuous existence of the self in subjective time has been argued to be one of the hallmarks of mental time travel into the future (Szpunar, 2010; Tulving, 1985).

Presently, the extent to which ASD-related impairments in episodic future thinking reflect difficulties in scene construction or self-projection through time (or both) is currently unclear, with limited empirical investigations undertaken, especially in children with the disorder. To date, only two studies have addressed this question in children with ASD. In the first, Marini et al. (2016) compared 6- to 11-year-old children with ASD and healthy controls on two types of tasks. The first were self-based tasks which required the projection of the self into hypothetical future situations (e.g., choosing whether to first put on the head or the body of a two-piece ant costume). The second were mechanical-based tasks which involved the prediction of mechanical outcomes (e.g., choosing between a slotted spoon and a small box without a lid to successfully transfer tapioca beads). The authors argued that the self-based tasks drew on self-projection into the future whereas the mechanical-based tasks relied on scene construction. Their findings showed that children with ASD performed worse than controls on both the self-based and mechanical-based tasks. In addition, the authors found that children with ASD performed significantly worse on the self-based tasks than on the mechanical-based tasks. Overall, it was concluded that episodic future thinking impairments in ASD appear to reflect underlying difficulties in both scene construction and self-projection into the future, but that self-projection into the future is more severely compromised in this clinical group.

The second study by Ciaramelli et al. (2018) yielded findings that only partially supported the conclusions in Marini et al.'s (2016) study. In this study, Ciaramelli et al. (2018) compared children and adolescents with ASD aged 7 to 15 years with healthy controls and concluded that diminished capacity for scene construction, but not self-projection, appeared to underpin episodic future thinking impairments in this clinical

group. This conclusion was based on two findings of that study. The first was that, relative to controls, children with ASD showed significantly more difficulty generating specific episodic details about their imagined future scenarios compared to their ability to provide general details about these scenarios (which was similar to controls). This suggests a selective impairment in the process of generating and combining elements into a complex future experience (i.e., scene construction; Ciaramelli et al., 2018). The second was that individuals with ASD revealed not only impairments in imagining future events that were self-relevant, but also difficulties in imagining the future from another person's perspective. On the basis of these data, it was therefore argued that impairments in episodic future thinking were less likely attributable to difficulties in the projection of the *self* into the future, but more due to the compromised constructive processes of generating and combining details into coherent future experiences (Ciaramelli et al., 2018). This conclusion is also in line with a study of adults with ASD that concluded that scene construction difficulties rather than reduced ability to project the self through time was the major contributor to impairments in episodic future thinking. (Lind, Williams, et al., 2014). Given the discrepancy in these two studies, further work is required to establish the extent to which scene construction and self-projection difficulties contribute to episodic future thinking impairments in children with ASD.

In order to better understand the basis of these deficits in children with ASD, a useful approach would be to systematically vary demands of scene construction and self-projection to disentangle the contribution of these two processes to episodic future thinking. This approach was taken in the current study by using an imagination task previously employed by Mercuri et al. (2016) in which participants are asked to imagine themselves in

various situations and give a detailed description of those imagined experiences. This task was developed based on Hassabis et al.'s (2007) paradigm and comprises three conditions (i.e., narrative, atemporal and future) which differ in their scene construction and self-projection demands. More specifically, all three conditions require scene construction although this is substantially reduced in the narrative condition because a story structure to set the scene is provided. The demands on self-projection are also differentiated for each condition in the task. The atemporal and narrative conditions place similar demands on self-projection as in both cases participants must adopt alternative perspectives in order to construct hypothetical scenarios that are removed from the immediate environment. However, while the future condition also requires adopting an alternative perspective, it has an additional temporal element whereby participants must describe experiencing an event *in the future*. It is therefore the only condition that requires self-projection *through time*. Since the demands on scene construction and self-projection are systematically differentiated on this imagination task, the pattern of performance across all three conditions allows investigation of the underlying processes that might be compromised in ASD.

As noted, the aim of the current study was to establish the extent to which scene construction and self-projection through time underpin episodic future thinking deficits in children with ASD. In terms of hypotheses, should scene construction deficits primarily contribute to episodic future thinking impairments, performance of children with ASD would be expected to be equally compromised on the atemporal and future conditions (which have similar scene construction demands) relative to the narrative condition (which has lower scene construction demands). This would be consistent with the suggestion that

hippocampal abnormalities previously reported in individuals with ASD could be contributing to problems in relational binding (Bowler et al. 2011; Sussman et al., 2015). However, should deficits in self-projection through time primarily contribute to episodic future thinking impairments, performance of children with ASD would be expected to be poorer on the future condition relative to the other conditions. As noted, this is the only condition which requires the projection of the self through time, while both the atemporal and narrative conditions require general self-projection, but not into the future. Such a pattern of performance would potentially reflect difficulties with self-awareness through time among individuals with ASD as previously highlighted in the literature (Lind, 2010; Lind & Bowler, 2008). Finally, should deficits in both scene construction and self-projection through time contribute to episodic future thinking impairments, the performance of children with ASD would be poorer on the atemporal and future conditions compared to the narrative condition as the former two conditions have similarly higher scene construction demands than the narrative condition. However, the future condition would be further impaired than the atemporal condition because only the future condition requires projecting the self into a future time period.

5.2 Method

5.2.1 Participants

Thirty-seven children with ASD (68% males) and 60 healthy controls (50% males) aged 8 to 12 years participated in the current study. The two groups did not differ with respect to the proportion of males and females, $\chi^2(1, N = 97) = 2.88, p = .09$, and there were also no significant group differences in age or intellectual functioning (see Table 5.1.

for background characteristics). Clinical reports by paediatricians or psychologists were provided by parents of children with ASD confirming their diagnosis based on the DSM-IV-TR (American Psychiatric Association, 2000) or DSM-5 (American Psychiatric Association, 2013). Consistent with these diagnoses, participants with ASD scored significantly higher than the controls on the Social Communication Questionnaire (SCQ; Rutter et al., 2008). The SCQ is a 40-item parent-report questionnaire that assesses children’s social and communication skills across their developmental history. Higher scores on the SCQ indicate poorer social and communication skills, which are the core areas of impairment commonly observed in individuals with ASD (American Psychiatric Association, 2013).

Table 5.1.

Background Characteristics of Participants in the ASD and Control Groups

	ASD group <i>n</i> = 37		Control group <i>n</i> = 60		<i>t</i> (95) ^a	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Age (in years)	9.78	1.37	10.20	1.35	1.48	0.31
Intelligence						
FSIQ	109.32	13.09	111.48	11.25	0.86	0.18
VCI	107.97	13.94	110.70	10.38	1.10	0.22
PRI	109.78	15.81	109.53	12.92	0.09	0.02
SCQ						
Total Score	12.00	5.10	2.95	2.86	9.87*	2.19

Note. **p* < .001; *d* = Cohen’s index of effect size; Cohen (1988) defines effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large

^aAll *ns* = 37 for ASD and *ns* = 60 for controls, except SCQ *n* = 59 for controls.

Homogeneity of variance was violated therefore *df* = 50.34 for SCQ.

ASD = Autism Spectrum Disorder, FSIQ = Full Scale IQ, VCI = Verbal Comprehension Index, PRI = Perceptual Reasoning Index, SCQ = Social Communication Questionnaire

5.2.2 Materials

5.2.2.1 *Imagination task*

The imagination task used in the current study was previously used in Mercuri et al.'s (2016) study. The measure is an adaptation of the Adapted Autobiographical Interview (AI; Addis et al., 2008), which is a semi-structured interview that assesses the number of episodic and non-episodic details generated by participants when describing past and future events. As the main variable of interest in the current study was episodic future thinking, only the future condition was used. The future condition requires participants to imagine and describe a plausible self-relevant event that might happen in their next summer holiday. Two other conditions, namely narrative and atemporal, were added to the AI. The narrative condition requires participants to describe their experience of climbing to a tower in a medieval castle. The atemporal condition involves participants mentally creating a novel, fictitious scene in a familiar context, specifically imagining having a drink in a café (see Table 5.2. for verbal cues). These latter two conditions were derived from a task originally developed by Hassabis, Kumaran, Vaan, et al. (2007).

As previously mentioned, demands for scene construction and self-projection vary in each condition on this imagination task, therefore allowing the processes that may underlie episodic future thinking impairments to be disentangled. More specifically, the narrative condition places lower demands on scene construction relative to the atemporal and future conditions. This is because a story structure is provided in the former condition, but new scenes need to be generated in the latter two conditions. In addition, the future condition imposes the highest demands on self-projection as it additionally involves a

temporal element, although it relies on scene construction to a similar extent as the atemporal condition.

Table 5.2.

Verbal Cues Provided in Each Condition on the Imagination Task

Conditions	Verbal Cues
Narrative	<i>Imagine you are standing in the middle of an entrance hall of a large medieval castle. There is tower somewhere in the castle and the top of the tower can be reached by climbing up a tall winding staircase. I want you to describe to me in as much detail as possible your way through the castle’s many rooms and floors until you reach the top of the tower. Use all of your senses including what you see, feel, and do on the way to the tower.</i>
Atemporal	<i>Imagine you are sitting having a drink in a café. I want you to describe the experience and the surroundings in as much detail as possible using all your senses including what you can see, hear, and feel.</i>
Future	<i>Imagine something you will be doing on your next summer holidays, but just give me one event. I want you to describe that event and the surroundings in as much detail as possible using all your senses including what you can see, hear, and feel.</i>

5.2.2.2 Intellectual functioning

The Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II; Wechsler, 2011) was used to estimate participants’ intellectual functioning. The WASI-II consists of four subtests: Block Design, Vocabulary, Matrix Reasoning and Similarities. Scores on these four subtests are combined to form a Full-Scale IQ score. In addition, the combination of scores on Vocabulary and Similarities subtests form the Verbal Comprehension Index score, and scores on Block Design and Matrix Reasoning subtests

form the Perceptual Reasoning Index score. Higher scores indicate higher levels of intellectual functioning. The WASI-II shows good concurrent validity, and has internal consistency ranging from .92 to .96, and test-retest reliability ranging from .79 to .95 in children aged 6 to 16 years (Wechsler, 2011).

5.2.3 Testing session

All participants were tested individually in a room free of distraction. Standardised procedures were followed as outlined in the manual for the WASI-II. On the imagination task, participants were asked to imagine and describe each scenario in as much detail as possible using all their senses including what they can see, hear, smell, and feel.

Participants were specifically instructed to create new scenes in their minds and not just describe a past event. Prompts were given when participants' responses were short and vague (e.g., "I see people") to elicit more detailed descriptions of their imagined scenes. The experimenter was only allowed to provide the task's prescribed set of prompts where appropriate and was strictly prohibited from introducing any concept, idea, detail, or entity that participants had not already mentioned (e.g., "What do the people look/sound/smell like?"). The number of prompts provided to each participant slightly varied (i.e., from one to four prompts per participant), but all participants in both groups were given an approximately equal amount of time to describe each scenario (i.e., two to three minutes per scenario). An example of a scenario was first given to the participants with a sample response to ensure that participants understood the instructions of the task. Responses were audio recorded for later scoring and all conditions were counterbalanced across all participants. Parents were asked to complete the SCQ during the session while their child was being tested. Written consent was obtained from all parents and child participants prior

to the commencement of testing. The research was conducted with the approval of the human research ethics committee of Australian Catholic University (No. V201012; “Prospective memory and episodic future thinking in middle childhood”).

5.2.4 Scoring

Standardised scoring procedures for the imagination task were followed as outlined in the training manuals provided by Donna Rose Addis. For each transcribed scenario description, a central event was first identified and then details were segmented and categorised as either internal (episodic details specific to the central event) or external (semantic information, repetitions, errors, and information not specific to the central event). The number of internal details generated in each condition provided an index of the extent to which participants were personally experiencing the scenario in their imagination.

Two independent scorers who were blinded to the aims of the study and group membership scored all transcripts. Both scorers completed training procedures where they were required to segment 20 training events into internal and external details. Inter-rater reliability between each scorer and the scoring of these events provided in the training manuals were examined using a two-way mixed-design analysis of variance (ANOVA) intraclass correlation analysis. The Cronbach alphas obtained for the scorers and those in the manual were .99 for internal details and .94 for external details.

5.2.5 Data analyses

All statistical tests were two-tailed. An alpha level of $p < .05$ was considered significant in all analyses. Three cases were identified as univariate outliers, with z -scores of more than 3.29 (Tabachnick & Fidell, 2013), These outliers were rectified by changing

the scores to the next highest score plus one (Field, 2013). There were no significant deviations from normality for any variables. Greenhouse-Geisser correction was applied in analyses where the assumption of sphericity was violated.

5.3 Results

A mixed $2 \times 3 \times 2$ ANOVA was conducted comparing the ASD and control groups on the number of internal and external details generated across the three conditions. The between-groups variable was *group* (ASD, control), and the within-groups variables were *condition* (narrative, atemporal, future) and *type of details* (internal, external). The number of details generated for narrative, atemporal and future conditions is displayed in Figure 5.1. as a function of group, condition and type of details. Results revealed significant main effects of group, $F(1, 95) = 13.58, p < .001, \eta_p^2 = 0.13$, condition, $F(1.80, 171.24) = 44.08, p < .001, \eta_p^2 = 0.32$, and type of details, $F(1, 95) = 463.93, p < .001, \eta_p^2 = 0.83$. All two-way interactions were found to be significant: group and condition, $F(2, 190) = 3.95, p = .02, \eta_p^2 = 0.04$, group and type of details, $F(1, 95) = 23.16, p < .001, \eta_p^2 = 0.20$, and condition and type of details, $F(1.72, 163.15) = 51.82, p < .001, \eta_p^2 = 0.35$. There was also a significant three-way interaction, $F(2, 190) = 5.18, p = .006, \eta_p^2 = 0.05$. This three-way interaction was further investigated with two mixed-model 2 (group status: ASD, control) \times 3 (condition: narrative, atemporal, future) ANOVAs conducted separately for internal and external details.

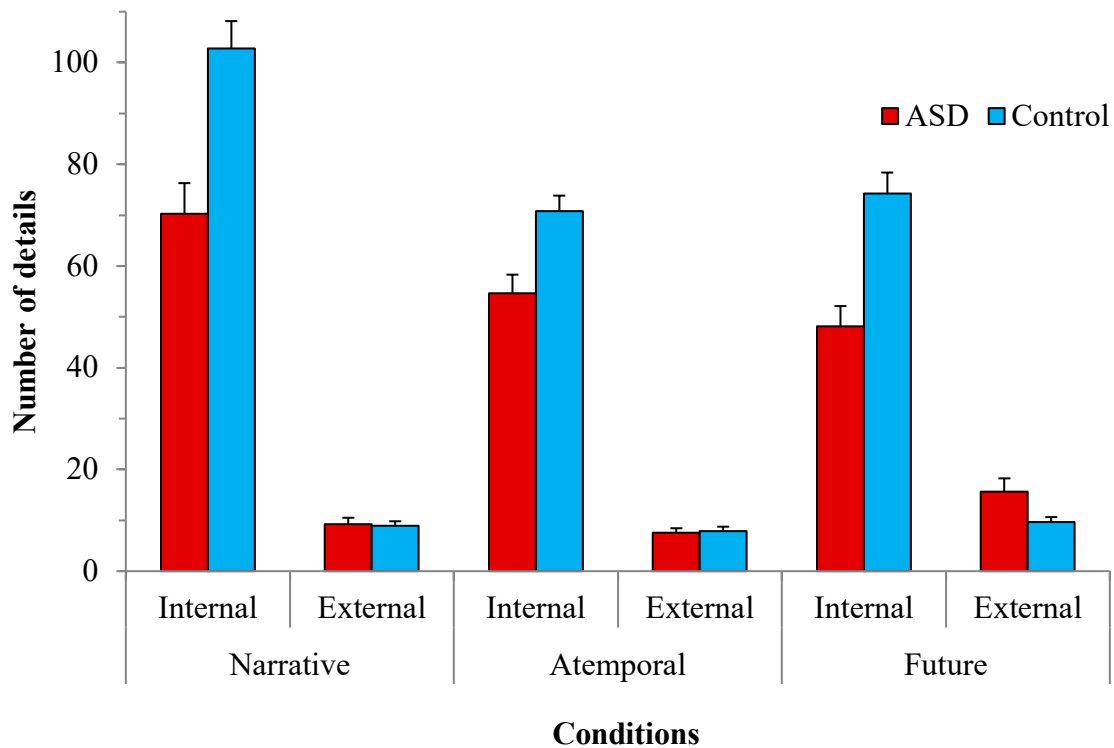


Figure 5.1. Mean number of internal and external details generated on the imagination task as a function of group (ASD, $n = 37$; control, $n = 60$) and condition. Error bars represent mean standard error.

5.3.1 Analysis of the number of internal details

Of primary interest for the research questions addressed in the current study were the follow-up analyses regarding internal details. The results showed significant main effects of group, $F(1, 95) = 18.62, p < .001, \eta_p^2 = 0.16$, and condition, $F(1.70, 161.48) = 54.28, p < .001, \eta_p^2 = 0.36$. More importantly, the two-way interaction of group and condition was found to be significant, $F(2, 190) = 4.53, p = .01, \eta_p^2 = 0.05$. This interaction was analysed with tests of simple effects that revealed a simple effect of group for the

narrative condition, $F(1, 95) = 15.31, p < .001, \eta_p^2 = 0.14$, the atemporal condition, $F(1, 95) = 11.09, p = .001, \eta_p^2 = 0.11$, and the future condition, $F(1, 95) = 18.22, p < .001, \eta_p^2 = 0.16$, with the ASD participants providing less internal details than healthy controls in all conditions (see Figure 5.1.). Further analysis of the interaction revealed a simple effect of condition within the control group, $F(2, 94) = 39.58, p < .001, \eta_p^2 = .46$, and within the ASD group, $F(2, 94) = 10.41, p < .001, \eta_p^2 = .18$. Post-hoc analyses showed that controls generated significantly less internal details in the atemporal and future conditions than the narrative condition, $d_s = 0.95$ (large) and 0.77 (medium), respectively. However, no difference in performance was found between the atemporal and future conditions in the control group. A similar pattern was found for the participants with ASD who also produced significantly less internal details in the atemporal and future conditions than the narrative condition, $d_s = 0.52$ (medium) and 0.72 (medium), respectively. Participants with ASD performed no differently in the atemporal and future conditions (see Table 5.3. for means and standard deviations).

5.3.2 Analysis of the number of external details

The analyses focused on the number of external details revealed there was no main effect of group, $F(1, 95) = 2.53, p = .12, \eta_p^2 = 0.03$. However, there was a significant main effect of condition, $F(1.53, 144.93) = 10.45, p < .001, \eta_p^2 = 0.10$, and a significant two-way interaction of group and condition, $F(2, 190) = 4.89, p = .008, \eta_p^2 = 0.05$. This interaction was analysed with tests of simple effects that revealed a simple effect of group for the future condition, $F(1, 95) = 6.30, p = .01, \eta_p^2 = 0.06$, but not for the narrative condition,

$F(1, 95) = .06, p = .82, \eta_p^2 = .001$, or the atemporal condition, $F(1, 95) = .06, p = .81, \eta_p^2 = .001$. Specifically, participants with ASD generated more external details than controls in the future condition. Further analysis of the interaction showed a simple effect of condition within the ASD group, $F(2, 94) = 9.40, p < .001, \eta_p^2 = .17$, but not within the control group, $F(2, 94) = 1.11, p = .33, \eta_p^2 = .02$. Post-hoc analyses revealed that participants with ASD provided significantly more external details in the future condition than the narrative and atemporal conditions, $ds = 0.52$ (medium) and 0.69 (medium), respectively. There was no difference in the number of external details produced in the narrative and atemporal conditions by the ASD group (see Table 5.3. for means and standard deviations).

Table 5.3.

Means and Standard Deviations in Each Condition for ASD and Control Groups

	ASD <i>n</i> = 37		Control <i>n</i> = 60	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Narrative				
Internals	70.30	36.45	102.78	41.59
Externals	9.24	7.65	8.88	7.19
Atemporal				
Internals	54.59	22.55	70.78	23.67
Externals	7.57	5.25	7.88	6.70
Future				
Internals	48.11	24.37	74.25	31.93
Externals	15.65	15.79	9.63	7.72

5.4 Discussion

As expected, children with ASD produced significantly fewer internal details than controls when imagining the future scenario, consistent with other literature showing that episodic future thinking is impaired in this clinical group (e.g., Ciaramelli et al., 2018; Terrett et al., 2013). Moreover, it was found that children with ASD provided significantly more external details than controls in the future condition, and more external details in this condition than in the narrative and atemporal conditions. This indicates that children with ASD found the task of imagining themselves experiencing a future event to be the most cognitively challenging of the three conditions, leading to the production of more non-relevant information.

