A detailed exploration of changes in everyday task performance in people with dementia

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Submitted for the degree of

Doctor of Philosophy in Psychology

School of Psychology

University of Sussex

November, 2014

DECLARATION

The thesis conforms to an 'article format': section 2 comprises discrete articles for publication in peer-reviewed journals. The first and final sections present synthetic overviews and discussions of the field and the research undertaken.

Study 1 is published in the Journal of the International Neuropsychological Society:

Balouch, S. & Rusted, J. M. (2013). Age related changes in error monitoring of an everyday task. *Journal of the International Neuropsychological Society, 19* (7), 763-772.

Study 2 is published in the Journal of Clinical and Experimental Neuropsychology:

Balouch, S. & Rusted, J. M. (2014). Error-monitoring in an everyday task in people with Alzheimer-type dementia: Observations over five years of performance decline. *Journal of Clinical and Experimental Neuropsychology*, DOI:10.1080/13803395.2014.943697

Study 3a is under review in Neuropsychological Rehabilitation:

Balouch, S. & Rusted, J. M. (under review). Can verbal instruction enhance the recall of an everyday task and promote error-monitoring in people with dementia of the Alzheimer-type? *Neuropsychological Rehabilitation*.

The author contributions are as follows: Sara Balouch was responsible for all novel data collection, data analysis, and writing of manuscripts. A volunteer, Lucy Morrell, assisted data collection in *Study 1* and contributed inter-rater reliability for all studies. Archive data in *Studies 2* and *3a* was collected under grants awarded to Jennifer Rusted by the Wellcome Trust, 1995-1998. Sara Balouch and Jennifer Rusted were collectively responsible for the initial conception of the research.

I hereby declare that this has not been and will not be, submitted in whole or in part to another University for the award of any other degree.

Signature:

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ACKNOWLEDGEMENTS

There are so many people who I owe my gratitude to for helping me get through the five years of my PhD. First and foremost, I am truly grateful to my supervisor, Jenny Rusted, for giving me the opportunity to undertake a PhD and for her continued support, encouragement and motivation that kept me on track. I thank Susan Ayers for encouraging me to do a PhD in the first place and for seeing potential in me. My office mates, past and present, who I now consider to be some of my closest friends, especially Katie Atwell, Abbie Coy, Pete Hovard and Aaron Brace. Kate and Abbie, thank you for the girly chats, cups of tea, for being such great listeners and always being there for me through thick and thin. Thank you Pete and Aaron for the ridiculous conversations, the music and for always making me laugh. I owe a big thank you to Nat Gould for being such a great friend, for being there for me through my highs and lows, for all the fantastic advice, for being my drinking buddy one too many times, and for proof reading my thesis - you're a star! Other university friends and lab colleagues, who I thank for not only their academic support, but also for making the whole process so much more enjoyable are, in no particular order: Una Masic, Camilla During, Keri McKrickerd, Renata Fialo, Rachel Entwistle, Marika De Scalzi, Becky Grist, Hazel Anderson, Alex Sawyer, Tomo Ridley-Siegert, Stephen Jeffs, Kate Doran, Jenny Wathan, Vicky Ratcliffe, Donna Ewing, Molly Berenhaus, Sam Berens, Nick Farina, Lucy Nelson, Simon Evans, Kevin Butler, and Leanne Trick, to name a few.

I am in debt to Dan Hyndman and Martha Casey, who provided me with invaluable technical support, especially Dan, who helped me so much with The Observer; Lucy Morrell for volunteering her time to help me with inter-rater reliability; and Pennie Ingram and Elly Adams for their general support and caring nature.

Finally, thanks to my wonderful family for always believing in me, even when I didn't believe in myself, and for instilling in me the desire to learn and to never give up. Last, but certainly not least, I am grateful for my fiancé, my Craig, my rock. His support, encouragement, perpetual belief in me, cuddles, cooking, car lifts, and ability to make me laugh got me through this rollercoaster of a PhD.

This work was supported by the Michael Chowen Scholarship and the University of Sussex Graduate Teaching Assistantship. Thanks to my all participants and their families for taking part in my research and the staff at the memory clinics and day centres in Sussex who helped with recruitment.

UNIVERSITY OF SUSSEX

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Summary

For most people, everyday tasks, such as tea making, are familiar, routine tasks that are normally performed without effort. A diagnostic feature of dementia, however, is an insidious decline in the ability to perform everyday tasks. Through a series of six studies, I examined how everyday task performance changes in people with dementia and I piloted two behavioural strategies that might enhance memory for everyday tasks in people with dementia.

Study 1 developed a detailed error and error-monitoring taxonomy to explore the minutia of everyday task performance in healthy ageing. The study demonstrated that older adults without dementia rarely make errors in everyday tasks, even when conditions are manipulated to reduce cognitive resources.

Study 2 documented errors and error-monitoring of everyday task performance in individuals with a developing dementia, using archive data to chart performance change over 5 years. While errors increased with dementia progression, there was no reactive increase in error-monitoring, suggesting a lack of awareness characterises the breakdown of task performance.

Study 3a explored the impact of verbally instructing another person how to perform an everyday task on recall of an everyday task. People with dementia were able to do this surprisingly well, appearing to use both visual and motor cues to support recall.

Study 3b piloted the impact of verbal self-explanation on everyday task performance, in four people with dementia. Self-explanation did not benefit recall and implementation of a familiar task.

Study 4a compared observation with verbal instruction on acquisition of a novel routine. Results showed that people with mild-moderate dementia learned a new routine better under observation compared to verbal instruction.

Study 4b tested observational learning of an everyday task over five weeks in three people with dementia. The initial benefit over verbal instruction was sustained, but did not increase over time.

These studies constitute a detailed and meticulous exploration of everyday task performance in people with dementia and provide pilot evidence of a potential strategy that could support memory of everyday tasks in people with dementia.

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1 General Introduction

1.1 Introductory remarks

Everyday tasks, such as teeth brushing, tea-making, cooking a meal, and dressing oneself are tasks that are normally performed without effort by most adults. For an individual with dementia, however, these tasks become increasingly difficult to perform independently (American Psychiatric Association, 2013). This loss of independence often leads to frustration, depression (Rosness, Barca, & Engedal, 2010), anxiety (Seignourel, Kunik, Snow, Wilson, & Stanley, 2008), reduced quality of life (Giebel, Sutcliffe, & Challis, 2014) and care-giver burden (Burns & Rabins, 2000). Furthermore, with the incidence of dementia doubling by 2030 (Alzheimer's Disease International, 2013; World Health Organization & Alzheimer's Disease International, 2012), efforts to help people with dementia perform daily routine tasks with greater independence are surely worthwhile. The present PhD research explores changes in everyday task performance in people with dementia to inform potential behavioural strategies.

1.2 Dementia

Dementia (*major neurocognitive disorder* in DSM-V; American Psychiatric Association, 2013) is characterised as a significant cognitive decline from a previous level of functioning in one or more of the following cognitive domains: complex attention, executive function, learning and memory, language, perceptual-motor, or social cognition. For a diagnosis of dementia these deficits must interfere with the individual's independence in everyday tasks (American Psychiatric Association, 2013). Dementia is caused by a number of diseases or conditions; the most common being dementia of the Alzheimer-type (DAT; characterised by two major types of lesions in the neocortex - neurofibrillary tangles and neuritic plaques; Cairns, 2013), followed by vascular dementia (VaD; associated with repeated episodes of ischaemia, infarction or haemorrhage, blocking blood flow to the brain; Cairns, 2013) and mixed dementia (DAT and VaD). A diagnosis of mixed dementia has been more prevalent in recent years, due to the difficulty of disentangling the two diseases in old age (Korczyn, 2002; Langa, Foster, & Larson, 2004). The primary characteristic of DAT is that the cognitive decline is gradual and progressive. In addition to cognitive deficits, a number of neuropsychiatric and behavioural symptoms, such as aggression/agitation, depression, apathy, anxiety, delusions and hallucinations are experienced in dementia (American Psychiatric Association, 2013; Jalbert, Daiello, & Lapane, 2008; McKhann et al., 2011).