However, of primary interest was the pattern of performance in the ASD group in relation to the number of internal details generated across the three conditions, given the main aim of the current study was to identify processes that might underlie deficits in episodic future thinking in children with ASD. In this regard, the findings showed that children with ASD generated a similar number of internal details in the atemporal and future conditions, which in both cases was less than for the narrative condition. Since the atemporal and future conditions have been argued to place similar demands on scene construction, but these demands are reduced in the narrative condition, these findings suggest that difficulties with scene construction may contribute to impairments in episodic future thinking in children with ASD. Further support for this possibility is provided by the finding that, compared to controls, children with ASD demonstrate a reduced capacity to describe themselves experiencing an atemporal scene, a condition which is argued to impose considerable demands on scene construction (Hassabis & Maguire, 2007, 2009).

Importantly, our findings that impaired scene construction ability may particularly contribute to episodic future thinking deficits in children with ASD is also consistent with Ciaramelli et al.'s (2018) study of children, and Lind et al.'s (2014) study of adults, with the disorder. Taken together, then, these findings suggest that difficulties mentally constructing scenes persistently disrupt episodic future thinking ability throughout development in individuals with ASD. Theoretically, such impairments in scene construction may reflect a reduced capacity for relational binding potentially stemming from hippocampal abnormalities which have previously been reported in individuals with the disorder (Bowler et al., 2014; Gaigg et al., 2008; Sussman et al., 2015). As such, it may be that these individuals experience difficulties with processing information in an integrative manner that is essential for the construction of coherent subjective experiences. Consequently, this may contribute to their impairments in pre-experiencing meaningful future episodes. This argument aligns with claims made in previous studies implicating relational binding deficits and hippocampal abnormalities in episodic memory impairments (i.e., difficulty re-experiencing personal past events; Bowler et al., 2011; Lind, 2010). Overall then it is possible that disruption in the processes of generating and combining separate elements as mediated by the hippocampus impairs the capacity for mental time travel in children with ASD. Further cognitive and neuroimaging studies are however needed to provide more empirical support for this claim.

Another key finding in the current study was that difficulties with self-projection *through time* did not appear to contribute to the deficits in episodic future thinking observed in children with ASD. This is indicated by the results which, as previously noted, revealed similarly decreased numbers of internal details produced in the atemporal and

future conditions compared to the narrative condition in the ASD group. Thus, it appears that the additional demand for self-projection through time in the future condition was not associated with any greater impairment than that shown in the atemporal condition which largely required scene construction and general self-projection ability. This conclusion is, again, in alignment with the findings of Ciaramelli et al. (2018) who showed that the ability to project the self through time did not appear to contribute to episodic future thinking deficits in children with ASD. The current findings are, however, not consistent with Marini et al. (2016) who found diminished performances on tasks that required self-projection into the future among children with ASD, as well as on tasks requiring scene construction.

One possible explanation for the discrepancy in these findings may relate to the different methodological approaches used across these studies. For example, unlike the current study (which asked children to verbally describe themselves mentally experiencing different scenarios), Marini et al. (2016) investigated scene construction and self-projection through time separately using two independent tasks that required participants to solve problems. Thus, it is possible that participants could to some extent have used problem-solving strategies that did not necessarily involve scene construction or self-projection through time. By contrast, Ciaramelli et al. (2018) utilised a verbal measure that was more similar to that used in the current study. However, it should be noted that the lack of an atemporal condition in Ciaramelli et al.'s (2018) study meant that demands for scene construction and self-projection through time were not systematically varied, consequently restricting the conclusions that can be made regarding the specific contributions of these processes to episodic future thinking in children with ASD from that study.

While difficulties with self-projection *through time* was not found to be a critical process impairing episodic future thinking in children with ASD in the current study, the findings however suggest that these impairments may be attributable, at least in part, to a general deficit in perspective shifting. This claim is based on the results showing that the clinical group had attenuated performance in the narrative condition, as well as the atemporal and future conditions, compared to controls. Given that the narrative condition imposes substantially reduced demands on scene construction but overlaps with the other two conditions in its requirement to adopt the perspective of the self in another spatial context, it appears that children with ASD may have a more generalised difficulty with self-projection that may also be contributing to their deficits in episodic future thinking. However, it is notable that this difficulty was more prominent when the self-projection demand involved a temporal element, as children with ASD performed similarly worse on the future condition, which required projection of the self into a future event, as the atemporal condition, which did not involve mental time travel.

5.4.1 Conclusions and future directions

While recent evidence has highlighted impairments in episodic future thinking in children with ASD, the underlying processes contributing to these deficits remain poorly delineated. This is the first empirical study to provide key insights into the mechanisms that underpin these impairments, implicating difficulties in scene construction and a general deficit in perspective shifting ability as contributors. One consideration for future studies is, however, the inclusion of a verbal description task to assess whether verbal ability might contribute to the group differences across all conditions on the imagination task. Nonetheless, these clinically significant findings raise the importance of developing

effective early interventions where specific compromised processes may be targeted to improve episodic future thinking and in turn potentially reduce behavioural inflexibility in children with ASD. For example, interventions that have been used to target impairments in episodic memory and/or relational binding may be extended to remediate episodic future thinking deficits in this group of children. In turn, this may assist in improving their adaptive skills for independent daily functioning.

Chapter 6: A Selective Impairment in Episodic Foresight in Children with Autism Spectrum Disorder

Preamble

Findings of Study 1 supported past studies that showed significant impairments in episodic future thinking in children with ASD and indicated that these impairments may be linked to difficulties in scene construction and general perspective shifting. This second study (Study 2) aimed to investigate whether children with ASD also show impairments in the adaptive application of episodic future thinking (i.e., episodic foresight). In other words, Study 2 endeavoured to explore whether the ability to take actions in the present in anticipation of future needs might be attenuated in this clinical group. In addition, Study 2 examined cognitive abilities that might contribute to any identified deficits in episodic foresight in children with ASD, as well as the relationship between episodic foresight and functional capacity in daily life in this clinical group. This is the first study to investigate episodic foresight using a novel behavioural measure that was recently adapted for school-aged children.

6.1 Introduction

ASD is a neurodevelopmental disorder that encompasses a broad spectrum of symptom severity and varying levels of intellectual functioning (American Psychiatric Association, 2013). Regardless of the severity of symptoms and level of intellectual functioning, significant impairments in daily living skills are often apparent in all children with the disorder (Chang, Yen, & Yang, 2013; Howlin, 2003). For example, children with ASD often struggle to complete homework on time, follow instructions or transition from one activity to another in the classroom (Jordan, 2011; Thomeer et al., 2019). These behavioural issues often place substantial burden on parents and teachers due to the increased need for support in these children's everyday functioning, and heightened stress in parents and teachers is frequently reported as a result (Bonis, 2016; Green & Carter, 2014). Given the increasing prevalence of ASD diagnoses (May, Sciberras, Brignell, & Williams, 2017; Özerk, 2016), identification of specific factors that might be contributing to difficulties coping with the demands of everyday life in children with the disorder becomes critically important, and may lead to the development of effective strategies to help parents and teachers better manage the challenges these children may face at home and at school.

One recent proposed contributor to the functional difficulties observed in children with ASD is a reduced capacity for episodic foresight. Episodic foresight involves the capacity to mentally simulate hypothetical future events and to use such future event simulations to guide behaviours in the present (Suddendorf & Moore, 2011). This capacity has been argued to have considerable adaptive significance in daily life (Baumeister et al., 2016; Suddendorf, 2017; Suddendorf & Corballis, 2007) because impairments in this

ability may limit the identification of, and preparation for, potential future obstacles, in turn reducing the chance of achieving optimal future outcomes. Thus, impaired episodic foresight may result in reduced behavioural flexibility and adaptability to various life circumstances, and limit independent functioning across different domains of daily living (Henry et al., 2016; Schacter et al., 2017; Suddendorf & Corballis, 1997), all of which are features commonly seen in children with ASD (Boulter, Freeston, South, & Rodgers, 2014; Thomeer et al., 2019).

There has been emerging evidence from studies using a range of measures that showed the capacity to imagine hypothetical future scenarios is impaired in children with ASD (Ferretti, Adornetti, et al., 2018; Hanson & Atance, 2014; Jackson & Atance, 2008; Marini et al., 2016, 2019). For example, past studies showed that children with the disorder were impaired in the ability to verbally provide rich episodic details about an imagined future scenario (Ciaramelli et al., 2018; Terrett et al., 2013), and showed a reduced capacity to generate specific and plausible future events (Lind, Bowler, et al., 2014). However, in these studies, participants were explicitly asked to imagine and construct events that might happen to them in a specified future time period and their verbal responses were analysed in terms of the quantity of episodic details produced (Ciaramelli et al., 2018; Terrett et al., 2013), or the level of specificity in the plausible future events generated (Lind, Bowler, et al., 2014). Whilst these previous studies showed that children with ASD were compromised in the capacity to pre-experience hypothetical future scenarios, the functional application of imagining the future was not assessed. Therefore, the nature and extent of impairment in the more applied capacity of episodic foresight remains unclear in this clinical group. This represents an important gap in the literature given that episodic foresight is likely to be

more closely tied to successful daily functioning than the capacity to simply imagine the self in a future scenario (Baumeister et al., 2016; Bulley et al., in press).

Suddendorf and colleagues have highlighted that it is challenging to capture behaviours that specifically reflect episodic foresight as not all future-directed actions necessarily reflect this capacity. Indeed, in some cases, future-directed actions may be the result of an innate predisposition, learned behaviour from previous experiences, or a behaviour that occurs coincidentally (Suddendorf & Busby, 2003, 2005; Suddendorf & Corballis, 2010). To exclude these possible alternative explanations for the occurrence of future-directed behaviours, Suddendorf and Corballis (2010) proposed four stringent criteria that should be met in behavioural measures that aim to capture episodic foresight. These criteria are (a) the use of single trials; (b) the use of novel problems; (c) the use of different temporal and/or spatial contexts within which the targeted future-directed action is demonstrated; and (d) the use of problems across different domains (Suddendorf & Corballis, 2010; Suddendorf et al., 2011). To date, there have been no studies of children with ASD that have investigated the capacity to imagine the future from this applied perspective using a behavioural measure developed according to the four criteria proposed by Suddendorf and Corballis (2010). There have however been a limited number of studies with other clinical groups that have utilised a measure based on those criteria. For example, in one recent study by Lyons et al. (2015), episodic foresight was examined in adults with schizophrenia using a behavioural measure called Virtual Week-Foresight (VW-Foresight). It is a computerised board game that includes a range of problems that need to be resolved through the application of episodic foresight. More specifically, problems are presented that need to be independently identified and resolved by accurately acquiring and later using

relevant items without overt prompts, thus resembling everyday life situations where episodic foresight is flexibly applied. Results of Lyons et al.'s (2015) study showed that adults with schizophrenia acquired and later used significantly less items than controls, which led the authors to conclude that the capacity for episodic foresight is impaired in this clinical group. Two subsequent studies also used the VW-Foresight paradigm in clinical populations and reported deficits in episodic foresight in opiate users (Terrett, Lyons, et al., 2016) and stroke patients (Lyons et al., 2019). The current study will be the first to test episodic foresight ability in children with ASD using the VW-Foresight measure.

The primary aim of the current study was to investigate whether impairments in episodic foresight might be apparent in children with ASD using a version of the VW-Foresight measure adapted for children. Given that episodic foresight encompasses the capacity to pre-experience future events, an ability that has consistently been found to be impaired in children with ASD, it was anticipated that impairments would extend to episodic foresight. Should such a deficit be identified, a key follow-up question to be addressed in the current study relates to what might underpin this deficit. While there is a lack of studies on episodic foresight, past studies that investigated the capacity of children with ASD to imagine themselves in future scenarios could provide some guidance as to which potential cognitive abilities might be involved in the functional application of imagining the future. In this regard, Hanson and Atance (2014) found that children with ASD who had poorer ability than controls to imagine themselves in future situations also showed poorer performances on a range of executive function tasks. It should be noted though that this study did not directly assess the relationships between these capacities. By contrast, Terrett et al. (2013) directly tested this relationship but failed to find executive

functioning (indexed by cognitive flexibility) to be a significant contributor to deficits in the ability to imagine and describe future events in children with ASD. However, they found that retrospective memory significantly contributed to the capacity to imagine future scenarios, supporting the suggestion that memories of past events provide the building blocks for the construction of future scenes in imagination (Schacter & Addis, 2007; Schacter et al., 2008). The authors thus concluded that retrospective memory, but not executive functions, may be an important contributor to the capacity to mentally simulate hypothetical future scenarios (Terrett et al., 2013). Episodic foresight might be considered more cognitively demanding than future event simulation alone, however, given that it arguably requires not only the imagination of the self experiencing the future, but also involves identifying future needs, taking steps in the present to ensure those future needs are met, remembering the nature of the preparatory steps, and actioning them at the appropriate future point. It could thus be suggested that executive functions and retrospective memory might be particularly implicated in episodic foresight (Terrett, Lyons, et al., 2016). Given that children with ASD have often been reported to show deficits in both of these abilities (Bowler et al., 2011; Craig et al., 2016), a secondary, exploratory aim in the current study was to investigate whether any impairment in episodic foresight identified in children with ASD might be contributed to by deficits in retrospective memory and/or executive functions. A final aim of the current study was to examine whether any difficulties in episodic foresight might be related to real-world outcomes in this clinical group.

6.2 Method

6.2.1 Participants

Forty children with ASD (75% males) and 55 healthy controls (56% males) aged 8 to 12 years participated in the present study. Independent-samples *t*-tests showed no significant differences between participants with ASD and controls on age, intellectual functioning and retrospective memory. Executive functioning and functional capacity were, however, found to be significantly poorer in participants with ASD than controls (see Table 6.1.). In addition, the ASD and control groups also did not differ in the proportion of males and females, $\chi^2(1, N = 95) = 3.50, p = .06$. Clinical reports from psychologists or paediatricians were provided by parents of participants with ASD to confirm their diagnosis. The Social Communication Questionnaire (SCQ; Rutter et al., 2008) was used to further support the diagnosis of ASD for participants in the clinical group, and to screen for possible symptoms of ASD in healthy controls. The SCQ is a 40-item parent-report questionnaire that evaluates communication skills and social functioning in individuals who may or may not have ASD. Consistent with their diagnosis of ASD, participants in the ASD group were rated as having significantly poorer social and communication skills than the control group, $t(47.38) = 10.66, p < .001, d = 2.34$.

Table 6.1.

Characteristics of Participants in the ASD and Control Groups

	ASD group <i>n</i> = 40		Control group <i>n</i> = 55		<i>t</i> (93) ^a	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Age (in years)	9.75	1.35	10.27	1.33	1.81	0.37
Intelligence						
FSIQ	107.98	11.79	111.07	12.09	1.35	0.28
VCI	107.08	12.76	108.69	11.15	0.75	0.16
PRI	108.23	13.25	111.58	14.65	1.19	0.25
Retrospective memory	9.90	3.01	10.96	2.37	1.93	0.39
Executive functions						
Cognitive flexibility	119.60	50.27	91.80	29.35	3.13**	0.68
Inhibition	98.65	23.68	80.38	22.10	3.86***	0.80
Functional capacity	39.83	10.33	52.53	11.88	5.43***	1.14

Note. **p* < .05, ***p* < .01, ****p* < .001

d = Cohen's index of effect size; Cohen (1988) defines effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large

^aHomogeneity of variance was violated for cognitive flexibility, *df* = 58.16

ASD = Autism Spectrum Disorder, FSIQ = Full Scale IQ, VCI = Verbal Comprehension Index, PRI = Perceptual Reasoning Index, Retrospective memory = Retrospective memory measured on the NEPSY-II List Memory Delayed

6.2.2 Materials

6.2.2.1 Episodic foresight

The VW-Foresight (Lyons et al., 2014) is a computerised board game that simulates real life situations where episodic foresight might be flexibly exercised in an everyday life context. The episodic foresight tasks included in the game are presented as problems that

require participants to independently identify and resolve. The current version used in this study is an adapted children's version of the measure.

On this measure, participants are required to roll a die and move a token around the board. A circuit around the board represents one virtual day (see Figure 6.1. for the game's interface). As participants move around the board, they are required to make decisions about daily activities and carry out tasks that draw on episodic foresight. Participants pass a total of 10 green 'S' squares on the board on each virtual day and every time they land on or pass an 'S' square, they are prompted to pick up a *Situation Card*. Each *Situation Card* presents a realistic daily situation (e.g., having breakfast) and participants are asked to choose one of the options on the card in response to the situation (e.g., choosing yogurt, honey or chocolate milk to have with your breakfast). Depending on the option the participants select, they are then prompted to roll a specific number on the die to continue moving around the board (e.g., roll a three, roll an even number, or roll any number).

Each participant is asked to complete two virtual days in which they encounter 20 *Situation Cards*. Seven of these cards present an episodic foresight problem; seven present the context for a resolution of that problem; and the remaining six are distracters that are unrelated to the episodic foresight problems. Problem, resolution, and distracter *Situation Cards* are encountered interchangeably throughout each virtual day. In addition to *Situation Cards*, seven *Daily Activity Cards* are presented to provide an opportunity for participants to acquire one item (from a list of five items, with four items being distracter items) that may be used to resolve a previously encountered problem. Other *Daily Activity Cards* are distracter activities where no items on these cards are useful for problem resolution. The purpose of including distracter situation cards, daily activity cards and distracter items

throughout the game is to simulate problems related to episodic foresight that are typically encountered in everyday life, which are commonly embedded among other ongoing activities.

There are two outcomes measures in the VW-Foresight game: item acquisition and item use. The ability to imagine future scenarios to secure benefits and avoid problems later is indexed by percentage of correct items acquired. The ability to subsequently follow through by applying items to resolve problems at the appropriate future time is operationalised as percentage of items correctly used. Both the acquisition and use stages are critical for the flexible application of episodic foresight in everyday life contexts, and issues with either stage alone are suggestive of difficulties in this capacity (see Chapter 4.3.2 for detailed description of VW-Foresight). Reliability estimates were calculated using Cronbach's alpha in the current study: item acquisition, .58 for ASD and .35 for controls; item use, .62 for ASD and .63 for controls.

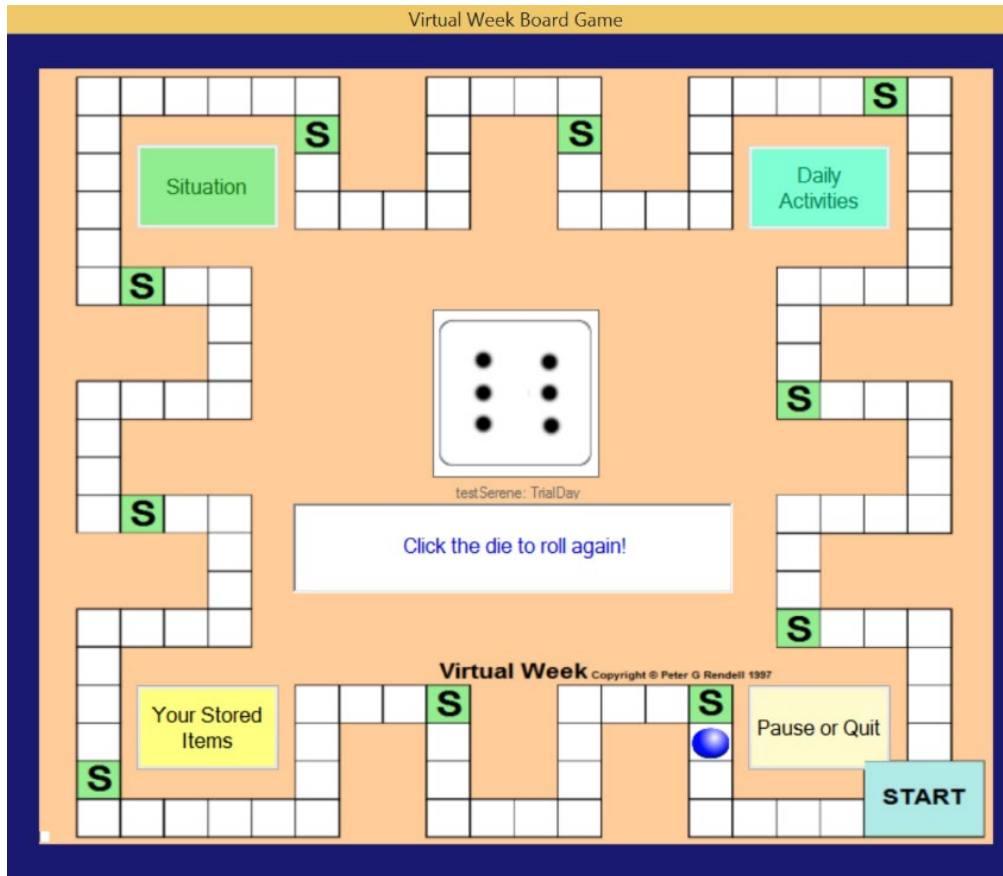


Figure 6.1. Children's version of Virtual Week-Foresight game interface

6.2.2.2 Intellectual functioning

The Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II; Wechsler, 2011) is a reliable measure of intellectual functioning. It consists of four subtests (Block Design, Vocabulary, Matrix Reasoning and Similarities) that provide scores on Verbal Comprehension, Perceptual Reasoning and Full Scale IQ. Higher scores indicate higher levels of intellectual functioning. The WASI-II has internal consistency ranging from .92 to .96, and test-retest reliability ranging from .79 to .95 for children aged 6 to 16 years. It also shows good concurrent validity (Wechsler, 2011).