1.3 How are everyday tasks measured in people with dementia?

1.3.1 Activities of daily living scales

Impairment in everyday functioning is a diagnostic feature in dementia (American Psychiatric Association, 2013). Screening for this impairment normally involves informant-based questionnaires on activities of daily living (ADL; Desai, Grossberg, & Sheth, 2004). Basic activities of daily living (BADL) include simple self-maintenance tasks, such as bathing, eating and toileting. Instrumental activities of daily living (IADL), that require higher-order cognitive abilities, include more complex everyday tasks, such as preparing a meal, using medication and handling finances (Mack & Patterson, 2006). In the early stages of dementia IADLs are affected and in the later stages of dementia, when cognitive functioning declines further, BADLs become impaired (Gauthier, Gelinas, & Gauthier, 1997). Some recent studies have shown that IADL measures can predict dementia up to two years before symptoms begin to show (Regal & Heatherington, 2012; Sikkes et al., 2011).

ADL scales commonly consist of caregiver reports on the patients or participants' functioning, because it is thought that the patient is too impaired to accurately report his/her ability (Marshall, Amariglio, Sperling, & Rentz, 2012). For example, the earliest and most common informant-report ADL scale is by Lawton and Brody (1969), which requires the caregiver to rate the patient/participant's ability to perform a number of different tasks, ranging from food preparation to handling finances. Many more recent scales have been developed since Lawton and Brody (1969) in order to reduce the administration time, reduce the burden on the individual, incorporate self-report with informer-report, assess IADLs in earlier stages of AD (particularly mild cognitive impairment), and to improve ecological validity (e.g. the Clinical Dementia Rating Scale, Morris, 1993; the Everyday Cognition Scale, Farias et al., 2008). Although most of these measures are relatively quick and easy to use, the use of informant-based measures have been criticised, because they do not objectively measure the participants' ability to perform ADLs (Marshall et al., 2012). Additionally, the psychometric properties of these measures have not been sufficiently tested and those that have only show moderate quality (see Sikkes, Klerk, Pijnenburg, Scheltens, & Uitdehaag, 2009, for a review). Caregiver bias is also a problem (Argüelles, Loewenstein, Eisdorfer, & Argüelles, 2001).

In order to address these concerns, performance based ADL scales have been developed. For example, the Texas Functional Living Scale (Cullum et al., 2001) assesses mostly IADLs (rather than BADLs to avoid floor effects in mild dementia) by requiring the participant to perform a number of tasks that fall under five subscales: dressing, memory, time, money and communication. However, measures like this have also been criticised due to the artificial environments in which they are administered (Gold, 2012). Previous research has shown that participants with dementia perform poorly when everyday tasks are carried out in an unfamiliar setting, compared to a familiar routine setting (Rusted & Sheppard, 2002). At best these scales distinguish between the different levels of dementia (Marshall et al., 2012), but they do not provide rich, qualitative information of everyday task impairment that would be required to develop a behavioural strategy that targets everyday task impairment in people with dementia.

1.3.2 A detailed, observational analysis of everyday tasks

Cognitive neuropsychologists have taken a more detailed approach to assessing the nature of everyday task impairments in people with dementia.

1.3.2.1 Action Errors

Everyday tasks involve a series of naturalistic action sequences (learned and habitual sequences of movements) that are performed in a sequential order to achieve a goal (Schwartz, 2006; Schwartz, Segal, Veramonti, Ferraro, & Buxbaum, 2002). Although, these tasks are routine, they require a complex online processing of actions, environmental cues and outcome, in order to perform the correct task steps to achieve the task goals (Bettcher & Giovannetti, 2009; Schwartz, 2006). In healthy people, these routine everyday tasks are normally executed automatically without conscious awareness, i.e. on 'auto-pilot', but distraction and absent mindedness even in healthy adults can cause errors on these tasks (Reason, 1984; Reason & Mycielska, 1982). Reason (1990) described an error as "a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome…" (p. 9).

In order to categorise errors and explain the source and impact of errors, Reason (1990) devised one of the most influential error-taxonomies (see also Norman, 1981), which encompasses errors in the form of three cognitive processing stages: 1) planning, 2) storage of information and 3) execution of action. An error in the first stage is referred to as a 'mistake', whereby the actions do not fit to the right intention or plan. Reason (1990) suggested that it would be more difficult for the individual to detect the error in this stage, because their actions are based on incorrect intentions. An error in the second stage is referred to as a 'lapse', which involves failures in memory and is often more covert. It may not become apparent in the individual's behaviour and may only be noticeable to the individual. An error in the final stage is called a 'slip' and occurs when the individual has developed an appropriate intention, but has failed to execute it in the correct manner. A slip is normally overt and observable to others. Reason's (1990) error taxonomy emphasised the importance of the internal and cognitive aspects of error production, which provided a basis for understanding how errors are detected (Bettcher & Giovannetti, 2009).

Further understanding of everyday action impairment came largely from studies of people with brain damage and disease, performing naturalistic everyday tasks (Schwartz, 2006, for a review). Schwartz and colleagues (2002), developed performance-based naturalistic everyday tasks, such as the Multi-Level Action Task (MLAT; Schwartz et al., 1998) and its updated successor, the Naturalistic Action Task (NAT; Schwartz et al., 2002). The MLAT was devised to measure and compare error tendencies in various inpatient groups undergoing rehabilitation (e.g. closed head injury [CHI]: Schwartz et al., 1998; right-hemisphere cerebrovascular accident [RCVA]: Schwartz et al., 1999); left-hemisphere cerebrovascular accident [LCVA]: Buxbaum, 1998), and it was later administered to patients diagnosed with dementia (Giovannetti, Libon, Buxbaum, & Schwartz, 2002a). In the MLAT participants were presented with a table of objects and were required to perform three naturalistic everyday tasks using those objects. These tasks included: 1) make toast and a cup of coffee; 2) wrap a gift; and 3) pack a lunchbox and school bag, and could be administered in increasing levels of complexity. The aim was to simulate real world demands, where distractions are always present. An error-taxonomy was used for coding errors into either *omissions* (when a step or subtask was never performed) or a number of different *commissions* (when a task step was inaccurately performed or an extra off-task step was performed), including object substitution, perseveration, anticipation or reversal of the task steps, action-addition, and tool omission. In addition to an 'error score' (sum of all errors), participants were also credited with the task steps that they accomplished, without penalty for commissions: an 'accomplishment score'.

However, the MLAT and its coding scheme were lengthy, labour intensive and required substantial coder training (Schwartz et al., 2002). Consequently, the tasks of the MLAT were shortened in the MLAT-S (Buxbaum, Veramontil, & Schwartz, 2000; Giovannetti, Libon, Buxbaum, et al., 2002a) and the coding system was simplified in the NAT (Schwartz et al., 2002). In the NAT, twelve commission errors specific to the tasks of the NAT were tracked during coding (e.g. 'toasts more than one slice of bread'). These errors were selected due to their frequency in the MLAT studies, involving participants with CHI (Schwartz et al., 1998), RCVA (Schwartz et al., 1999) and LCVA (Buxbaum, 1998), but were not based on a dementia sample, which may have yielded different errors.