6.2.2.3 *Retrospective memory*

The List Memory Delayed of the NEPSY-II (Korkman et al., 2007) was used to assess retrospective memory ability. A list of 15 words is first presented to participants and they are asked to recall them in any order on five separate trials, followed by an interference trial where another list of 15 words is presented, and participants are again asked to recall these words. After approximately 25 to 35 minutes, List Memory Delayed is administered where participants are instructed to recall the first list of words, with the first word on the list provided as a cue. The raw score of List Memory Delayed was used as an index of retrospective memory (maximum score = 15). Higher scores indicate better retrospective memory ability. Internal consistency for this subtest is .91 and test-retest reliability is .75 for children aged 7 to 10 years (Korkman et al., 2007).

6.2.2.4 *Executive functions*

The Trail Making Test and Color-Word Interference Test from the Delis-Kaplan Executive Functioning System (D-KEFS; Delis et al., 2001) were used to index cognitive flexibility and inhibition, respectively. The Number-Letter Switching condition in the Trail Making test assesses participants' ability to switch between connecting numbers and letters in a sequential order as fast as possible without making mistakes. On the Inhibition condition of the Color-Word Interference Test, colour names are presented in different coloured ink, and participants are asked to name the ink colour, and not read the word, as fast as possible without making mistakes. Performances on both these subtests are timed and the completion times are recorded as raw scores. Higher scores indicate poorer cognitive flexibility and inhibition. The D-KEFS Trail Making Test and Color-Word Interference Test have internal consistency ranging from .57 to .79 for children aged 8 to 12

years, and test-retest reliability ranging from .20 to .90 for children and adolescents aged 8 to 19 years (Delis et al., 2001).

6.2.2.5 *Functional capacity*

The Self-Direction scale from the Adaptive Behavior Assessment System – Second Edition (ABAS-II; Harrison & Oakland, 2003) was used to assess participants’ functional capacity in everyday living. This scale requires parents to rate how frequently their child displays the behaviours listed (e.g., “Routinely arrives at places on time”) on a 4-point Likert scale. The sum of all items on this scale provides a raw score. Higher scores indicate higher levels of self-direction and functional independence. The Self-Direction scale has internal consistency ranging from .91 to .94 for children aged 8 to 12 years and inter-rater reliability of .84 for individuals aged 5 to 21 years (Harrison & Oakland, 2003).

6.2.3 Procedure

Written consent was obtained from all participants prior to the commencement of testing sessions. Participants were then tested in their homes in a room free from distractions. All participants took approximately two hours to complete all cognitive measures included in the current study. For VW-Foresight, participants took on average an hour to complete it. Two movie vouchers were given as an appreciation for their time in participating in the research project. The research was conducted with the approval of the human research ethics committee of Australian Catholic University (No. V201012; “Prospective memory and episodic future thinking in middle childhood”).

6.2.4 Data analyses

All statistical tests were two-tailed and an alpha level of $p < .05$ was considered significant in all analyses. Raw scores on all measures were used in all analyses, except for the FSIQ, Verbal Comprehension and Perceptual Reasoning Index on the WASI-II where the composite scores were used. One participant in the control group was found to be an outlier on most of the variables ($z > \pm 3.29$; Tabachnick & Fidell, 2013) and was excluded. Another participant in the control group did not appear to understand the instructions of the VW-Foresight and was also excluded from the analyses. In addition, one participant in the control group was identified as a univariate outlier on the D-KEFS Trail Making Test. This was rectified by replacing the obtained score with the next highest score plus one (Field, 2013). Missing values for one control participant and one ASD participant on the D-KEFS Trail Making Test and Color-Word Interference Test were replaced with the respective group means (Tabachnick & Fidell, 2013). All assumptions were checked and found to be satisfied.

6.2.4.1 VW-Foresight measures

Item acquisition was the percentage of target items correctly acquired from the *Daily Activities Cards* and item use was the percentage of target items correctly used when the appropriate *Situation Cards* was encountered. Three controls and one participant with ASD experienced technical errors during administration where a target item could not be acquired because the target *Daily Activities Card* did not appear in the game. Prorated scores were used for these participants where item acquisition and item use were calculated as the number of target items correctly acquired or used divided by the total number of

opportunities they had to acquire or use items in the game. All scores for item acquisition and item use were expressed as percentages in all analyses.

6.3 Results

The two outcome measures produced on the VW-Foresight task were analysed using a mixed-model two-way analysis of variance (ANOVA), with *group* (ASD, control) as the between-groups variable and *foresight task* (item acquisition, item use) as the within-groups variable. The results showed a main effect of group, $F(1, 93) = 5.03, p = .03, \eta_p^2 = .05$ (small effect), and of foresight task, $F(1, 93) = 197.21, p < .001, \eta_p^2 = .68$ (large effect). More importantly, there was a significant interaction between group and foresight task, $F(1, 93) = 5.30, p = .02, \eta_p^2 = .05$ (small effect). This interaction was followed up with tests of simple effects that revealed a simple effect of group for item use, $F(1, 93) = 6.71, p = .01, \eta_p^2 = .07$ (small effect), with participants with ASD using significantly less items to resolve problems than controls. However, there was no group difference for item acquisition, $F(1, 93) = 1.64, p = .20, \eta_p^2 = .02$. Further analysis of the interaction revealed a simple effect of condition within the ASD group, $F(1, 93) = 115.36, p < .001, \eta_p^2 = .55$ (large effect), and within the control group, $F(1, 93) = 81.86, p < .001, \eta_p^2 = .47$ (large effect), with both groups more likely to acquire items than use them (see Figure 6.2.).

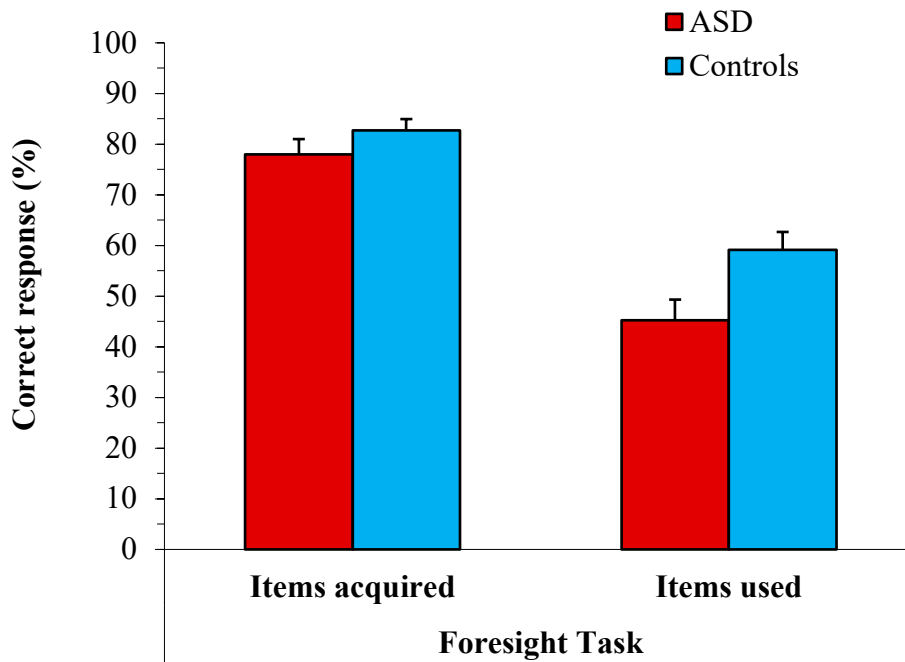


Figure 6.2. Mean proportion of the number of items acquired and used expressed as a percentage of seven possible items for participants with autism spectrum disorder (ASD) and controls. Error bars represent mean standard error.

6.3.1 Correlation analyses

Pearson’s bivariate correlations were performed for age, intellectual functioning, measures of episodic foresight (item acquisition and item use), measures of executive functioning (cognitive flexibility and inhibition), retrospective memory and functional capacity for ASD and control groups separately (see Table 6.2.). For the ASD group, it was found that better cognitive flexibility was associated with better episodic foresight

performances. For the control group, better episodic foresight abilities were found to be associated with better functional capacity¹.

Table 6.2.

Correlations between Intellectual Functioning, Measures of Cognitive Functioning and Functional Capacity for ASD and Controls Separately

	ASD <i>n</i> = 40		Control <i>n</i> = 55	
	Acquired	Used	Acquired	Used
Full Scale IQ	.42**	.22	.25	.35**
Retrospective memory	.25	.21	.23	.23
Executive functions				
Cognitive flexibility	- .41**	- .44**	- .23	- .24
Inhibition	- .06	- .13	- .24	- .19
Functional capacity	.06	.13	.53***	.42**

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

ASD = Autism Spectrum Disorder, Acquired = Item acquisition on VW-Foresight, Used = Item use on the VW-Foresight

6.3.2 Cognitive predictors of episodic foresight

Hierarchical regressions were then performed to investigate the contributions of cognitive flexibility, inhibition and retrospective memory to item acquisition and item use

¹ Partial correlations were also performed on measures of foresight, executive functions, retrospective memory and functional capacity while controlling for age in ASD and controls separately. A similar pattern of results to those reported in Table 6.2. was obtained where measures of foresight significantly correlated with cognitive flexibility in ASD and measures of foresight significantly correlated with functional capacity in controls. Therefore, a separate table reporting results of these partial correlations was not additionally included.

in children with ASD and controls separately. The contributions of age and intellectual functioning was first controlled by entering age and Full Scale IQ in step 1 of the analyses, followed by cognitive flexibility, inhibition and retrospective memory in step 2. For the ASD group, the regression models in step 2 for both items acquired and items used were not found to be significant, with measures of executive function and retrospective memory not significantly predicting item acquisition ($\Delta R^2 = .09, p = .25$) or item use ($\Delta R^2 = .12, p = .17$) over and above age and intellectual functioning. This was also the case for the control group, where the regression models in step 2 were not significant, with measures of executive function and retrospective memory again not significantly predicting item acquisition ($\Delta R^2 = .05, p = .43$) and item use ($\Delta R^2 = .02, p = .82$) over and above age and intellectual functioning (see Table 6.3.).

Table 6.3.

Cognitive Predictors of Episodic Foresight Controlling for Age and Intellectual Functioning in Children with Autism Spectrum Disorder (ASD) and Controls Separately

	ASD <i>n</i> = 40			Control <i>n</i> = 55		
	<i>R</i> ²	<i>B</i> (<i>SE</i>)	β	<i>R</i> ²	<i>B</i> (<i>SE</i>)	β
Item acquisition						
<i>Step 1</i>	.15*			.07		
Age		2.30 (2.14)	.16		2.63 (1.66)	.21
Full Scale IQ		0.72 (0.25)	.44**		0.36 (0.18)	.26
<i>Step 2</i>	.18			.07		
Age		0.97 (2.69)	.07		1.32 (2.01)	.10
Full Scale IQ		0.45 (0.29)	.28		0.18 (0.22)	.13
Cog flex		- 0.14 (0.08)	.35		- 0.02 (0.09)	.04
Inhibition		0.16 (0.15)	.19		- 0.09 (0.12)	.11
Memory		0.21 (0.28)	.12		0.38 (0.30)	.20
Item use						
<i>Step 1</i>	.09			.12*		
Age		5.86 (2.97)	.30		3.18 (2.50)	.16
Full Scale IQ		0.59 (0.34)	.27		0.78 (0.27)	.36**
<i>Step 2</i>	.15			.08		
Age		3.65 (3.69)	.19		1.53 (3.09)	.08
Full Scale IQ		0.17 (0.39)	.07		0.67 (0.34)	.31
Cog flex		- 0.20 (0.11)	-.38		- 0.08 (0.15)	.09
Inhibition		0.19 (0.21)	.18		- 0.09 (0.18)	.08
Memory		0.40 (0.38)	.17		0.11 (0.46)	.04

Note. **p* < .05, ***p* < .01

*R*² = Adjusted *R*², Outcome variables = item acquisition and item use measured on the Virtual Week-Foresight, Cog flex = Cognitive flexibility

6.4 Discussion

The current study is the first to investigate the practical capacity to apply episodic foresight in a simulated everyday life context in children with ASD. The first key finding was that children with ASD showed comparable performance to typically developing children on item acquisition, indicating that the capacity to initiate preparatory behaviours in anticipation of future events may be intact in children with the disorder. This is a positive finding for the ASD group who showed capability in a core component of episodic foresight. Assuming this aspect of foresight relies on the creation of future scenes in imagination on which judgements about future needs are based (Suddendorf, 2017; Suddendorf & Moore, 2011), however, this finding does not appear consistent with previous studies showing children with ASD are less able than controls to provide detailed descriptions of themselves experiencing hypothetical future scenarios (Ciaramelli et al., 2018; Ferretti, Adornetti, et al., 2018; Hanson & Atance, 2014; Lind, Bowler, et al., 2014; Marini et al., 2016, 2019; Terrett et al., 2013).

One possible explanation to reconcile these findings could be that while children with ASD may indeed be less able to imagine experiencing a future event with the rich level of details that typically developing children are capable of, taking preparatory action (indexed in the current study by item acquisition) may not require the generation of high levels of episodic details about an imagined future event. Rather, all that may be required are *enough* details to be able to identify future needs, which then allows steps to be taken in the present to meet those needs. If this is the case, children with ASD may be able to generate an adequate level of details to be able to successfully acquire relevant items. This suggestion can be linked to the constructive episodic simulation hypothesis (Addis et al.,

2007) which suggests there are two phases involved in the mental simulation of future scenarios – a basic construction phase which involves the retrieval of information from various cognitive systems to create a hypothetical future event, followed by an elaboration phase which involves the generation of additional episodic and contextual details that aid the simulation of the future event (Addis et al., 2007; Schacter & Addis, 2007). As participants in most past studies have been probed to provide rich details about their imagined future (e.g., Ciaramelli et al., 2018; Terrett et al., 2013), both the construction and elaboration phases may have been involved in the imagination of future events in those studies. By contrast, in the current study, it is possible that the successful acquisition of items only needed to tap into the construction phase, with a basic mental representation of a future scenario proving sufficient to guide preparatory behaviours in the present. Thus, children with ASD may be comparable to typically developing children on the initial construction of a future event in their imagination but show impairments at the point of elaboration. This would explain why children with ASD were equally as capable as typically developing children on item acquisition in the current study but did not perform as well as controls in previous studies that explicitly required rich details of imagined future events.

The second key finding in the current study was that children with ASD performed significantly worse than controls on item use, indicating that the capacity to subsequently follow through and use acquired items to resolve problems at the appropriate future point was impaired. This is an important finding because even if items are appropriately acquired, not using those items at the relevant future time essentially means episodic foresight was not successfully implemented. In real life, this in turn is likely to have

negative consequences for successful daily functioning. Given the value of following through and using items appropriately, the current study then investigated what might be underpinning this deficit in children with ASD. As previously noted, using items at the appropriate time in the future is likely to be a cognitively demanding aspect of the foresight process as conceptualised in the current study given that it is the point at which an individual must remember what items they previously acquired as well as the contexts they might use them in, and must also action the preparatory steps (i.e., use the acquired items) when an appropriate context presents itself. This argument is in fact supported by findings of the current study showing that participants in both groups used significantly fewer items than they acquired, suggesting that item use may be more cognitively challenging than item acquisition. It was therefore anticipated that impaired ability to use items in children with ASD might reflect executive functioning and/or retrospective memory deficits. However, the results of the current study suggest this is not the case. More specifically, while the ASD group were indeed worse than controls on executive functioning, this capacity did not significantly contribute to item use in the regression analyses. In addition, our findings showed that children with ASD did not differ from controls on the retrospective memory task, and retrospective memory was not a significant contributor to item use in the ASD group. Together, then, these findings indicate that the observed deficits in the capacity for item use in children with ASD do not appear to be contributed to by impairments in executive functions or retrospective memory and raise the question of what other processes might underpin this deficit.

One possible explanation could be that while item acquisition may not be affected by the impoverished capacity to generate rich detailed images of the self experiencing

future events shown in previous studies of children with ASD (e.g., Ciaramelli et al., 2018), item use may be more adversely affected by this impairment. It should be noted that the contexts in which the acquired items might be used to resolve anticipated problems in the future were not explicitly stated in the current study (as also often the case in real life). As such, it is suggested that individuals engaging in foresight may generate images of themselves in multiple plausible future situations that are likely to be adversely affected by the presented problem (e.g., breaking glasses), and which would benefit from acquiring particular items (e.g., old pair of glasses). If those future plausible situations are imagined in high levels of detail, they are likely to be more strongly encoded in memory (Kretschmer-Trendowicz, Ellis, & Altgassen, 2016; Kretschmer-Trendowicz, Schnitzspahn, Reuter, & Altgassen, 2019; Terrett et al., 2019), thus making them more likely to be recognised when encountered later in the game, a proposal consistent with the levels of processing model (Craik & Lockhart, 1972). This in turn may lead to greater likelihood that the acquired items will be used at the appropriate future point. However, this suggestion is speculative and requires further investigation.

Lastly, our findings showed that item acquisition and item use were significantly associated with functional capacity in the control group, suggesting that the capacities to secure and apply items to resolve anticipated problems in the future are linked to the ability to function independently in daily life in typically developing children. Our study is the first to provide evidence for the association between episodic foresight and functional capacity in typically developing children, and supports widespread claims in the literature that episodic foresight is a cognitive ability with significant adaptive value in everyday living (Atance & O'Neill, 2001; Baumeister et al., 2016; Schacter et al., 2017; Suddendorf,

2017). By contrast, functional capacity was not found to be associated with item acquisition or item use in children with ASD, suggesting that episodic foresight may not be a key contributor to their functional difficulties. However, it should be noted that only one, quite restricted, domain of daily functioning was assessed in the current study. It is possible that other domains of daily functioning may be more impacted by difficulties in the capacity to follow through for successful problem resolutions in the future that might be associated with episodic foresight ability in children with ASD. Future studies should therefore consider assessing a range of functional skills to determine the specific area of deficit in daily functioning that may be more closely linked with impairments in episodic foresight in this clinical group.

In sum, the current findings have provided novel evidence of impairments in the capacity to complete episodic foresight tasks in children with ASD. More specifically, while an intact capacity to initiate preparatory behaviours in anticipation of future scenarios was observed, significant difficulties in subsequently following through to ultimately achieve desirable future outcomes were apparent. In addition, our findings showed that retrospective memory and executive function deficits did not underpin difficulties in item use in the ASD group. Rather, we suggest that the difficulties in using items appropriately may reflect impoverished ability to imagine richly detailed future scenes, although this proposal requires further exploration. Future studies that aim to investigate episodic foresight and the mechanisms that underpin it in children with ASD will be important given the adaptive value of this ability in everyday life. Such findings will be beneficial in informing parents and teachers of the specific cognitive limitations in children with ASD and in turn implement appropriate strategies that accommodate their daily needs. Finally,

although our study found no associations between episodic foresight and our measure of daily functioning in this clinical group, we do not rule out the possibility that the impairments in episodic foresight, as reflected in poorer capacity to use items when appropriate, may impact other domains of daily functioning in children with ASD. This should therefore be further investigated in future studies.