In these non-dementia studies, action errors were widespread and the distribution of error types was almost identical across the different patient groups: they all made mostly errors of omission, followed by sequence errors. However, not all patients were high error producers and the low error producers made mostly errors of commission than omission. Age-matched controls showed the same pattern of errors as low error producers. Furthermore, the presence of distractors significantly increased errors, particularly omissions. Schwartz and colleagues suggested that this commonality in error profiles across CHI, RCVA and LCVA patients was due to a reduced cognitive or attentional capacity, which is necessary for sustaining goal-directed behaviour in the presence of other competing goals and distractors (Buxbaum, 1998; Schwartz et al., 1999; Schwartz, 2006; Schwartz et al., 2002). Schwartz and colleagues (1999) suggested that this limited-capacity resource account explained errors seen in both controls and patient groups and argued that action errors in patients may be an exaggeration of the slips of memory and distraction that happen in healthy individuals (Norman, 1981; Reason, 1990). Patient groups have additional restriction to resource capacity, hence why more errors are observed. Furthermore, omissions are particularly sensitive to task difficulty and clinical severity, because there is a failure to resolve the competition for schema selection and as a result the patient makes no effort to select a schema (Schwartz et al., 1999; Schwartz, 2006). Further support for this account shows that total errors are strongly linked to decreased measures of global cognitive functioning, rather than specific errors being linked to specific cognitive processes (Buxbaum, 1998; Giovannetti et al., 2002; Schwartz et al., 1999; Schwartz et al., 1998).

In one of the first studies of action errors in people with dementia (using the MLAT-S in participants with mild-moderate dementia diagnosis), Giovannetti et al. (2002a) found the pattern of errors to be similar to the other clinical populations: omissions were the most frequent type of error, these increased significantly with higher task complexity and omissions were linked to measures of global cognitive decline. Rusted and Sheppard (2002) were the first (and only study to date) to explore everyday task impairment longitudinally in a developing dementia, in contrast to the cross-sectional design of previous studies (e.g. Giovannetti et al, 2002a). Rusted and Sheppard (2002) assessed a decline in functioning in the participants' own routine activity – tea-making – in their own homes. This is unique because it measures errors in a task that was premorbidly routine and well established, rather than for tasks that may not have been particularly routine in participants prior to the onset of dementia (for example, packing a schoolbag in the MLAT or NAT). Each participant's individual tea-making protocol was established at the outset, before everyday task impairment was apparent, and individual protocols were used to measure deviations from the routine, omissions, action repetitions, semantic errors (i.e. substitutions), and intrusions (i.e. action-additions). Tea-making was documented every 1-2 months for 4-6 years and this data was filmed for coding. The participants with dementia preserved their tea-making routines surprisingly well throughout the course of dementia. Only 12% of all tea-making attempts failed to reach the end goal. The key finding was that errors increased significantly with dementia progression, especially errors of omission. This matches the pattern of errors observed in other patient groups (Buxbaum, 1998; Schwartz et al., 1999; Schwartz et al., 1998), but the high percentage of task completions well into the severe stage is not consistent with a general resource deficit. This may be due to the routine task that was used in this study. If a less familiar task had been used, then perhaps more omissions might have been observed in the severe stage of dementia. Interestingly, the omissions in this study were ‘non-critical’ actions, rather than the basic actions required to make tea, suggesting a hierarchical schema representation of routine tasks that is largely intact in people with dementia, supporting traditional models of routine every day action schemas (e.g. Cooper & Shallice, 2000).

In recent studies of people with dementia Giovannetti and colleagues have linked omissions to measures of global cognitive functioning, and commissions to measures of executive functioning (Giovannetti et al., 2008; Giovannetti, Schmidt, Gallo, Sestito, & Libon, 2006; Seidel et al., 2013). Giovannetti and colleagues (2008) proposed the omission-commission model of everyday action that suggests that these two main error categories may reflect impairment in two distinct dissociable cognitive processes: episodic memory impairments predict omission errors, whilst executive functioning deficits predict commissions (Giovannetti et al., 2008; Seidel et al., 2013). In support of this model, Seidel and colleagues (2013) investigated the neurological correlates of omissions and commissions in people with dementia and found that greater numbers of omission errors were associated with smaller hippocampal volume, which is well known for its role in episodic memory (Ben-Yakov & Dudai, 2011). Conversely, increased commissions were associated with deep white matter, known for its role in executive functioning (Delano-Wood et al., 2008).

Giovannetti and colleagues (2008) suggest that patients with specific ‘omissive’ patterns may respond best to strategies involving task retraining, goal reminders and checklists, whilst patients with ‘commissive’ error patterns may respond best to increasing cognitive control over performance (e.g. Goal Management Training, Levine et al., 2011).

1.3.2.2 Error-monitoring

Bettcher and Giovannetti (2009) argued that action errors in people with dementia are unavoidable, and thus research should focus on how errors are handled, rather than the prevention of errors. Error-monitoring refers to error detection, explanation and correction (Bettcher & Giovannetti, 2009; Blavier, Rouy, Nyssen, & de Keyser, 2005). However, the first two processes are normally merged in the cognitive psychology literature and thus error-monitoring is commonly measured as error detection and error correction only (Bettcher & Giovannetti, 2009). Reason (1990) suggested that the route to error detection relies on whether the intention was correct or incorrect. If the intention was correct, then detection occurs due to a mismatch between the intention and outcome. The mechanism in which errors are detected in this way can be either through internal and external feedback and thus can be detected rapidly or after a delay. However, when the intention is incorrect, these errors are detected through external feedback only, e.g. the outcome of the task, thus these error detections are delayed. Error correction involves rectifying the problem or minimising the negative consequences of an error (Ohlsson, 1996). Due to the intention being incorrect and feedback only occurring at the end of task through external feedback, mistakes are detected later and hence corrected later than other errors (Blavier et al., 2005). Overt slips are easier to detect, and therefore corrected more quickly. Some corrections can occur before the error is fully executed, reflecting a less conscious and more efficient monitoring system – these are known as *microslips* (Smid, Mulder, & Mulder, 1990).

Studies measuring the electrophysiological responses to an error via brain event related potentials (ERP) have consistently shown evidence for error detection and error correction being separate processes (see Bettcher & Giovannetti, 2009, for a review). These studies show that older adults have significantly smaller and slower ERP responses to an error than younger adults (Band & Kok, 2000; Falkenstein, Hoormann, Christ, & Hohnsbein, 2000; Mathewson, Dywan, & Segalowitz, 2005; Nieuwenhuis et al., 2002). Behaviourally, in laboratory-based cognitive tasks, these studies show increased error rates, slower reaction times and greater post-error slowing in older adults. In one study, older adults corrected more of their errors than young adults, but only in simple task conditions (Band & Kok, 2000). Error-monitoring is further compromised in people with dementia: while they still generate ERP responses, these are smaller and slower than those of age-matched controls. Behaviourally, in these laboratory-based tasks, people with dementia perform worse than age-matched controls, as evidenced by slower reaction times, increased error rates (Ito & Kitagawa, 2005; Mathalon et al., 2003) and fewer corrections (Ito & Kitagawa, 2005). In sum, error-monitoring becomes impaired in healthy ageing and is further impaired in people with dementia.