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Chapter 7: Pervasive Impairments in Prospective Memory and Its Cognitive Underpinnings in Children with Autism Spectrum Disorder

Preamble

Studies 1 and 2 focused on the investigation of episodic future thinking in children with ASD. More specifically, findings of Study 1 showed that children with ASD have limited capacity to mentally pre-experience hypothetical future scenarios and that these difficulties may be underpinned by the compromised processes of creating coherent complex scenes and shifting to different perspectives in the mind. Results of Study 2 addressed a more applied form of episodic future thinking and revealed that the ability to initiate preparatory behaviours in anticipation of potential future problems may be intact but the capacity to follow through to resolve these problems at the appropriate future time point may be impaired in this clinical group. The final study (Study 3) investigated another form of prospection, namely prospective memory (PM), in order to further extend current understanding of the cognitive impairments in relation to prospection in children with ASD. In this study, the primary aim was to investigate PM ability across two types of PM tasks using a reliable measure called Virtual Week-Prospective Memory (VW-PM). In addition, the relationships between retrospective memory, executive functioning and PM were explored, as was the relationship between functional outcomes in daily living and PM deficits.

7.1 Introduction

ASD is an increasingly common neurodevelopmental disorder that involves impaired social and communication skills, as well as repetitive and restricted patterns of behaviour. The disorder presents in childhood with widely varying levels of intellectual functioning (e.g., from intellectually disabled to average and above average), and with a broad spectrum of severity in core symptoms (American Psychiatric Association, 2013). Regardless of intellectual ability or symptom severity, however, poor daily living skills are frequently observed in ASD (Chang et al., 2013; Howlin, 2003; Thomeer et al., 2019). In children with the disorder, such difficulties in daily functioning can lead to higher levels of parenting stress due to an increased demand for parental monitoring of children's everyday needs (Bonis, 2016; Jordan, 2011). Children with ASD also experience heightened distress from struggling to cope with various demands across different areas in daily life (Jordan, 2011; Thomeer et al., 2019). Therefore, a better understanding of specific factors that may underpin these difficulties is necessary so that effective strategies can be developed for the management of the daily life challenges that children with ASD and their parents encounter.

The capacity to independently complete future tasks is an important factor in meeting the demands of daily life, with expectations regarding this capacity increasing as children move through the school years (Mahy, Moses, et al., 2014). For example, once children enter school, they may be expected to remember to bring homework to school for submission tomorrow or to remember to go to sports practice at 5 p.m. As such, one suggested contributor to poor functional outcomes in children with ASD is difficulties with prospective memory (PM). PM refers to the ability to remember to carry out intentions at

an appropriate moment in the future (Einstein & McDaniel, 1990), and has been argued to be crucial for independent functioning (Hering et al., 2018; Mahy, Moses, et al., 2014). There are generally considered to be two main types of PM tasks: event-based and time-based. Event-based PM tasks are carried out in relation to an event and are thus prompted by external environmental cues (e.g., remember to buy dog food *at the supermarket*), while time-based PM tasks are required to be completed at a particular time, or after a period of time has passed, and lack the inherent environmental cue associated with event-based tasks (e.g., ring a friend *at 6 p.m.*; Einstein & McDaniel, 1990).

The proposal that PM might be impaired in children with ASD is supported by past evidence of deficits in retrospective memory in this clinical group (Boucher et al., 2012; Bowler et al., 2011). Retrospective memory is the ability to remember past information and has been argued to play a key role in the completion of PM tasks (Einstein & McDaniel, 1990; Ellis & Freeman, 2008). This is because PM task performance involves not only the ability to remember to carry out the task at the appropriate point (prospective component), but also the capacity to remember what the task is and when to perform it (retrospective component; Einstein & McDaniel, 1990; Ellis & Kvavilashvili, 2000). As such, the retrospective component of PM relies heavily on retrospective memory and indeed previous studies have shown that retrospective memory is significantly associated with PM task performance in children (e.g., Terrett et al., 2019) and adults (e.g., Foster et al., 2013). Impaired retrospective memory ability has been shown in numerous studies of children with ASD (Bowler et al., 2011) and would therefore potentially render this group vulnerable to failures on PM tasks.

Another line of evidence to suggest that PM might be compromised in children with ASD is reduced executive functioning (Humphrey, Golan, Wilson, & Sopena, 2011; McCrimmon et al., 2016). Executive functioning is an umbrella term that encompasses a range of higher-order cognitive control processes that are responsible for behavioural regulation and goal attainment (Kenworthy et al., 2008). PM tasks have been argued to involve executive functioning through processes such as cognitive flexibility which may be needed to switch from an ongoing task to perform PM tasks at appropriate future points, and thus may be particularly relevant for the prospective component of PM (Mahy, Moses, et al., 2014; Spiess et al., 2016; Zuber et al., 2019). However, it has been suggested that different PM tasks may impose different demands on executive functioning depending on factors such as the type of cue available to support the execution of future intentions (Mahy, Moses, et al., 2014; McDaniel & Einstein, 2000, 2007). For example, time-based PM tasks are often claimed to place higher demands on executive functioning than event-based PM tasks because for time-based tasks an individual has to self-initiate processes to monitor for appropriate task cues (i.e., the specific time) to execute the intention (Einstein & McDaniel, 1996). As such, it has been suggested that time-based PM might be particularly sensitive to ASD-related impairments given that executive dysfunction is a typical cognitive characteristic of the disorder (Craig et al., 2016; McCrimmon et al., 2016).

Whilst investigations of PM in children with ASD is currently limited to seven studies, there is converging evidence showing that time-based PM is impaired in this clinical group (see Landsiedel et al., 2017, for a review). By contrast, findings regarding event-based PM have been mixed, with some studies showing impairment (Brandimonte et al., 2011; Jones et al., 2011; Sheppard et al., 2016; Yi et al., 2014), while others have

reported intact event-based task performance (Altgassen et al., 2010; Williams et al., 2013). However, there are several limitations that need to be noted in these past studies. For example, the assessment of PM ability has often been restricted to only one or two tasks which consequently limits the reliability of these measures (McDaniel & Einstein, 2007; Rendell & Henry, 2009; Rose et al., 2010). In addition, most past studies have employed the typical laboratory-based paradigm which generally has low ecological validity and thus findings may be limited in the extent to which they reflect PM abilities in real-world settings. Furthermore, most previous studies have examined only one type of PM (i.e., either event-based or time-based). This is problematic when attempting to make conclusions about the profile of event-based versus time-based PM ability in children with ASD given the heterogeneity of the disorder. To address the question of event-based versus time-based PM ability, therefore, studies should ideally measure both in the same sample of children.

The current literature also remains scarce in terms of empirical investigation of factors that might underpin ASD-related deficits in PM. As previously noted, retrospective memory deficits are commonly observed in individuals with the disorder (Boucher et al., 2012; Bowler et al., 2011) potentially placing them at risk of PM impairment. It is thus surprising that no study to date has directly measured retrospective memory and investigated its relationship with PM performance in children with ASD. While two of the seven studies on PM in children with ASD assessed retrospective memory for PM task content, these studies did not examine the association between retrospective memory and PM performance. Rather, the purpose of assessing retrospective memory was to exclude participants who failed to recall PM task content in order to investigate differences in the

prospective component of PM task completion (Brandimonte et al., 2011; Williams et al., 2013). Thus, the extent to which failures in retrospective memory are associated with poor PM task completion in this clinical group remains unclear. Furthermore, few studies thus far have examined the possible link between executive dysfunction and PM impairments in children with ASD. Findings from one of these studies showed that poorer event-based PM was associated with reduced working memory but not cognitive flexibility or inhibition (Yi et al., 2014), while another found no association between time-based PM and cognitive flexibility (Williams et al., 2013). Conclusions that can be made from these studies regarding the role of executive functions in PM performance are however restricted given that they each investigated a different type of PM task, and only Yi et al. (2014) assessed more than one executive function.

To date, one study has attempted to investigate PM abilities in children with ASD addressing a number of the limitations of previous studies. Henry et al. (2014) assessed both event-based and time-based PM in the same sample of 8- to 12-year-old children with ASD in a simulated everyday life context using a reliable computer-based measure of PM, namely Virtual Week-Prospective Memory (VW-PM; Rendell & Craik, 2000). On the VW-PM, children are required to carry out plausible PM tasks that are embedded in everyday life-like activities. Results showed that while time-based PM was impaired, event-based PM was intact in the ASD group. In addition, the authors concluded that retrospective memory may not be underpinning the time-based PM impairment identified in this clinical group. It should however be noted that this study did not include a direct measure of retrospective memory and based this conclusion on the finding that the performance of the ASD group did not differ across PM tasks that varied in retrospective memory demands. In

terms of the role of executive functions, Henry et al. (2014) focused on cognitive flexibility and found the children with ASD did not differ from controls on this ability. In addition, only one of the three measures used to index cognitive flexibility was associated with time-based PM performance, and none was associated with event-based PM performance in the clinical group. Together, these findings indicate that poorer executive functioning may not underpin the time-based PM deficits in children with ASD and makes only a limited contribution to time-based and event-based PM performance in this group. However, the assessment of executive functions was restricted to cognitive flexibility in this study, and it is possible that other executive functions could be more relevant. Given the apparent dearth of literature and limitations elucidated above, the specific role of retrospective memory and the range of executive functions in PM performance across different task types currently remain unclear in ASD.

The primary aim of the current study, therefore, was to extend the work of Henry et al. (2014) and further clarify the extent of ASD-related impairment on event-based and time-based PM tasks in children with the disorder using the VW-PM. Given the consistent evidence of impaired time-based PM reported in previous studies, we hypothesised that this ability would be impaired in our clinical sample. However, the predictions for event-based PM in children with ASD remain open considering the mixed findings thus far in the literature.

The secondary aim of the current study was to further explore possible cognitive mechanisms that might underpin PM impairments in children with ASD. The role of retrospective memory in PM performance was investigated by (1) participants' ability to remember specific PM task content; and (2) their task performance on a delayed recall task.

In terms of executive functioning, three key executive functions were assessed in relation to PM performance (i.e., working memory, cognitive flexibility and inhibition). While there is currently limited empirical evidence of the relationships between retrospective memory, executive functioning and PM in the ASD literature, theoretical models lead to the prediction that poorer retrospective memory and executive functioning should be associated with poorer time-based PM task performances in the ASD group. In addition, it was expected that any difficulty in event-based PM would also be linked to poorer retrospective memory and executive functioning. Finally, the extent to which PM difficulties might be related to poor functional capacity was examined so that a better understanding of the implications of these deficits in daily life may be established in children with ASD.

7.2 Method

7.2.1 Participants

Thirty-two children with ASD (72% males) and 42 healthy controls (60% males) aged 8 to 12 years participated in the current study². The two groups did not differ with respect to the proportion of males and females, $\chi^2(1, N = 74) = 1.22, p = .27$. Paediatric or psychological assessment reports were provided by parents of children with ASD to confirm their diagnosis. Consistent with these diagnoses, the Social Communication Questionnaire (SCQ; Rutter et al., 2008) revealed significantly lower social and communication skills in children with ASD compared to controls, $t(38.37) = 9.28, p < .001$,

² This is a subset of participants with ASD and controls who also took part in Study 2. All participants in Study 3 completed the full battery of cognitive measures across the two testing sessions (see Chapter 4 for details). However, only data on the VW-PM, retrospective memory and executive functions were included in the analyses for Study 3 as they were the measures relevant to answer the research questions in this study.

$d = 2.28$. The SCQ is a 40-item parent-report questionnaire that evaluates social and communication skills in a child's developmental history. Higher scores on the SCQ indicate poorer social and communication functioning.

7.2.2 Materials

7.2.2.1 Prospective memory

VW-PM (Rendell & Craik, 2000) is a computerised board game that assesses PM presented in an everyday life context where tasks are required to be carried out at specific points in the game (see Figure 7.1. for the game interface). The VW-PM used in this study was the two-day version presented on an iPad. In this game, participants roll a die and move a token around the board. Each circuit of the board represents a virtual day with the time of the virtual day displayed in the centre of the board. Fifteen virtual minutes go by for every two squares moved. Participants are prompted to pick up an Event Card each time they land on or pass an 'E' square. On each virtual day, participants pick up ten Event Cards, and each event card presents a different activity that relates to the time of the day (e.g., This morning at school you sit next to your friend. You are both...). Participants then choose from the three options on these event cards (e.g., participating in the lesson actively, drawing a picture while listening, or chatting a lot). In addition, participants carry out PM tasks while engaging in the ongoing activities of rolling the die, moving the token, reading event cards, and making decisions related to each event card.

Participants encounter two types of PM tasks throughout the game: event-based and time-based tasks. Each virtual day has four event-based and four time-based PM tasks that participants are asked to complete. Event-based tasks are required to be performed when

participants encounter the appropriate *Event Card* (e.g., buy some pencils when the event card “Go Shopping” is encountered). Time-based tasks are performed when the appropriate time is shown on the virtual clock shown in the middle of the board (e.g., help set up the school hall when the virtual clock shows 10:30 a.m.). In total, participants are asked to complete eight PM tasks on each virtual day. When participants are required to carry out a task (either in response to an event presented on an *Event Card*, or at a particular time on the virtual clock), they are asked to press a ‘Perform Task’ button and select the appropriate task to perform. The percentage of correct responses for each of the PM task types was used as the measure of PM performance.

At the completion of each virtual day, participants are also presented with *Task Review Cards* to assess retrospective memory for task content. This requires each PM task completed on the day (e.g., buy some pencils) to be matched with the corresponding PM cue (e.g., when shopping). Four distractor tasks are also included on the *Task Review Cards* and participants are expected to indicate that these actions are ‘not required’. Tasks are individually presented on the screen and are automatically swiped to the next task once participants have responded to each task. This recognition task provides an index of the retrospective memory component of the PM tasks (see Chapter 4.3.3 for detailed description of VW-PM). The overall reliability of the PM tasks was found to be relatively good in both the children with ASD and controls in the current study (Cronbach’s $\alpha = .82$ and $.65$, respectively).

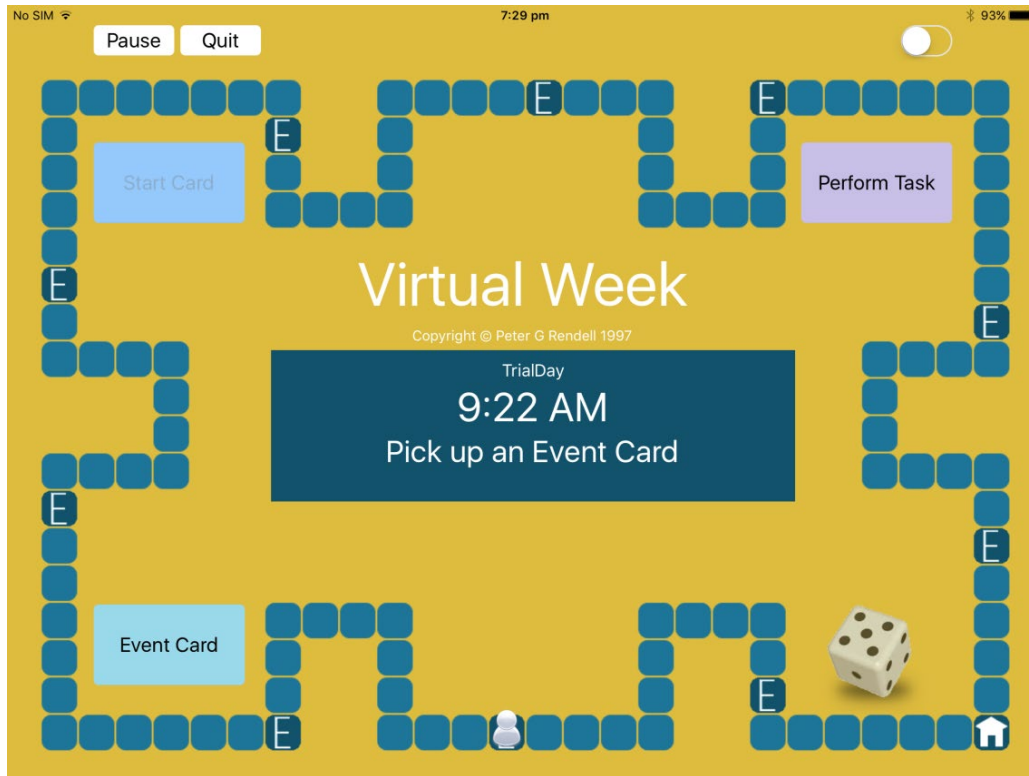


Figure 7.1. Children Virtual Week-Prospective Memory iPad version game interface

7.2.2.2 *Intellectual functioning*

The Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II; Wechsler, 2011) is a reliable measure of intellectual functioning. It consists of four subtests (Block Design, Vocabulary, Matrix Reasoning and Similarities) that provide scores on Verbal Comprehension, Perceptual Reasoning and Full Scale IQ. Higher scores indicate higher levels of intellectual functioning. The WASI-II has internal consistency ranging from .92 to .96, and test-retest reliability ranging from .79 to .95 for children aged 6 to 16 years. It also shows good concurrent validity (Wechsler, 2011).

7.2.2.3 *Retrospective memory*

The List Memory Delayed of the NEPSY-II (Korkman et al., 2007) was used to assess retrospective memory ability. A list of 15 words is first presented to participants and they are asked to recall them in any order on five separate trials, followed by an interference trial where another list of 15 words is presented. Then, participants are immediately asked again to recall the first list of words. After approximately 25 to 35 minutes, List Memory Delayed is administered where participants are instructed to recall the first list of words, with the first word on the list provided as a cue. The raw score of List Memory Delayed was used as an index of retrospective memory (maximum score = 15). Higher scores indicate better retrospective memory ability. Internal consistency for this subtest is .91 and test-retest reliability is .75 for children aged 7 to 10 years (Korkman et al., 2007).

7.2.2.4 *Executive functions*

The Trail Making Test and Color-Word Interference Test from the Delis-Kaplan Executive Functioning System (D-KEFS; Delis et al., 2001) were used to index cognitive flexibility and inhibition, respectively. The Number-Letter Switching condition in the Trail Making test assesses participants' ability to switch between connecting numbers and letters in a sequential order as fast as possible without making mistakes. On the Inhibition condition on the Color-Word Interference Test, colour names are presented in different coloured ink, and participants are asked to name the ink colour and not read the word as fast as possible without making mistakes. Performances on both these subtests are timed and the completion time is recorded as raw scores. Higher scores indicate poorer cognitive flexibility and inhibition. The D-KEFS Trail Making Test and Color-Word Interference

Test have internal consistency ranging from .57 to .79 for children aged 8 to 12 years, and test-retest reliability ranging from .20 to .90 for children and adolescents aged 8 to 19 years (Delis et al., 2001).

The Letter Number Sequencing subtest from the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V; Wechsler, 2016) was used to index working memory. Participants are verbally presented with a combination of letters and numbers and are asked to recall the numbers first, in order, starting with the smallest number, then the letters in alphabetical order. The number of correct responses is summed to form a total raw score. Higher scores indicate better working memory ability. The Letter Number Sequencing has an internal consistency of .86 (Wechsler, 2016).

7.2.2.5 *Functional capacity*

The Self-Direction scale from the Adaptive Behavior Assessment System – Second Edition (ABAS-II; Harrison & Oakland, 2003) was used to assess participants' functional capacity in everyday living. This scale requires parents to rate how frequent their child displays the 25 behaviours listed (e.g., “Routinely arrives at places on time”) on a 4-point Likert scale. The sum of all items on this scale provides a raw score. Higher scores indicate higher levels of self-direction and functional independence. The Self-Direction scale has internal consistency ranging from .91 to .94 for children aged 8 to 12 years and inter-rater reliability of .84 for individuals aged 5 to 21 years (Harrison & Oakland, 2003).

7.2.3 Procedure

After obtaining written consent, participants were tested at their homes in a room free of distractions. As these participants took part in a larger testing protocol, all cognitive

measures were completed in approximately four hours over two sessions. For the VW-PM, participants took on average an hour to complete. At the end of the second session, participants were given movie vouchers as reimbursement of their time. The research was conducted with the approval of the human research ethics committee of Australian Catholic University (No. V201012; “Prospective memory and episodic future thinking in middle childhood”).