Studies of error-monitoring mostly derive from ERP and laboratory-based cognitive tasks (see Bettcher & Giovannetti, 2009, for a review), which have little ecological validity. Naturalistic behavioural studies examining error-monitoring in people with dementia are limited. In the first study to explore naturalistic error-monitoring in people with dementia, Giovannetti, Libon, and Hart (2002b) errors in the MLAT-S were coded as 'aware' if the participant corrected the error, made an unsuccessful attempt to correct an error or made any verbal or non-verbal reaction to an error. The participants with dementia were less aware of their errors and corrected a significantly smaller proportion of their errors than healthy age-matched controls. In a follow-up study, Bettcher, Giovannetti, Macmullen, and Libon (2008) investigated microslips in people with dementia performing the NAT. All errors and error awareness were coded as before (Giovannetti et al., 2002b). Corrections were further classified by the timeframe in which they occurred: microslip (occurring before the full execution of the error); immediate correction (occurring directly after the action error); and delayed correction (occurring sometime after the action error had taken place, after an additional task step). Participants with dementia corrected most of the errors they detected (75.8%), but they only detected one third of their total errors (32.7%) even with the inclusion of microslips, whereas controls detected 73% of their errors. Out of the errors that were detected, most corrections in the dementia group were microslips (31.9%), followed by immediate corrections (23.8%) and delayed corrections (19.9%). Thus, while microslips were still rare, the longer the time elapsed from the error, the less likely it was to be corrected.

Giovannetti et al. (2002b) and Bettcher et al. (2008) are the only studies to date to document naturalistic error-monitoring in people with dementia. Overall, they show that people with dementia do error-monitor in these standardised, essentially ‘novel’ everyday tasks. Little is known about error-monitoring in a routine everyday task that is familiar to people with dementia, despite this being more pertinent in the development of individualised interventions. Moreover, these studies assessed error-monitoring in a single snap shot of time in people with mild-moderate dementia; again, little is known about how error-monitoring processes might change over time as dementia develops. Furthermore, other error-monitoring processes, for instance ‘checking’, have not been explored, which may be more informative regarding awareness of errors in people with dementia. In conclusion, further studies exploring error-monitoring in people with dementia, using a more detailed and longitudinal approach, are overdue.

1.3.3 Summary

Everyday task performance in people with dementia is either measured through ADL scales or naturalistic everyday tasks. The ADL scales are mostly informant-based or at best provide information on dementia severity. While studies of naturalistic everyday tasks provide information on the types of action errors and error-monitoring behaviours that people with dementia make, studies of this kind in people with dementia are limited and little is known about longitudinal changes in everyday task performance as dementia develops. Furthermore, categorisation of error-monitoring processes is limited to error detection and error correction, and other aspects of error-monitoring (e.g. checking) have not been explored).

1.4 What cognitive interventions exist to improve everyday task performance in people with dementia?

This section outlines existing cognitive-focused interventions and their impact on improving everyday functioning and enhancing error-monitoring in people with dementia, in particular cognitive stimulation, cognitive training, cognitive rehabilitation, and error-monitoring strategies.

1.4.1 Cognitive stimulation

Cognitive stimulation stems from reality orientation that was developed in the late 1950s as a response to the confusion and disorientation that was observed in many older adult patients in hospitals in the USA. Reality orientation aimed to engage nursing staff in the therapeutic process. Although reality orientation had good intentions, it became synonymous with a rigid and confrontational approach, and as a result its popularity declined over the years (Woods, Aguirre, Spector, & Orrell, 2012). Cognitive stimulation, which is implemented today in day centres and memory clinics, addressed the problems with reality orientation. It is based on the view that cognitive activity declines more quickly if it is not stimulated (Breuil et al., 1994). It makes use of the positive aspects of reality orientation, but in a more sensitive, respectful and person-centred approach (Woods et al., 2012). The aim is to improve everyday awareness, orientation and social functioning, through engaging the individual in a range of group activities and discussions in a group setting (Bahar-Fuchs, Clare, & Woods, 2013; Rusted & Moniz-Cook, 2013).

A recent Cochrane Review of fifteen randomised control trials (RCTs) assessing the efficacy of cognitive stimulation found that there were significant benefits to cognitive functioning (including tests of memory and orientation) in people with mild-moderate dementia. Improvements were also seen in quality of life, well-being, communication, and social interaction; however, no improvements were observed in activities of daily living (Woods et al., 2012). The RCTs in the review were of varying quality, consisted of small sample sizes and only limited information of the randomisation procedure was available; thus, more rigorous RCTs assessing cognitive stimulation are needed. Furthermore, in these RCTs everyday functioning was assessed via ADL scales, with only one study that used a performance-based, rather than, a care-giver report, which as discussed earlier do not provide an objective measure of everyday functioning. Therefore, although, cognitive stimulation is promising for some aspects of dementia, its impact on everyday functioning is unclear.