7.2.4 Data analysis

All statistical tests were two-tailed and an alpha level of $p < .05$ was considered significant in all analyses. Raw scores on all measures were used in all analyses, except for the WASI-II where composite scores were used. Two participants in the control group were excluded from all analyses due to technical failure during task administration of the VW-PM. Another control participant was also excluded because scores of 0 were obtained on all variables of the VW-PM, suggesting that this participant might not have understood the instructions of the game or was not sampled from our population of interest. Moreover, a missing value on the Letter Number Sequencing subtest for one control participant was replaced with the group mean (Tabachnick & Fidell, 2013). All assumptions were checked and found to be satisfied³.

³ Given the smaller sample sizes included in Study 3 ($n = 32$ ASD, $n = 42$ controls) compared to Study 2 ($n = 40$ ASD, $n = 55$ controls), only correlations were run to address the secondary research question regarding which cognitive ability might be related to PM in Study 3. Additional multiple regression analyses could not be reliably performed.

7.2.4.1 *VW-PM measures*

One of the time-based PM tasks had to be excluded due to an unforeseen technical error across all participants. In total, there were 15 PM tasks included in the analyses which comprised eight event-based PM tasks and seven time-based PM tasks. The retrospective memory variables obtained on *Task Review Cards* were also categorised into eight event-based and seven time-based tasks, with the same time-based task excluded from all analyses. The percentages of correct PM tasks performed and retrospective memory for PM task content were used in all analyses.

7.3 Results

7.3.1 Cognitive function and functional capacity

Independent samples *t*-tests were performed to examine group differences on all cognitive function and functional capacity measures. Results revealed that there were no significant differences in age, Verbal Comprehension and retrospective memory between the ASD and control groups. However, children with ASD performed significantly lower than controls on Full Scale IQ⁴, Perceptual Reasoning, cognitive flexibility, inhibition and

⁴ Two children with ASD were identified with comorbid medical conditions. These participants were initially included in the sample because additional information collected during the screening phase indicated that they showed no cognitive impairments (e.g., they attended mainstream schools and performed academically at the level expected for their age). When these two participants were excluded from the analyses, FSIQ and Perceptual Reasoning were not significantly different between the ASD and control groups ($ps > .05$, $ds = 0.41$ and 0.45 , respectively). However, the same pattern of results was obtained in the ANOVA analyses where ASD participants performed significantly poorer than controls on PM task performances. This indicates that the significant group difference in FSIQ with these two participants included in the sample is not likely to be the major cause for the poor PM task performance observed in the ASD group. Considering the challenges with recruiting ASD participants, these two participants were therefore included in the final analyses of the current study. Furthermore, it has been argued that groups are considered matched when the effect size of the group difference is $d \leq 0.5$ (Landsiedel et al., 2017; Mervis & Klein-Tasman, 2004; Williams et al., 2013). Since the group difference on FSIQ obtained $d \leq 0.5$, our groups were considered matched on intellectual functioning and verbal ability.

working memory. In addition, children with ASD were rated significantly lower on the ABAS-II Self-Direction scale than controls, indicating poorer functional behaviour (see Table 7.1. for descriptive statistics).

Table 7.1.

Background Characteristics of Participants in the ASD and Control Groups

	ASD group		Control group		$t(72)^a$	d
	$n = 32$		$n = 42$			
	M	SD	M	SD		
Age (in years)	9.83	1.42	10.26	1.27	1.35	0.32
Intelligence						
FSIQ	107.22	11.89	112.52	9.72	2.11*	0.49
VCI	106.78	11.43	109.79	10.62	1.17	0.27
PRI	106.44	13.33	112.76	11.47	2.19*	0.51
Retrospective memory	10.06	2.65	10.88	2.42	1.38	0.32
Executive functions						
Cognitive flexibility	123.09	55.45	91.69	29.89	2.90**	0.70
Inhibition	98.75	25.39	76.24	20.96	4.18***	0.97
Working memory	15.61	3.68	18.02	2.84	3.24**	0.73
Functional capacity	40.09	10.60	53.24	11.05	5.16***	1.21

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

d = Cohen's index of effect size; Cohen (1988) defines effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large

^aHomogeneity of variance was violated for cognitive flexibility, $df = 44.59$

ASD = Autism Spectrum Disorder, FSIQ = Full Scale IQ, VCI = Verbal Comprehension Index, PRI = Perceptual Reasoning Index, Retrospective memory = Retrospective memory measured on the NEPSY-II List Memory Delayed

7.3.2 Prospective memory

A mixed-model two-way analysis of variance (ANOVA) was used to assess group differences and compare performance on event-based and time-based PM task types. *Group* (ASD, control) was the between-groups variable and *PM task type* (event, time) was the within-groups variable⁵. The dependent variable was the percentage of PM tasks correctly performed. The results showed a significant main effect of group, $F(1, 72) = 14.41, p < .001, \eta_p^2 = .17$ (medium effect), with participants with ASD performing significantly poorer than controls across all PM tasks. Results also showed a significant main effect of PM task type, $F(1, 72) = 48.96, p < .001, \eta_p^2 = .41$ (large effect), where all participants performed significantly poorer on time-based PM than event-based PM tasks. The two-way interaction between group and PM task type was not significant, $F(1, 72) = .12, p = .73, \eta_p^2 = .002$. Figure 7.2. presents task performance on each PM task type as a function of group.

⁵ An analysis of covariance (ANCOVA) was considered to control for FSIQ as a potential confound. However, this analysis was deemed inappropriate in this situation because a significant difference in FSIQ was found between the ASD and control groups (Field, 2018; Miller & Chapman, 2001). Moreover, as previously noted, when two of the ASD participants were excluded, FSIQ was no longer found to be significant between the ASD and control group but the group difference in PM task performances remained significant. Therefore, we proceeded with ANOVA analyses for the current study.

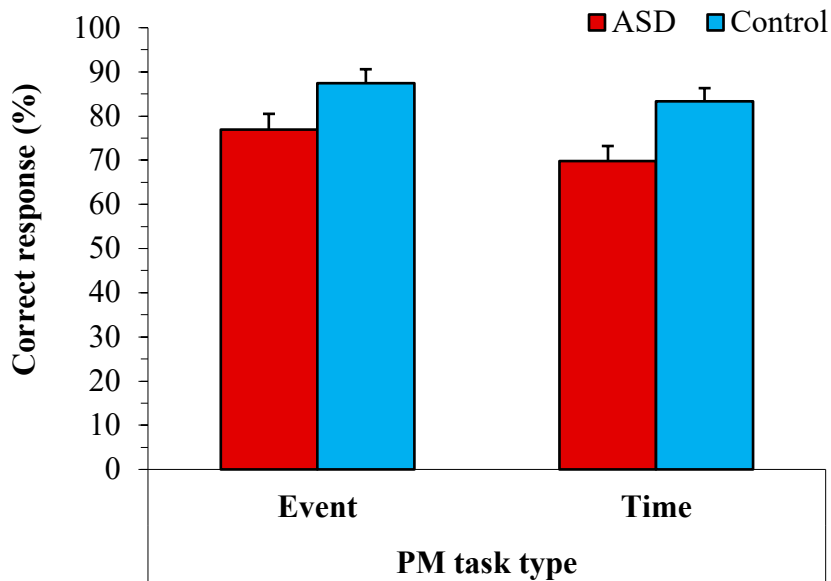


Figure 7.2. Mean percentage of the correct number of prospective memory (PM) tasks performed for participants with autism spectrum disorder (ASD) and controls. Error bars represent mean standard error.

7.3.3 Retrospective component of prospective memory

A further two-way ANOVA was performed to assess participants' ability to remember the task content of the PM tasks they were required to carry out, with the same between-groups variable of *group* (ASD, control) and the same within-groups variable of *PM task type* (event, time). The dependent variable was the percentage of PM tasks correctly remembered. Results revealed a significant main effect of group, $F(1, 72) = 8.86$, $p = .004$, $\eta_p^2 = .11$ (medium effect), which suggested that participants with ASD showed more difficulties remembering the task content across all PM tasks compared to controls. In

addition, there was a significant main effect of PM task type, $F(1, 72) = 6.30, p = .01, \eta_p^2 = .08$ (small effect), where all participants showed more difficulties remembering the content of time-based PM tasks than event-based PM tasks. There was no significant interaction between group and PM task type, $F(1, 72) = .44, p = .51, \eta_p^2 = .01$ (see Figure 7.3.).

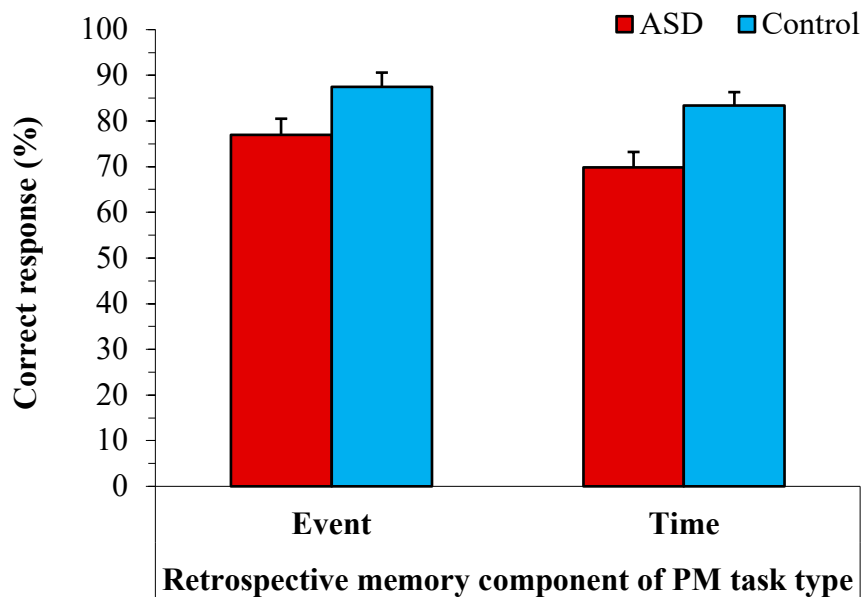


Figure 7.3. Mean percentage of the correct number of prospective memory (PM) tasks remembered for participants with autism spectrum disorder (ASD) and controls. Error bars represent mean standard error.

7.3.4 Correlates of prospective memory

Partial correlations were run on measures of executive functioning, retrospective memory, retrospective memory for PM task content and functional capacity with event-

based and time-based PM while controlling for age in ASD and control groups separately (see Table 7.2.). For the ASD group, retrospective memory for PM task content and retrospective memory (as measured on the List Memory Delayed) were significantly associated with event-based and time-based PM. By contrast, only the relationship between retrospective memory for PM task content and event-based PM task performance was significant for the control group. In addition, better event-based and time-based PM task performances were significantly correlated with executive functions for participants with ASD, but only time-based PM task performance was significantly correlated with working memory for controls.

Table 7.2.

Partial Correlations between PM Task Types, Retrospective Memory, Executive Functions and Functional Capacity, Controlling for Age for ASD and Control Groups Separately

	ASD <i>n</i> = 32		Control <i>n</i> = 42	
	PM event	PM time	PM event	PM time
Retrospective memory				
Task content	.77***	.50**	.66***	.28
LMD	.65***	.40*	.05	.09
Executive functions				
Cognitive flexibility	-.57**	-.37*	-.07	-.24
Inhibition	-.37*	-.22	-.04	-.15
Working memory	.57**	.55**	.12	.43**
Functional capacity	.02	.29	.05	.13

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

ASD = Autism Spectrum Disorder, PM = Prospective Memory, Task content = Retrospective memory for PM task content measured on Virtual Week-Prospective Memory, LMD = Retrospective memory measured on the NEPSY-II List Memory Delayed

7.4 Discussion

The current study adds to a growing body of literature demonstrating PM impairment in children with ASD relative to typically developing children. More specifically, consistent with our hypothesis, the first key finding was that children with ASD performed worse than controls on time-based PM tasks. This is in line with six previous studies that have identified ASD-related impairment on time-based PM (Altgassen et al., 2012; Altgassen, Williams, et al., 2009; Henry et al., 2014; Kretschmer, Altgassen, et al., 2014; Williams et al., 2013; Williams et al., 2014), and as such supports the claim that these types of PM tasks are challenging for this clinical population. In addition, the current study provided insights into the possible contributions of retrospective memory and executive functions to this difficulty. In terms of retrospective memory, the results showed that children with ASD were poorer at remembering the content of the time-based PM tasks relative to the controls, which is consistent with past findings reporting retrospective memory deficits associated with the disorder (Boucher et al., 2012; Bowler et al., 2011). We also found that poorer retrospective memory for PM task content was significantly associated with poorer time-based PM task performance the ASD group. Together, then, the current findings suggest that children with ASD have significant difficulties encoding and retaining PM task information, and that these difficulties may contribute to their time-based PM impairments. This finding contrasts with that of Henry et al. (2014) who concluded that difficulty with time-based PM tasks in children with ASD was unlikely to be related to reduced retrospective memory. However, as previously noted, their conclusion was based on the ASD group's lack of difference in performance on PM tasks that varied in retrospective memory demands rather than a direct assessment of retrospective memory for

PM task content. Although other studies have directly examined retrospective memory for PM task content (Brandimonte et al., 2011; Williams et al., 2013), the specific contribution of retrospective memory to PM performance was not explored in these studies. In sum then, our study is the first to investigate the role of retrospective memory in PM in children with ASD using a direct measure of retrospective memory. Our findings suggest that failures in the retrospective component of PM may, at least in part, contribute to failures on time-based PM tasks in this clinical group, and supports the argument that retrospective memory is integral to the successful completion of PM tasks (Ellis & Kvavilashvili, 2000; McDaniel & Einstein, 2007). Interestingly, our findings revealed that the ASD group did not significantly differ from controls on the delayed recall task which indexes the ability to recall general past information. Hence, this suggests that it is more valuable to assess retrospective memory for specific PM task content when investigating factors that might affect PM performance in children with ASD, rather than assessing more general retrospective memory ability.

Consistent with the possibility that time-based PM deficits might also be linked to reduced executive functioning ability in children with ASD, significant group differences were found on all three measures of executive function in the current study (i.e., cognitive flexibility, working memory and inhibition). This is in line with the broader literature that highlights executive dysfunction as being a common feature of the disorder (Humphrey et al., 2011; McCrimmon et al., 2016). Furthermore, two of the three executive function measures (i.e., cognitive flexibility and working memory) were significantly associated with time-based PM performance in the ASD group. These findings therefore suggest, firstly, that ASD-related deficits in time-based PM are related to poorer working memory,

which may compromise the ability to maintain the PM intention during the completion of the ongoing task while monitoring for task cues. They also suggest that time-based PM deficits may be related to lower cognitive flexibility, possibly by hindering efficient switching between the ongoing tasks and execution of the PM tasks at the appropriate points. However, it should be noted that the current findings are not in line with a past study that failed to find an association between cognitive flexibility and time-based PM in children with ASD (Williams et al., 2013) nor with another study that showed limited evidence of this relationship (Henry et al., 2014). As such, future work is needed to establish the robustness of the current pattern of findings to other clinical samples.

With regard to event-based PM, the current study showed that children with ASD performed significantly worse than controls, suggesting deficits in this aspect of PM. This finding supports past evidence from some studies that reported similar impairment (Brandimonte et al., 2011; Sheppard et al., 2016; Yi et al., 2014), but is inconsistent with others showing intact event-based PM ability in this clinical group (Altgassen et al., 2010; Henry et al., 2014; Williams et al., 2013). Our results also revealed impaired ability to remember the content of event-based PM tasks in children with ASD relative to controls and showed that poorer retrospective memory for task content was associated with poorer event-based PM in the clinical group. Because previous studies investigating event-based PM in ASD did not assess the association between retrospective memory for PM task content and PM performance (Altgassen et al., 2010; Henry et al., 2014; Williams et al., 2013; Yi et al., 2014), our findings provide the first evidence for this relationship and reinforce the argument that reduced retrospective memory for PM task content may be an important contributor to the PM difficulties in this clinical group.

In relation to executive functions, as previously noted, the children with ASD showed poorer performances on all three measures of executive functions than controls in the current study. Furthermore, given that all three executive functions were also significantly associated with event-based PM performance, this suggests that executive dysfunction may also be an important contributor to event-based PM deficits in the ASD group. While these findings are not in line with Henry et al.'s (2014) study, which did not suggest a key role for cognitive flexibility in event-based PM, they do align to some degree with the study by Yi et al. (2014). Specifically, Yi et al. (2014) found impaired event-based PM to be related to reduced working memory, although not to reduced cognitive flexibility or inhibition in children with ASD. Taken together, then, it appears that there is some evidence to suggest that executive dysfunctions are related to poorer event-based PM function in children with ASD, further emphasising the importance of executive functions in supporting the completion of PM tasks (Mahy, Moses, et al., 2014). However, given limited number of studies and the mixed findings to date, more work is needed to further clarify the nature and extent of these relationships in this clinical group.

Within the context of typical development, our findings revealed that better retrospective memory for PM task content was associated with better event-based PM performance, but not with better time-based PM performance in the control group (i.e., typically developing children). Such a pattern of findings is perhaps unsurprising as event-based PM task performance is more likely to be a reflection of the capacity to remember PM task content and less influenced by variations in other complex cognitive skills, at least for typical developing populations, considering that cognitive demands are generally lower for event-based tasks compared to time-based tasks (Einstein & McDaniel, 1996; McDaniel

& Einstein, 2007). This claim is supported, for example, by the current findings which showed a lack of association between executive functions and event-based PM, but a positive association between executive function (specifically working memory) and time-based PM. This relationship between time-based PM and working memory was also reported in another recent study of typically developing children (Zuber et al., 2019). Given that time-based tasks require the ability to self-monitor for task cues, as previously mentioned, these findings together may suggest that time-based PM specifically imposes demands on working memory because PM intentions may need to be constantly rehearsed in mind so that PM tasks can be performed at the appropriate time (McDaniel & Einstein, 2007; Williams et al., 2014; Zuber et al., 2019). That said, because the current study and the study by Zuber et al. (2019) found that time-based PM was not associated with cognitive flexibility and inhibition, these findings together suggest that executive functions may play a less central role in time-based PM for typically developing populations than previously argued in the literature (Kliegel et al., 2008; Mahy, Moses, et al., 2014). As such, future studies should aim to explore other possible cognitive abilities such as time-monitoring to achieve a more comprehensive picture of the contributors to time-based PM performance in typically developing children.

Other notable findings in the current study were that both children with ASD and controls performed significantly worse on time-based PM relative to event-based PM tasks, and also showed poorer retrospective memory for time-based PM task content than event-based PM task content. These results therefore suggest that the greater impairments in time-based PM relative to event-based PM in the ASD group may partly be explained by poorer ability to remember time-based PM task content than event-based PM task content. This

then raises the question of why this might be the case. It is unlikely to be due to varying retrospective demands across the two PM task types, as both similarly require the ability to encode and retain information related to the PM tasks. Instead, one possibility is that during the process of encoding PM intentions, it might be easier to imagine the context in which an event-based task needs to be carried out (e.g., buy milk at the supermarket) than when a time-based PM task is to be performed (e.g., ring the plumber at 5 p.m.). Mentally pre-experiencing the specific context in which the PM task needs to be completed may thus strengthen encoding of the association between event-based PM task cue and execution of the PM task, leading to greater likelihood that the PM intention will be retrieved and executed when the task cue is encountered (Altgassen et al., 2015; Schacter et al., 2017; Szpunar, 2010). There is indeed emerging evidence showing a link between episodic future thinking (i.e., the ability to mentally pre-experience hypothetical self-relevant future scenarios; Atance & O'Neill, 2001), retrospective memory for PM task content, and PM performance in typically developing children of a similar age group to that in the current study (Terrett et al., 2019). Episodic future thinking may therefore be another important contributor that underpins PM task performance in children with ASD. This possibility is worthy of direct investigation in future empirical studies, particularly given that episodic future thinking has been shown to be impaired in this clinical group (e.g., Hanson & Atance, 2014; Terrett et al., 2013).

The final aim of the current study was to examine whether PM difficulties were related to functional capacity in children with ASD. Our results revealed that there were no associations between functional capacity and event-based or time-based PM in either groups. These findings were unexpected because they did not support the argument that PM

is crucial in supporting daily functioning in children (Mahy, Moses, et al., 2014), and are not in line with past findings of a relationship between time-based PM and functional capacity in children with ASD (Henry et al., 2014). It is possible that these discrepant findings could reflect differences between the two samples of children with ASD in their exposure to interventions that aim to improve daily functioning, which were neither assessed in the current study nor reported in Henry et al.'s study. Another possibility is that the Self-Direction subscale on the ABAS-II may be limited in capturing the relevant aspects of daily functioning that might be related to PM in children. Since this is only the second study to examine whether PM difficulties relate to functional outcomes in children with ASD, further research will be needed to clarify these relationships.

In sum, our findings contribute to the growing evidence of impaired time-based PM ability in children with ASD and add to the currently mixed literature on event-based PM ability, specifically supporting past studies that suggest this aspect of PM is also impaired. Importantly, our results identified difficulties in retrospective memory for PM task content and executive functioning as potential cognitive abilities that contribute to the pervasive impairments in PM performance in children with the disorder. Given that there remains limited understanding about the mechanisms underlying PM performance in this clinical group, it is suggested that future studies focus on delineating these mechanisms. Such research could shed further light on the possible preserved or impaired mechanisms that support or hinder the completion of PM tasks. Furthermore, our findings suggest that retrospective memory for PM task content and executive functioning could be targeted in interventions to improve PM performance in children with ASD. Finally, although significant associations between PM abilities and functional capacity were not detected in

the current study, future studies could explore the influence of PM on functional outcomes in children with ASD using a more appropriate daily functioning measure that might be more closely linked to PM ability.

Chapter 8: General Discussion

Preamble

This final chapter aims to integrate the findings of the three empirical studies presented in Chapters 5, 6 and 7 in the current thesis. The chapter will begin by reiterating the objectives of the three studies and summarising the results of each, followed by a discussion of the implications of these findings. Limitations and strengths of the overall research project will be presented before concluding the chapter with a section highlighting the importance of further research on prospection in children with ASD.

8.1 Summary of Aims and Results of Empirical Studies

8.1.1 Study 1

The aim of Study 1 was to investigate whether difficulties in scene construction and/or self-projection through time might contribute to impairments in episodic future thinking in children with ASD. The results firstly demonstrated that children with ASD performed worse than controls when asked to imagine and describe a personal future scenario, thus confirming past findings of an impairment in episodic future thinking in this group. However, the findings of Study 1 also extended the ASD literature by showing that difficulties in scene construction may be a key factor underlying these episodic future thinking deficits, while difficulty in self-projection through time does not appear to be a major contributor. In addition, the data revealed that compromised general perspective shifting ability may be additionally contributing to impairments in episodic future thinking in this clinical group.

8.1.2 Study 2

The primary aim of Study 2 was to extend prior research in ASD by investigating whether the functional aspect of episodic future thinking (i.e., episodic foresight) might be impaired in children with the disorder. This study also aimed to identify the extent to which any deficits in episodic foresight in ASD might be contributed to by difficulties in retrospective memory and/or executive functions. Moreover, Study 2 examined whether any deficits in episodic foresight in ASD might be related to poor adaptive functioning. This study provided the first evidence of a reduced capacity for episodic foresight in children with ASD using a novel behavioural measure that was developed based on the four criteria proposed by Suddendorf and colleagues (Suddendorf & Busby, 2005; Suddendorf

& Corballis, 2010; Suddendorf et al., 2011). More specifically, the findings revealed that while children with ASD were able to correctly acquire beneficial items in anticipation of potential future problems as well as controls, they were less able to subsequently use these items to solve the problems at the appropriate point in the future. This difficulty was not attributable to deficits in retrospective memory or executive functions. Finally, the results of Study 2 showed that better episodic foresight ability was associated with better functional capacity in controls, but no relationship was found between episodic foresight and adaptive behaviour in daily life in children with ASD.

8.1.3 Study 3

The primary aim of Study 3 was to investigate the pattern of performances on event-based and time-based PM tasks in children with ASD using a reliable measure called VW-PM. In addition, this study aimed to explore whether PM impairments might be related to difficulties in retrospective memory and/or executive functions, and poor adaptive behaviour in daily life in this clinical group. Study 3 is only the second in the literature to examine both event-based and time-based PM within the same sample of children with ASD in a context that simulates everyday life using a reliable PM measure. The findings revealed pervasive deficits across both event-based and time-based PM tasks types in children with ASD relative to controls. Failures to complete event-based and time-based PM tasks were related to poor retrospective memory for PM task content as well as disruptions in executive functioning in this clinical group. However, no associations were found between PM abilities and adaptive behaviour in daily life in either children with ASD or controls.

8.2 Contributions of the Study Findings to the ASD Literature

Children with ASD have well-established deficits on a range of cognitive abilities including theory of mind, executive functioning, episodic memory and relational memory, and these deficits have been argued to contribute to the functional difficulties associated with ASD (Bowler et al., 2011; Brent, Rios, Happé, & Charman, 2004; Craig et al., 2016; Kenny et al., 2019; Kring, Johnson, Davison, & Neale, 2014). By contrast, cognitive abilities of children with ASD in relation to prospection have attracted much less empirical attention. By focusing on this area, specifically on the key aspects of episodic future thinking (including episodic foresight) and PM, the current thesis extends the ASD literature by providing a more fine-grained profile of abilities in the area of prospection. More specifically, the current results indicate that different forms of prospection may be additional areas of cognitive impairment for children with the disorder. However, another key contribution of the current project was the positive finding that the capacity to initiate preparatory behaviours in the present in anticipation of future events, a core aspect of episodic foresight, appeared intact in children with ASD. This is an important finding as it may have important implications for the development of treatment approaches that aim to improve episodic foresight.

8.3 Implications for Interventions in Children with ASD

Children with ASD are often reported to struggle coping with the demands of everyday living, leading to poor functioning in the classroom and at home (Jordan, 2011; Mckeithan & Sabornie, 2019; Thomeer et al., 2019). Consequently, a range of classroom and home strategies have been developed and used by parents and teachers to support the needs of children with the disorder (Clark, Adams, Roberts, & Westerveld, 2019;

Mckeithan & Sabornie, 2019; Stokes et al., 2017). In addition, in clinical practice, interventions have been tailored for high-functioning children with ASD to remediate well-established cognitive deficits experienced such as executive dysfunction (McCrimmon et al., 2016). However, given the limited research on episodic future thinking and episodic foresight in children with ASD, no studies have yet reported the development of appropriate interventions for the remediation deficits in these abilities in this group. The findings of the current thesis are thus valuable in expanding current knowledge about this aspect of cognitive functioning in children with ASD and can help inform and guide the development of strategies to support it.

One possible avenue could be to adapt current interventions targeting other aspects of cognitive impairment in ASD such as episodic memory deficits, to address specific impairments in episodic future thinking, including episodic foresight, in this clinical group. For example, this could include adapting story-based interventions that have been proposed to be a useful approach in targeting impairments in recalling details of specific past events in children with ASD (Hutchins & Prelock, 2018). In this intervention, children are asked to reconstruct past scenarios in a story-based format with the support of an adult. Visual cues are used, as appropriate, to prompt children to draw a series of pictures of those past scenarios detailing what they saw, smelled, heard, thought and felt as a way of enhancing their re-experiencing of the past. The children are also asked to reflect on how their past experiences could guide their future behaviours (Hutchins & Prelock, 2018). It may be feasible then that this type of story-based intervention could be extended to target the impaired capacity to mentally construct and pre-experience hypothetical future scenarios.

Story-based interventions could also be extended to incorporate scenarios that require the application of episodic foresight, such as presenting situations in which children are required to acquire and use items to solve problems in anticipation of imagined future scenarios. Given the findings of Study 2 showed an intact capacity to acquire items but an impaired capacity to subsequently use the acquired items, however, it may be that specifically targeting impairments in the latter capacity might be most beneficial in increasing successful application of episodic foresight. For instance, using the story-based intervention, children may first be encouraged to independently initiate preparatory behaviours for an anticipated future and then taught to generate rich details of a range of scenarios in which their previously secured benefits may be adaptively applied at future time points. This may in turn increase the likelihood that they will recognise the appropriate context in which actions should be taken to achieve the most desirable outcomes. Such a direct training approach to improve cognitive functioning has been shown to be effective in past studies (Rose et al., 2015; Schaffer & Geva, 2016; Zhao, Fu, & Maes, 2019), and thus may be a potential treatment option for the remediation of deficits in episodic future thinking and episodic foresight, in children with ASD.

In relation to PM, there is currently limited understanding of strategies that may be useful in remediating deficits in this capacity in children with ASD. Research with other clinical populations may, however, inform the development of potential approaches to target PM impairments in this group. For example, compensatory strategies such as the use of external aids have been implemented to support successful PM performance in daily life for individuals with acquired brain injury (Mahan, Rous, & Adlam, 2017; Raskin, Williams, & Aiken, 2018) and older adults with Alzheimer's disease (Oriani et al., 2003).

These external aids may be an audio-visual message alert on a smartphone or an alarm tone to remind an individual to carry out required PM tasks at the appropriate future points (Dewar, Kapur, & Kopelman, 2018; Ewald, 2015; Mahan et al., 2017). These types of external devices may reduce demands on cognitive resources such as executive functions that may be involved in monitoring appropriate cues for task performance (Mahan et al., 2017; Talbot, Müller, & Kerns, 2018), and thus support the successful execution of PM tasks. Given the findings in Study 3 showed that children with ASD have significant difficulties carrying out PM tasks, the use of such external devices may therefore be helpful for this group. However, it should be noted that the findings in Study 3 also revealed that failures of the ASD group to complete PM tasks were related to a reduced capacity to remember specific PM task content. As such, strategies that primarily aid the execution of PM tasks at appropriate future points (e.g., an alarm tone) may not be sufficient to support successful task completion in children with ASD. Additional strategies may therefore be required to compensate for their difficulties with encoding and retention of PM task information (i.e., what action is required and when it is to be performed). One option could be that the use of electronic devices such as smartphones be extended to also save details of specific PM task content, as well as prompt the execution of PM tasks (Ewald, 2015).

While electronic devices such as smartphones have the capacity to provide valuable support for both the retrospective and prospective aspects of a PM task, they may not, however, be easily accessible in classroom settings for children to use. In that context then, it is suggested that other devices appropriate for children could be used to cue task execution, such as MotivAider which silently vibrates at specific set times (Moore, Anderson, Glassenbury, Lang, & Didden, 2013). This could be implemented together with

strategies that help alleviate difficulties in retrospective memory for PM task content, such as visual schedules. Visual schedules are commonly adopted in classrooms and at home to manage executive dysfunction and alleviate anxiety associated with unpredictability in children with ASD (Kellems, Gabrielsen, & Williams, 2016; McCrimmon et al., 2016), and could potentially be adapted to support PM performance (Altgassen et al., 2010; Altgassen, Williams, et al., 2009; Kretschmer, Altgassen, et al., 2014). More specifically, written instructions for the completion of PM tasks (i.e., what is to be performed and when to perform the tasks) may be incorporated into visual schedules to compensate for retrospective memory difficulties. Such an integrated approach to help manage difficulties regarding retention and execution of PM tasks in children with ASD may reduce their dependence on adults to provide prompts for task completion and in turn can facilitate independence in the classroom and at home.

Another approach to improving PM performance in children with ASD could be via training this group to implement strategies that enhance encoding of PM task content. This may involve making explicit plans about when, where, and how a PM task will be performed at a specific point in the future (e.g., When I walk into the classroom in the morning, I will hand the signed school note to the teacher; Foster, McDaniel, & Rendell, 2017; Mioni, Rendell, Terrett, & Stablum, 2015). It has been argued that this strategy, which often referred to as *implementation intentions*, is effective in facilitating PM task performance through strengthening associations between PM cue (i.e., walking into the classroom) and PM action (i.e., handing the school note to the teacher). Stronger encoding of the link between PM cue and action may lead to increased likelihood of automatic retrieval of the intended action, resulting in higher chances of successful performance of the

PM task (Foster et al., 2017; Spiess et al., 2016). There have in fact been preliminary findings of the beneficial effects of this strategy on PM task completion in adults with ASD (Kretschmer, Altgassen, et al., 2014), and as such it could also be used with children with ASD.

8.4 Future Research Directions

As noted, episodic foresight is a largely overlooked area of study in the current literature on prospection. However, given the suggested impact of this capacity on successful daily functioning, it is perhaps not surprising that there has been a recent call for increased research on this topic (Miloyan, McFarlane, & Suddendorf, 2019). After all, it has been argued that the primary function of imagining the future is to modify behaviours accordingly in the present to achieve optimal future outcomes (Baumeister et al., 2016; Suddendorf & Corballis, 2007). The first avenue for future research would therefore be to conduct further investigations of episodic foresight ability in ASD, and perhaps in other vulnerable clinical populations, to more clearly establish the extent and nature of impairments in this ability in these groups. However, it appears that there is currently a limited number of appropriate measures of episodic foresight in the literature. Therefore, an additional area of future research would be the further development of measurement approaches for episodic foresight based on the criteria proposed by Suddendorf and Corballis (2010). It is also suggested that researchers should consider an increased use of the VW-Foresight measure in future studies to investigate episodic foresight. In VW-Foresight, episodic foresight was operationalised as the capacity to acquire useful items in the present to avoid anticipated future problems and the capacity to use the acquired items

at appropriate future points to achieve the most desirable outcomes. This proved to be a valuable approach as it revealed an uneven profile of episodic foresight ability in children with ASD. The VW-Foresight measure as well as the development of other measures reflecting the principles outlined by Suddendorf and Corballis (2010) may therefore help identify specific areas of impairment in episodic foresight in clinical groups, which will in turn guide the development of tailored interventions targeting these impairments.

Additional research would also be valuable to further deconstruct mechanisms that underlie episodic future thinking, episodic foresight and PM in children with ASD. For example, it is suggested that the capacity to pre-experience the self in mentally simulated future scenarios may be a critical foundation for episodic foresight and PM. It may therefore be proposed that episodic future thinking, episodic foresight and PM are closely related forms of prospection. However, current understanding of the links between these future-oriented cognitive abilities remains limited in the literature as most past studies have investigated episodic future thinking and PM in isolation, and very few studies have explored episodic foresight. Although there is emerging evidence of an association between episodic future thinking and PM (Altgassen, Kretschmer, & Schnitzspahn, 2017; Altgassen et al., 2015; Kretschmer-Trendowicz et al., 2019; Nigro, Brandimonte, Cicogna, & Cosenza, 2014; Terrett et al., 2019; Terrett, Rose, et al., 2016), there are no studies to date that have examined episodic future thinking in relation to episodic foresight. Increased research will be needed to delineate processes that link the different forms of prospection to develop a better understanding of how deficits in common underlying abilities may simultaneously affect higher-order forms of prospection in individuals with ASD. Thus,

establishing a finer-grained profile of prospection abilities will enhance understanding of the disorder and determine specific areas of support needed for this clinical population.

8.5 Limitations and Strengths of the Overall Research Project

While the current research project has provided novel insights into prospection in children with ASD, there are some limitations that should be acknowledged. Firstly, it should be noted that the confirmation of ASD diagnoses was obtained via clinical reports from relevant professionals (i.e., paediatricians and psychologists) and supported by the results of the SCQ. However, information regarding the presence of other possible common comorbid developmental disorders or psychiatric conditions such as attention-deficit/hyperactivity disorder, oppositional defiant disorder and anxiety disorder was provided by parents of the children with ASD. Hence, it may be that some children with ASD recruited for the current project may also have had other conditions not yet formally diagnosed by clinicians. The potential inclusion of children with ASD who have comorbid conditions may impede an accurate understanding of prospection associated with ASD.

Secondly, the List Memory Delayed task used to index retrospective memory in Studies 2 and 3 appears to primarily assess the ability to recall a list of meaningless, unrelated words, which may not be relevant for the application of episodic foresight and PM in everyday life. Future studies should therefore consider using a different measure of memory, such as a more specific episodic memory measure, to allow further understanding of the role of specific types of memory in prospection in children with ASD. In addition, the ABAS-II Self-Direction subscale (Harrison & Oakland, 2003) used in the current research may not have captured the relevant aspects of daily functioning that might be

related to episodic foresight and PM. For example, while some items relevant to prospection are included within the Self-Direction subscale (e.g., “Plans ahead to allow enough time to complete big projects”), other items appear to be less relevant (e.g., “Works hard on assigned tasks or chores that are not liked”). A combination of these different types of items may cause this subscale to be less sensitive to prospection difficulties. This may have partially contributed to the non-significant relationships between aspects of prospection and adaptive functioning in Studies 2 and 3. Furthermore, the Self-Direction subscale only taps a relatively restricted domain of adaptive functioning. Future research should therefore consider assessing a wider range of adaptive skills and using a measure of daily functioning that reflects more closely the adaptive functions of prospection. This will in turn enable a better understanding of whether poor episodic foresight and PM might contribute to the poor functional outcomes observed in children with ASD.

Thirdly, it is noted that the precise executive processes that may be involved in episodic future thinking and episodic foresight cannot yet be fully determined in the current thesis. This is because there remains a paucity in research on the relationship between executive functioning and episodic future thinking or episodic foresight. In addition, most past studies in the broader literature have used different tasks to examine executive functioning, leading to the current lack of specificity in identifying which executive functions might be most implicated in episodic future thinking and episodic foresight. Increased research studies with the aim of systematically examining specific types of executive functions will therefore be useful in providing a clearer picture of which specific executive processes might be related to episodic future thinking and episodic foresight.

Despite the limitations in the current research project, there are a number of strengths that should be highlighted. The first is the inclusion of a large battery of cognitive measures in our testing protocol which allowed investigation of the relationships between a wide range of cognitive functions and prospection. Thus, our findings across the three studies have provided a comprehensive understanding of key aspects of prospection and their underlying mechanisms in children with ASD. Moreover, the empirical studies in the current thesis included relatively large samples of children with ASD ($n > 30$) in comparison to past studies of prospection which mostly comprised small samples of participants with ASD ($n \leq 20$). Larger samples of participants included in the current project thus provided greater power for the statistical analyses performed, in turn increased reliability of the obtained findings. Although larger sample sizes would have been desirable for the correlational and regression analyses in Studies 2 and 3 (as discussed in Chapter 4), findings in these studies have nevertheless provided preliminary understanding of the possible cognitive abilities that might be related to episodic foresight and PM. Future studies should aim to replicate these two studies with larger samples for increased confidence in the obtained findings.

Another strength of this research project was the use of a novel behavioural measure of episodic foresight that was developed strictly according to the proposed criteria in the literature (Suddendorf & Busby, 2005; Suddendorf & Corballis, 2010). As mentioned in Chapter 2, the use of a measure based on these criteria leads to increased confidence that the future-directed behaviours observed in participants were the result of the application of episodic foresight rather than other factors (Suddendorf & Busby, 2005). Although the reliability estimates would ideally have been higher on the VW-Foresight measure, it can

nevertheless be viewed as a valuable tool in assessing episodic foresight given its successful use in past adult studies (e.g., Lyons et al., 2019; Terrett, Lyons, et al., 2016). It is also acknowledged that further investigation of the validity of VW-Foresight two-day version in children will be required to increase confidence of its use in future studies. Considering the potential value of this measure in studies with various paediatric populations to investigate episodic foresight, it will therefore be beneficial for future research to invest in the refinement of the children's version of VW-Foresight.

Lastly, Study 3 in the thesis is one of the few studies in the current ASD literature that has employed a reliable behavioural measure of PM. As noted in Chapter 7, the reliability estimates for PM tasks on VW-PM in the current samples were found to be relatively high for both children with ASD and typically developing children. Furthermore, rather than repetitively pressing keys on a keyboard in response to target PM cues as in the typical laboratory-based measures of PM, the use of VW-PM allowed the assessment of PM abilities in a simulated everyday life context. Thus, results obtained on VW-PM reflect PM abilities that arguably have more direct relevance to real life functioning. As such, the current findings are suggested to be valuable in informing the development of effective strategies that are more applicable to the daily situations encountered by children with ASD. However, it is noted that increased research will be needed to investigate the validity of the measure in paediatric clinical populations.

8.6 Conclusions

Relative to the wealth of knowledge on various cognitive deficits such as theory of mind and executive functioning reported in children with ASD, research on episodic future

thinking, episodic foresight and PM has been somewhat neglected in the ASD literature. Whilst there is growing evidence of impairments in these abilities, much more remains to be understood regarding these cognitive abilities and how they might be compromised in this clinical group. This thesis extends our current knowledge of the cognitive deficits associated with ASD by shedding light on the specific areas that are intact and compromised in key aspects of prospection, as well as delineating the nature of these deficits. The unique pattern of results shown in this thesis may be an important stepping stone for future research to further explore different forms of prospection in children with ASD. A greater understanding in this area could in turn guide implementation of appropriate strategies to help alleviate difficulties in daily living for these children. The provision of a better support system for children with ASD could maximise their learning potential which will contribute to better developmental outcomes in life.

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Appendices

Appendix A. Screenshots of the Children's Version VW-Foresight Game


Appendix A – 1 An Example of VW-Foresight Situation Card with Problem Presentation

Situation

Trial

Getting Ready

Your Stored Items



As you are rushing around to get ready for school you drop your glasses and one of the lenses breaks! You tell yourself that you will deal with it later because you can't be late.

Before leaving you:

- brush your teeth
- watch TV
- pack your bag

OK

Appendix A – 2 An Example of VW-Foresight Daily Activity Card for Item Acquisition

ActivityCardWindowLabel

Trial

School



At school you sit at your desk. Your teacher comes over and starts looking through your desk drawer. "What a mess!" she says, "Clean it up, it's full of old junk!"

You take out:

- some chewing gum
- your old pair of glasses
- a pen
- a rotten apple
- your old sport socks

OK


Appendix A – 3 An Example of VW-Foresight Situation Card for Item Use

Situation

Trial

Watching a Movie

Your Stored Items



After a long day, you look for a comfy spot to sit to watch your movie.
You turn on your movie and realise it looks blurry!

To get comfortable you:

- get more cushions
- get out a warm blanket
- get a cup of hot chocolate

OK

Your Stored Items

Use...

- your towel
- your old pair of glasses
- a doughnut
- some Lego
- a bag of dog treats

Done

Appendix A – 4 An Example of VW-Foresight Distractor Situation Card

Situation

Trial

Breakfast

Your Stored Items



It's breakfast time, and you are starving! You take out some cereal and decide you will have something different with it.

With your cereal, you have:

- yoghurt
- honey
- chocolate milk


OK

Appendix A – 5 An Example of VW-Foresight Distractor Daily Activity Card

ActivityCardWindowLabel

Trial

Shower



After breakfast you have a shower. Looking in your bedroom you see some things your mum has been nagging you to put in the bathroom.

You take in:

- your towel
- a shower radio
- a hairbrush
- a new soap
- a rubber duckie

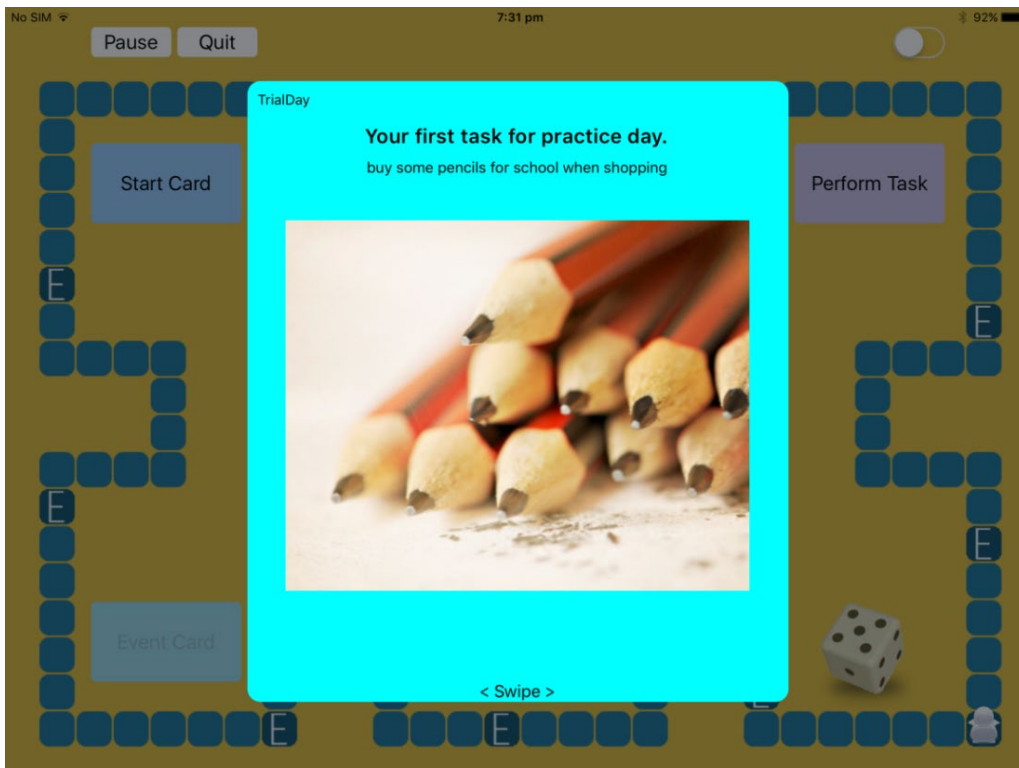
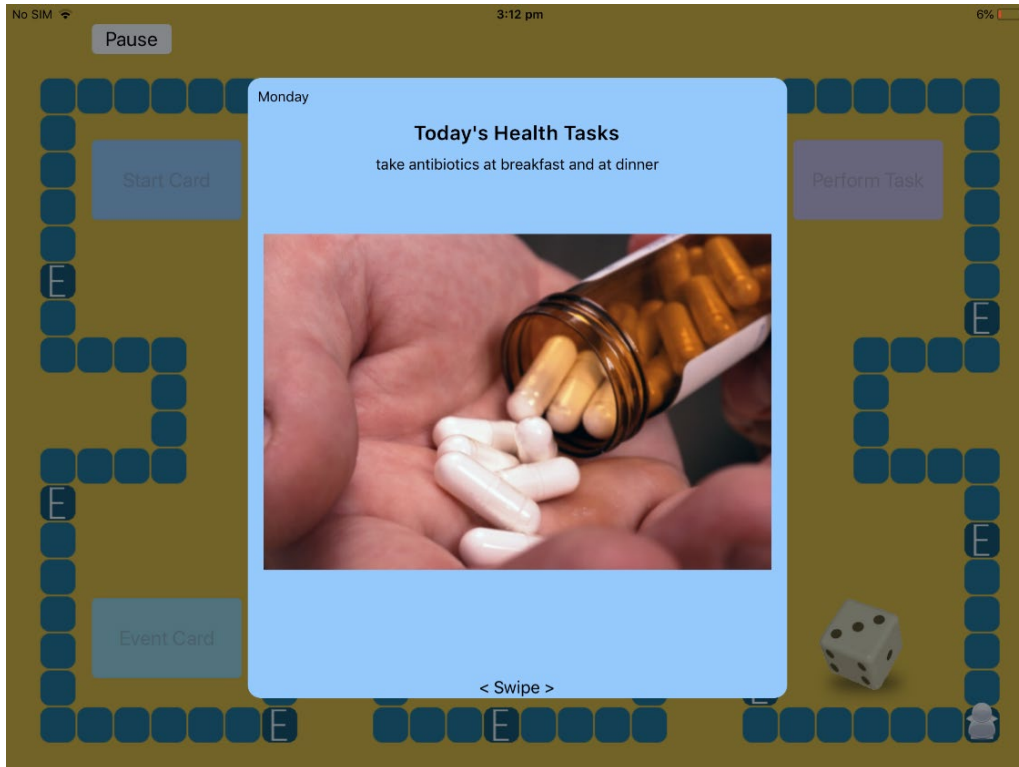
OK

Appendix B. Screenshots of the Children's Version VW-PM Game

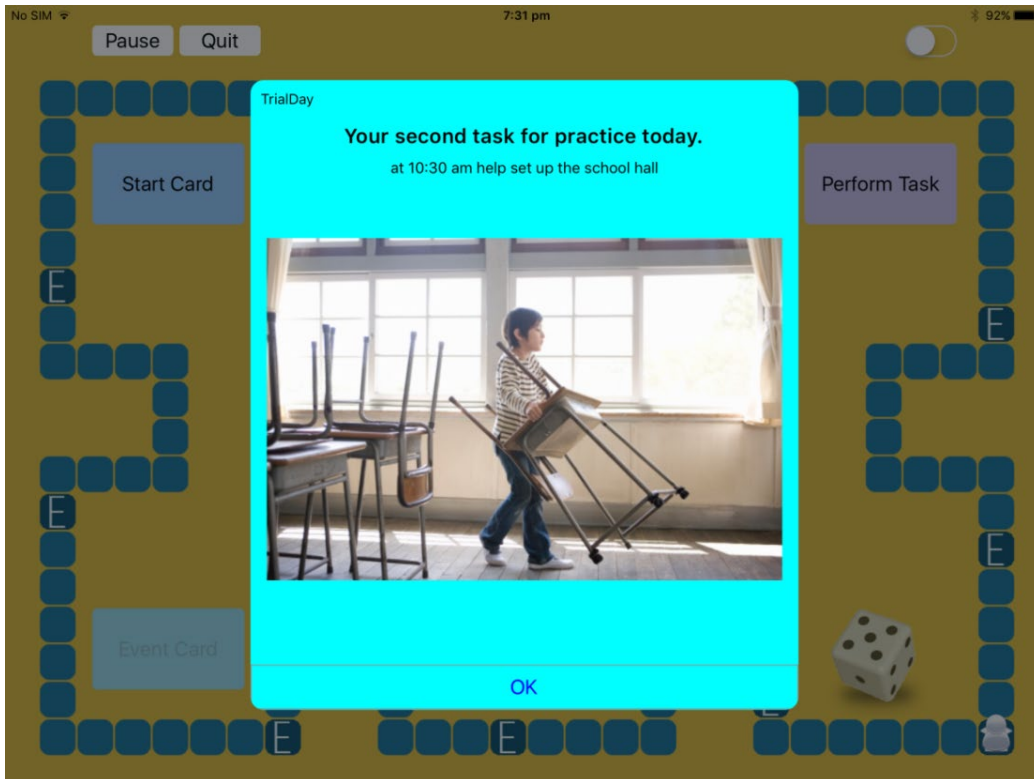
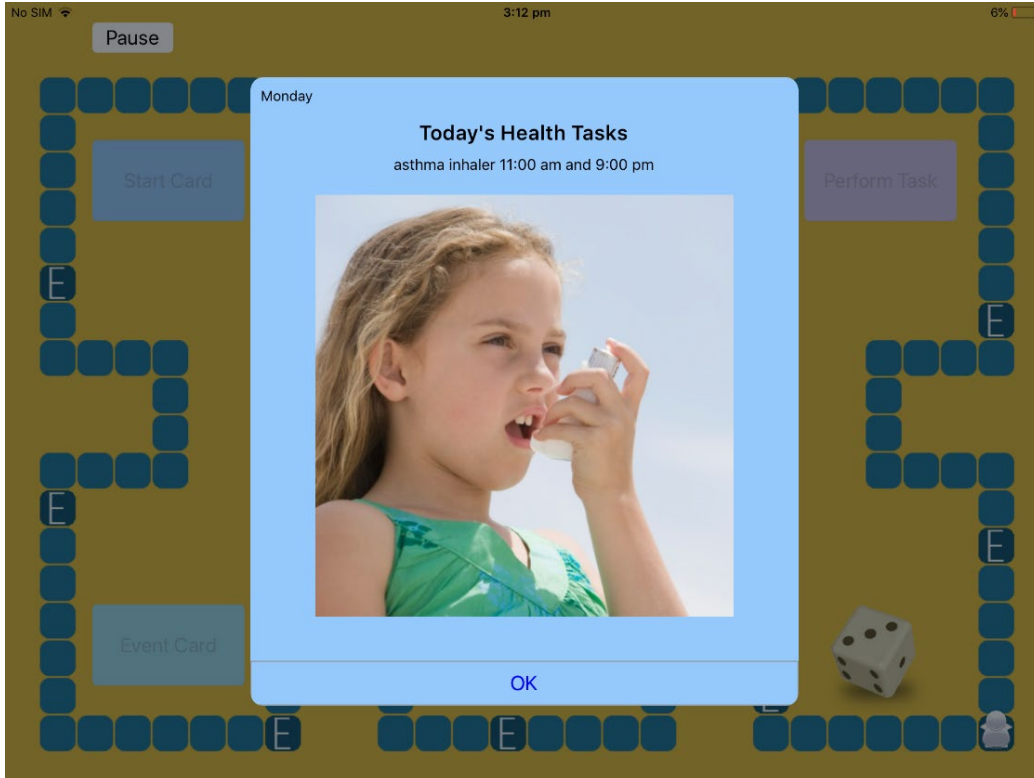
Appendix B – 1 An Example of VW-PM Event Card



Appendix B – 2 Examples of VW-PM Event-Based PM Tasks



Appendix B – 3 Examples of VW-PM Time-Based PM Tasks



Appendix B – 4 An Example of VW-PM Perform Task List

iPad 4:11 pm 88%

Pa TrialDay

Perform Tasks

- borrow a ds from your friend
- buy a Christmas present for your aunt
- hand school note to parents
- help set up the school hall
- buy some pencils
- wash your dog
- go to the doctor's to remove your stitches
- phone your sick friend

OK

Appendix B – 5 Examples of VW-PM Task Review Cards

12:03 pm Tue 10 Sep 33%

Task Review

buy some pencils

Not Required

when shopping

home before dinner

8:00 PM

10:30 AM

Task Review

This screenshot shows a mobile application interface. At the top, the status bar displays the time as 12:03 pm on Tuesday, September 10, and the battery level at 33%. The app's header is titled 'Task Review'. The main content area features a light blue background with a white card in the center. The card's title is 'buy some pencils'. Below the title, there are several input fields: 'Not Required', 'when shopping', 'home before dinner', '8:00 PM', and '10:30 AM'. The card is set against a background of a grid of blue squares, some of which contain the letter 'E'. A home indicator bar is visible at the bottom of the screen.

No SIM 1:16 pm 68%

Task Review

borrow a ds from your friend

Not Required

when shopping

home before dinner

8:00 PM

10:30 AM

Task Review

This screenshot shows a mobile application interface. At the top, the status bar displays the time as 1:16 pm and the battery level at 68%. The app's header is titled 'Task Review'. The main content area features a light blue background with a white card in the center. The card's title is 'borrow a ds from your friend'. Below the title, there are several input fields: 'Not Required', 'when shopping', 'home before dinner', '8:00 PM', and '10:30 AM'. The card is set against a background of a grid of blue squares, some of which contain the letter 'E'. A home indicator bar is visible at the bottom of the screen.

Appendix C. Ethics Approval

From: Ms Pratigya Pozniak [<mailto:pratigya.pozniak@acu.edu.au>]
Sent: Wednesday, 16 September 2015 2:08 PM
To: Gill Terrett
Cc: Pratigya Pozniak
Subject: V2010 12 Modification Approved

Dear Gill,

Ethics Register Number : V2010 12
Project Title : Prospective Memory and High Functioning Autism ('Future thinking in children with high functioning autism'.) End Date : 31/12/2016

Thank you for submitting the request to modify form for the above project.

The Chair of the Human Research Ethics Committee has approved the following modification(s) subject to replacing the word ' requires' with 'asks' in the Information Letter (The second questionnaire requires parents to answer 40 questions about their child's social functioning. The third questionnaire 'asks' parents to answer questions about their child's daily living skills.) and updating Research Ethics Manager contact details to North Sydney (not Melbourne):

1. Add two new student researchers (Jiu-Swan Chua and Ellen McDermott) to the research program 2. Modify the Information Letters, Consent forms and Recruitment/Expression of Interest flyers by removing the names of two other students (Madeleine Jolly, Roxanne White) and including the names of new student researchers (Jiu-Swan Chua and Ellen McDermott) 3.To change the measure of children's future thinking ability from an interview format measure to a computer board game measure(the game is already approved in this ethics program approval).
4. To include a daily living skills questionnaire for the parents to complete. (Again, this is a questionnaire that is already approved by this ethics program approval).
5. To change the background memory test to a slightly different memory test for the specific projects Jiu-Swan and Ellen will conduct 6. To extend the approved end date to 31/12/2016

We wish you well in this ongoing research project.

Kind regards,
Ms Pratigya Pozniak

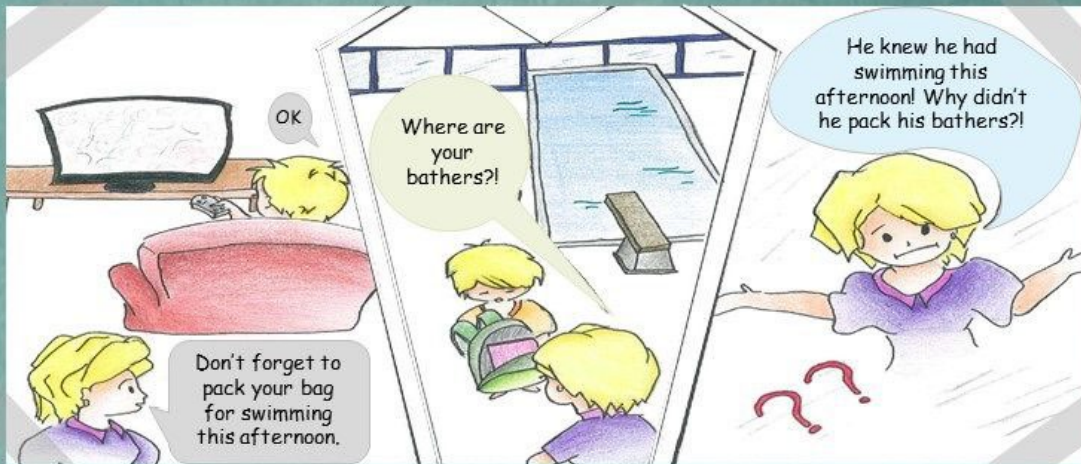
Ethics Officer | Research Services
Office of the Deputy Vice Chancellor (Research)

...
T: F:

THIS IS AN AUTOMATICALLY GENERATED RESEARCHMASTER EMAIL

Appendix D. Recruitment Flyer

WHY CAN'T MY CHILD PLAN AHEAD?



Have you been in situations like this before?

Help us understand more about how well children with autism plan ahead by participating in our research study!

We are looking for:

Children aged 8-12 years with high-functioning autism or Asperger's syndrome.

Two movie vouchers will be given to thank you for your time!



Cognition & Emotion
Research Centre

Contact

Serene Chua
jiuswan.chua3@myacu.edu.au
0490 307 412
HREC number: V201012

Appendix E. Expression of Interest Form



**Cognition & Emotion
Research Centre**



PARTICIPANTS NEEDED!



Have you ever wondered why your child just can't seem to plan ahead? Well we are researching this very thing! We are investigating children's ability to imagine themselves in future scenarios and how this affects their everyday living skills. We are interested in understanding this ability in children with autism spectrum disorder and children without autism.

You and your child are invited to participate in this study if your child is 8-12 years old, and has high functioning autism or Asperger's syndrome OR without a diagnosis of autism.

What is involved?

1. As part of the study and to assess children's memory and ability to think about the future, your child will participate in two computer games that are designed especially for children. The computer games simulate an actual week and represent tasks that occur in everyday life that require the ability to anticipate future events.
2. Your child will also be administered a series of tasks. These tasks include answering verbally presented questions and following instructions.
3. Parents are asked to complete three questionnaires regarding their children. This should take around 30 minutes to complete.
4. These tasks will be completed over two sessions which will take approximately 1-2 hours in each session. These can take place at a mutually convenient time and location - such as your home or at the Fitzroy campus at Australian Catholic University. We ask at least one parent to be present during these sessions.
5. Parents/Guardians are able to receive a summary of the results of the study on the completion of the project, however, individual results are unable to be discussed.

This study is conducted by Jiu-Swan (Serene) Chua as part of her postgraduate degree in psychology and is part of an ongoing research into future thinking in children by Professor Peter Rendell (HREC number: V201012). Parents and children will be reimbursed with a child and an adult movie ticket as a sincere thank you for your time. Any questions regarding this project can be directed to Prof. Peter Rendell on 03 9953 3126 or Associate Prof. Gill Terrett on 03 9953 3121 in the School of Psychology at ACU, 115 Victoria Parade, Fitzroy 3065. If you are interested in participating in this study or would like more information, please feel free to contact Jiu-Swan (Serene) Chua on 0490 307 412 or email to jiuswan.chua3@myacu.edu.au.

Thank you and we look forward to hearing from you.

Expression of interest to participate in remembering everyday tasks study

I am interested in participating in the Future Thinking in Children study. I agree to be contacted by telephone to confirm my and my child's participation and, if I agree to participate, arrange a mutually convenient time to complete the research task.

Signature:

Child's date of birth:

Phone:

Appendix F. Information Letters

Appendix F – 1 Information letters for ASD



**Cognition & Emotion
Research Centre**



TITLE OF PROJECT: Future Thinking in Children with High Functioning Autism
PRINCIPAL SUPERVISOR: Associate Prof. Gill Terrett and Prof. Peter Rendell
STUDENT RESEARCHER: Jiu-Swan (Serene) Chua
COURSE: Master of Psychology (Educational and Developmental) and Doctor of Philosophy

INFORMATION LETTER TO PARTICIPANTS

Dear Parents / Guardians,

You and your child are invited to participate in a study that focuses on investigating whether or not future thinking is affected by autism spectrum disorder. Future thinking is sometimes referred to as mental time travel. This is the ability to imagine future events and it appears to be crucial for planning ahead in daily life. As your child has an existing diagnosis of high-functioning autism or Asperger's syndrome and is of a similar age and gender to a group of typically developing children, we are inviting you and your child to participate in the study.

This study is conducted by Jiu-Swan (Serene) Chua as part of her postgraduate degree in Psychology and is part of ongoing research into future thinking in children by Professor Peter Rendell. It is emphasised that the measures used are primarily for the collection of research data and that this study will not attempt to provide a diagnosis or treatment of memory problems or autism. If you have concerns about these matters, we encourage you to see your general practitioner.

If you allow your child to take part in the study, he/she will complete a brief set of cognitive tasks that measure their intellectual ability, executive functioning and perspective taking. These tasks involve your child answering verbally presented questions and pointing to the appropriate picture on a page according to instruction. In addition, your child's memory will also be assessed via tasks that require him/her to recall lists of words, digits and letters. Future thinking will be assessed using two computer games that simulate an actual week and represent tasks that occur in everyday life that require the ability to anticipate future events. It will also be assessed through asking your child to imagine and describe future events (e.g., a holiday). This will be done in an interview format with the researcher and verbal responses will be recorded on audiotape for later scoring. These tasks will be completed over two sessions. Each session will take approximately 1-2 hours and will take place at a mutually convenient time and location, such as your home or at the St Patrick's campus of ACU. We ask at least one parent to be present during the sessions.

In addition, you will be given three questionnaires regarding your child to complete in the first session, which will take approximately 30 minutes. The first questionnaire is a background questionnaire, which asks parents to provide general information about their child. This includes, age, gender, grade, general health and specific information about their autism diagnosis (i.e., diagnosis and current treatment). The second questionnaire asks parents to answer 40 questions about their child's social functioning. The third questionnaire asks parents to answer questions about their child's daily living skills. You will be asked to complete the questionnaires while your child completes the first session. You will also be asked to sign a consent form and return it to the researcher before the commencement of the sessions. You will also be required to bring the completed consent form and any information/documentation regarding your child's diagnosis, (i.e., assessment reports or letters from professionals where a diagnosis is stated) to the first session in a sealed envelope. As an acknowledgement of the time and effort involved in participating in the study, we will be offering an adult and a child movie pass at the end of

Professor Peter Rendell

Tel: 03 9953 3126 **Fax:** 03 9953 3205 **Email:** peter.rendell@acu.edu.au **Web** www.acu.edu.au

Australian Catholic University Limited, ABN 15 050 192 660
Melbourne Campus, 115 Victoria Parade Fitzroy Vic 3065, Australia
Locked Bag 4115 Fitzroy MCD VIC 3065 Australia
CRICOS registered provider: 00004G, 00112C, 00873F, 00885B

Appendix F – 1 *Continued*



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the sessions. Parents and guardians can also indicate if they would like to receive a summary of the results of the study, which will be sent to them at the completion of the project.

We do not anticipate there to be any risks to your child in participating in the computer games and/or the other tasks listed above. It is anticipated that children will find the exercises fun and engaging. Participation in the research project is voluntary. If you decide to agree to your child taking part in the study, you are free to withdraw your consent and discontinue your child's participation in the study at any time without giving a reason. Confidentiality will be maintained throughout the study. All participants will be given a code and names will not be retained with the data. Individual participants will not be able to be identified in any report of the study, as only aggregated data will be reported. We plan to present the findings of this project at either a conference or in a scientific journal. It is emphasised that this will be in a form that does not allow the identification of any individual participant. Only the student researcher and the principal supervisors will have access to your child's results.

If you have any questions regarding this project, before or after participating, please contact the principal supervisor, Peter Rendell, on telephone number 03 9953 3126 in the School of Psychology at the Australian Catholic University, 115 Victoria Parade, FITZROY 3065. In particular, you are encouraged to contact Peter Rendell if you need any clarification of the questionnaires. After your child has completed the session, you are welcome to discuss your child's participation or the project in general.

This study has been approved by the Human Research Ethics Committee at Australian Catholic University (HREC number: V201012). In the event that you have any complaint or concern about the way you have been treated during the study, or if you have any query that the student researcher and principal supervisors have not been able to satisfy, you may write to:

Manager, Ethics
c/o Office of the Deputy Vice Chancellor (Research)
Australian Catholic University
North Sydney Campus
PO Box 968
NORTH SYDNEY, NSW 2059
Ph.: 02 9739 2519
Fax: 02 9739 2870
Email: resethics.manager@acu.edu.au

Any complaint will be treated in confidence and fully investigated. You, the parent of the child participant, will be informed of the outcome.

If you are willing to participate and willing to approve your child participating, please sign the attached informed consent form. You should sign both copies of the consent form and retain one copy for your records and return the other copy to the researcher. Even if you sign the consent form you are free to withdraw from the study at any time. Once we have received the signed consent form, the experimenter will contact you to organise session times that are convenient. Your support for the research project will be most appreciated.

Yours Sincerely,

Gill Terrett & Peter Rendell Jiu-Swan (Serene) Chua
Principal Supervisors Student Researcher

Professor Peter Rendell
Tel: 03 9953 3126 Fax: 03 9953 3205 Email: peter.rendell@acu.edu.au Web www.acu.edu.au

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Appendix F – 2 Information letters for controls



**Cognition & Emotion
Research Centre**



TITLE OF PROJECT: Future Thinking in Children with High Functioning Autism

PRINCIPAL SUPERVISOR: Associate Prof. Gill Terrett and Prof. Peter Rendell

STUDENT RESEARCHER: Jiu-Swan (Serene) Chua

COURSE: Master of Psychology (Educational and Developmental) and Doctor of Philosophy

INFORMATION LETTER TO PARTICIPANTS

Dear Parents / Guardians,

You and your child are invited to participate as part of a control group, for a study that focuses on investigating whether or not future thinking is affected by autism spectrum disorder. Future thinking is sometimes referred to as mental time travel. This is the ability to imagine future events and it appears to be crucial for planning ahead in daily life. Your child is invited to be a part of the control group, as they are typically developing and are of similar age and gender to a separate group of children, who have an existing diagnosis of high-functioning autism.

This study is conducted by Jiu-Swan (Serene) Chua as part of her postgraduate degree in Psychology and is part of an ongoing research into future thinking in children by Professor Peter Rendell. It is emphasised that the measures used are primarily for the collection of research data and that this study will not attempt to provide a diagnosis or treatment of memory problems or autism. If you have concerns about these matters, we encourage you to see your general practitioner.

If you allow your child to take part in the study, he/she will complete a brief set of cognitive tasks that measure their intellectual ability, executive functioning and perspective taking. These tasks involve your child answering verbally presented questions and pointing to the appropriate picture on a page according to instruction. In addition, your child's memory will also be assessed via tasks that require him/her to recall lists of words, digits and letters. Future thinking will be assessed using two computer games that simulate an actual week and represent tasks that occur in everyday life that require the ability to anticipate future events. It will also be assessed through asking your child to imagine and describe future events (e.g., a holiday). This will be done in an interview format with the researcher and verbal responses will be recorded on audiotape for later scoring. These tasks will be completed over two sessions. Each session will take approximately 1-2 hours and will take place at a mutually convenient time and location, such as your home or at the St Patrick's campus of ACU. We ask at least one parent to be present during the sessions.

In addition, you will be given three questionnaires regarding your child to complete in the first session, which will take approximately 30 minutes. The first questionnaire is a background questionnaire, which asks parents to provide general information about their child. This includes, age, gender and grade. The second questionnaire asks parents to answer 40 questions about their child's social functioning. The third questionnaire asks parents to answer questions about their child's daily living skills. You will be asked to complete the questionnaires while your child completes the first session. You will also be asked to sign a consent form and return it to the researcher before the commencement of the sessions. As an acknowledgement of the time and effort involved in participating in the study, we will be offering an adult and a child movie pass at the end of the sessions. Parents and guardians can also indicate if they would like to receive a summary of the results of the study, which will be sent to them at the completion of the project.

We do not anticipate there to be any risks to your child in participating in the computer games and/or the other tasks listed above. It is anticipated that children will find the exercises fun and engaging.

Professor Peter Rendell

Tel: 03 9953 3126 **Fax:** 03 9953 3205 **Email:** peter.rendell@acu.edu.au **Web** www.acu.edu.au

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Appendix F – 2 *Continued*



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Participation in the research project is voluntary. If you decide to agree to your child taking part in the study, you are free to withdraw your consent and discontinue your child's participation in the study at any time without giving a reason. Confidentiality will be maintained throughout the study. All participants will be given a code and names will not be retained with the data. Individual participants will not be able to be identified in any report of the study, as only aggregated data will be reported. We plan to present the findings of this project at either a conference or in a scientific journal. It is emphasised that this will be in a form that does not allow the identification of any individual participant. Only the student researcher and the principal supervisors will have access to your child's results.

If you have any questions regarding this project, before or after participating, please contact the principal supervisor, Peter Rendell, on telephone number 03 9953 3126 in the School of Psychology at the Australian Catholic University, 115 Victoria Parade, FITZROY 3065. In particular, you are encouraged to contact Peter Rendell if you need any clarification of the questionnaires included. After your child has completed the session, you are welcome to discuss your child's participation or the project in general.

This study has been approved by the Human Research Ethics Committee at Australian Catholic University (HREC number: V201012). In the event that you have any complaint or concern about the way you have been treated during the study, or if you have any query that the student researcher and principal supervisors have not been able to satisfy, you may write to:

Manager, Ethics
c/o Office of the Deputy Vice Chancellor (Research)
Australian Catholic University
North Sydney Campus
PO Box 968
NORTH SYDNEY, NSW 2059
Ph.: 02 9739 2519
Fax: 02 9739 2870
Email: resethics.manager@acu.edu.au

Any complaint will be treated in confidence and fully investigated. You, the parent of the child participant, will be informed of the outcome.

If you are willing to participate and willing to approve your child participating, please sign the attached informed consent form. You should sign both copies of the consent form and retain one copy for your records and return the other copy to the researcher. Even if you sign the consent form you are free to withdraw from the study at any time. Once we have received the signed consent form, the experimenter will contact you to organise session times that are convenient. Your support for the research project will be most appreciated.

Yours Sincerely,

Gill Terrett & Peter Rendell
Principal Supervisors

Jiu-Swan (Serene) Chua
Student Researcher

Professor Peter Rendell

Tel: 03 9953 3126 Fax: 03 9953 3205 Email: peter.rendell@acu.edu.au Web www.acu.edu.au

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Appendix G – 1 Continued



**Cognition & Emotion
Research Centre**



TITLE OF PROJECT: Future Thinking in Children with High Functioning Autism

PRINCIPAL SUPERVISOR: Associate Prof. Gill Terrett and Prof. Peter Rendell

STUDENT RESEARCHER: Jiu-Swan Chua

COURSE: Master of Psychology (Educational and Developmental) and Doctor of Philosophy

HREC NUMBER: V201012

INFORMED CONSENT FORM

Copy to be returned to researcher

Parent/Guardian Consent

I (*the parent/guardian*) have read and understood the information provided in the Information Letter to Participants inviting participation in this research project, and any questions I have, have been answered to my satisfaction.

I agree that my child, may participate in this activity. As outlined in the information letter, this involves completing two sessions, which will take approximately 1-2 hours in each session. Briefly, this involves my child playing computer games and completing an interview that assesses the ability to anticipate future events. I agree to my child's responses being recorded on audiotape for the task that requires responses to be said aloud. In addition, it involves my child completing a range of other activities measuring their general cognitive and memory ability, and the ability to understand that others have beliefs and intentions that differ from their own. I understand that whilst my child completes these tasks, I will be required to fill out three questionnaires that ask general information about my child. In addition, I understand that I have to bring the completed consent form and any other additional information about my child's diagnosis, to the session in a sealed envelope. I realise that at any time, I can withdraw my child from participating, without giving any reason. I agree that research data collected for the study may be published or provided to other researchers in a form that does not identify me or my child in any way.

Finally, I understand that a child and an adult movie voucher will be offered at the end of the sessions, as an acknowledgement of our participation.

Name of Parent/Guardian:

Signature Date

I would like a summary of the results of the study sent to the address below: Yes/No (please circle)

Address:

Child Assent

I.....(*the participant aged under 18 years*) agree to take part in this project. What I will be asked to do has been explained to me. I realise that I can withdraw at any time without having to give a reason for my decision.

Name of Child:

Signature: Date

Student Researchers: Jiu-Swan Chua

Signature:

Principal Supervisor: Associate Prof. Gill Terrett & Prof. Peter Rendell

Signature:

Professor Peter Rendell

Tel: 03 9953 3126 Fax: 03 9953 3205 Email: peter.rendell@acu.edu.au Web www.acu.edu.au

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Appendix G – 2 Consent forms for controls



**Cognition & Emotion
Research Centre**



TITLE OF PROJECT: Future Thinking in Children with High Functioning Autism
PRINCIPAL SUPERVISOR: Associate Prof. Gill Terrett and Prof. Peter Rendell
STUDENT RESEARCHER: Jiu-Swan Chua
COURSE: Master of Psychology (Educational and Developmental) and Doctor of Philosophy
HREC NUMBER: V201012

INFORMED CONSENT FORM

Copy for parents / guardian to keep

Parent/Guardian Consent

I (*the parent/guardian*) have read and understood the information provided in the Information Letter to Participants inviting participation in this research project, and any questions I have, have been answered to my satisfaction.

I agree that my child may participate in this activity. As outlined in the information letter, this involves completing two sessions, which will take approximately 1-2 hours in each session. Briefly, this involves my child playing computer games and completing an interview that assesses the ability to anticipate future events. I agree to my child's responses being recorded on audiotape for the task that requires responses to be said aloud. In addition, it involves my child completing a range of other activities measuring their general cognitive and memory ability, and the ability to understand that others have beliefs and intentions that differ from their own. I understand that whilst my child completes these tasks, I will be required to fill out three questionnaires that ask general information about my child. I realise that at any time, I can withdraw my child from participating, without giving any reason. I agree that research data collected for the study may be published or provided to other researchers in a form that does not identify me or my child in any way.

Finally, I understand that a child and an adult movie voucher will be offered at the end of the sessions, as an acknowledgement of our participation.

Name of Parent/Guardian:

Signature Date

I would like a summary of the results of the study sent to the address below: Yes/No (please circle)

Address:

Child Assent

I (*the participant aged under 18 years*) agree to take part in this project. What I will be asked to do has been explained to me. I realise that I can withdraw at any time without having to give a reason for my decision.

Name of Child:

Signature: Date

Student Researchers: Jiu-Swan Chua

Signature:

Principal Supervisor: Associate Prof. Gill Terrett & Prof. Peter Rendell

Signature:

Professor Peter Rendell

Tel: 03 9953 3126 Fax: 03 9953 3205 Email: peter.rendell@acu.edu.au Web www.acu.edu.au

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Appendix G – 2 *Continued*



**Cognition & Emotion
Research Centre**



TITLE OF PROJECT: Future Thinking in Children with High Functioning Autism
PRINCIPAL SUPERVISOR: Associate Prof. Gill Terrett and Prof. Peter Rendell
STUDENT RESEARCHER: Jiu-Swan Chua
COURSE: Master of Psychology (Educational and Developmental) and Doctor of Philosophy
HREC NUMBER: V201012

INFORMED CONSENT FORM

Copy to be returned to researcher

Parent/Guardian Consent

I (*the parent/guardian*) have read and understood the information provided in the Information Letter to Participants inviting participation in this research project, and any questions I have, have been answered to my satisfaction.

I agree that my child, may participate in this activity. As outlined in the information letter, this involves completing two sessions, which will approximately 1-2 hours in each session. Briefly, this involves my child playing computer games and completing an interview that assesses the ability to anticipate future events. I agree to my child's responses being recorded on audiotape for the task that requires responses to be said aloud. In addition, it involves my child completing a range of other activities measuring their general cognitive and memory ability, and the ability to understand that others have beliefs and intentions that differ from their own. I understand that whilst my child completes these tasks, I will be required to fill out three questionnaires that ask general information about my child. I realise that at any time, I can withdraw my child from participating, without giving any reason. I agree that research data collected for the study may be published or provided to other researchers in a form that does not identify me or my child in any way.

Finally, I understand that a child and an adult movie voucher will be offered at the end of the sessions, as an acknowledgement of our participation.

Name of Parent/Guardian:

Signature Date

I would like a summary of the results of the study sent to the address below: Yes/No (please circle)

Address:

Child Assent

I.....(*the participant aged under 18 years*) agree to take part in this project. What I will be asked to do has been explained to me. I realise that I can withdraw at any time without having to give a reason for my decision.

Name of Child:

Signature: Date.....

Student Researchers: Jiu-Swan Chua Signature:

Principal Supervisor: Associate Prof. Gill Terrett & Prof. Peter Rendell Signature:.....

Professor Peter Rendell
Tel: 03 9953 3126 **Fax:** 03 9953 3205 **Email:** peter.rendell@acu.edu.au **Web** www.acu.edu.au

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Appendix H. Background Questionnaire

Background Information

1. Information about your family

Child participating in this study:

➤ Name of Child: _____

➤ Child's Gender: Male Female

➤ Child's Date of Birth: ____/____/____

Parent/Guardian 1: (parent participating in study)

➤ Name: _____

➤ Address: _____

_____ Post Code: _____

➤ Phone Number: (Home) _____ (Mobile): _____

Parent/Guardian 2: (parent participating in study)

➤ Name: _____

➤ Relationship to you (Parent/Guardian 1): _____

➤ Relationship to child participating in the study: _____

Other children in the family:

➤ Please list names, date of birth, gender and age:

<u>Name</u>	<u>Date of Birth</u>	<u>Age</u>	<u>Gender</u>
			M/F
			M/F
			M/F

Appendix H *Continued*

2. General information about your child

What language did your child first speak? _____

➤ Does your child have any speech or language problems?

Please tick (✓) one: No: _____ Yes, a little _____ Yes, a lot: _____

➤ **If Yes**, have you sought help for your child's speech or language difficulties?

Please tick (✓) one: No: _____ Yes _____

➤ **If Yes**, describe what type of help: _____

Does your child have any of the following diagnoses?

Please tick (✓) one: Anxiety _____ Depression _____

Intellectual Disability _____ ADHD _____

Other _____ Please state: _____

Please tick (✓) one: No _____ Yes, a little _____ Yes, a lot: _____

➤ **If Yes**, have you sought help for your child's diagnosis?

Please tick (✓) one: No _____ Yes _____

➤ **If Yes**, describe what type of help: _____

Appendix H *Continued*

Does your child exhibit any behavioural problems that concern you?

Please tick (✓) one: No _____ Yes _____

➤ **If Yes**, have you sought help for your child's behavioural problems?

Please tick (✓) one: No _____ Yes _____

➤ **If Yes**, describe what type of help: _____

3. Your child's health

Using the following as a guide, please answer the three questions below (please tick the box which most describes your child).

- 1. **Excellent:** no problems
- 2. **Very good:** no major problems
- 3. **Good:** occasional bad days
- 4. **Not very good:** a number of problems
- 5. **Poor:** persistent serious problems

➤ How would you describe your child's state of health over the last month or so?

excellent very good good not very good poor

➤ How would you describe your child's state of health today?

excellent very good good not very good poor

➤ How well has your child been sleeping over the last few weeks?

excellent very good good not very good poor