1.4.2 Cognitive training

Cognitive training typically involves guided practice on a set of standardised tasks aimed at enhancing specific cognitive functions, such as short-term memory, attention, language, visuospatial abilities, and problem-solving. In cognitive training difficulty levels are normally adjusted within the standard set of tasks to suit the individual's ability and level of functioning (Bahar-Fuchs et al., 2013). It may be administered in individual or group sessions with pen and paper, computer based tasks or analogues of activities of daily living, such as laying tables, washing hands, making tea, etc. (Farina et al., 2006). It is assumed that repeated practice of these tasks will improve or maintain functioning in the given task and may even generalise onto other tasks beyond the training context (Bahar-Fuchs et al., 2013). However, Rusted and Moniz-Cook (2013) recognise that benefits observed in cognitive tests do not necessarily translate to real-world everyday difficulties that people with dementia experience (e.g. Owen et al., 2010). Indeed, a meta-analysis of 11 RCTs reporting cognitive training intervention in people with mild dementia found that, compared to control conditions, there was no benefit to cognitive training (Bahar-Fuchs et al., 2013). This meta-analysis included several outcome measures, but not everyday task functioning. The authors of the meta-analysis concluded that these null findings may have been due to the poor quality of the RCTs (Bahar-Fuchs et al., 2013).

1.4.3 Cognitive rehabilitation

Cognitive rehabilitation (also called neurorehabilitation) is a cognitive-focused intervention that provides an individually tailored approach to helping people with cognitive impairments (Clare & Jones, 2008). In contrast to cognitive training that focuses on pen and paper or computerised tasks, cognitive rehabilitation is concerned with tasks applicable to the real world, personalised to the individual (Bahar-Fuchs et al., 2013), and aims to help people with dementia by either optimising residual cognitive abilities or by finding ways to compensate for existing difficulties (Bahar-Fuchs et al., 2013; Rusted & Moniz-Cook, 2013). Cognitive rehabilitation may use any of the following methods: structured feedback, repetition, external aids (e.g. calendars and diaries), and errorless learning, to name but a few. Errorless learning has gained particular attention in recent years due to its positive outcomes for people with dementia (Clare & Jones, 2008; de Werd, Boelen, Olde Rikkert, & Kessels, 2013). A review of the literature confirmed that errorless learning had benefits for everyday tasks and skills used in day-to-day living (de Werd et al., 2013), as well as face-name associations (Clare, Wilson, Breen, & Hodges, 1999; Clare, Wilson, Carter, Roth, & Hodges, 2002a), personal information and use of memory aids (Clare et al., 2000). Only six studies reviewed focused on procedural or sequential tasks, such as IADLs, and all of these found positive benefits from errorless learning (Bier et al., 2008; Dechamps et al., 2011; Lekeu, Wojtasik, Van der Linden, & Salmon, 2002; Thivierge, Simard, Jean, & Grandmaison, 2008; van Tilborg, Kessels, & Hulstijn, 2011; Yamaguchi, Foloppe, Richard, Richard, & Allain, 2012). However, out of these studies, only one study had a control condition (Dechamps et al., 2011), thus for the remaining studies it is unclear whether errorless learning was responsible for the positive results or simply the fact that the participant was involved in an activity. Furthermore, the errorless learning conditions from these studies involved different techniques within the same condition, making it difficult to ascertain which technique was more useful. Lastly, the outcome measures in these studies were simply the proportion/number of task steps that the participant performed correctly – there was no information on the *types* of errors that were reduced and no information on error-monitoring.

1.4.4 Error-monitoring strategies

There has been a limited amount of research into strategies aimed directly at enhancing error-monitoring in people with dementia performing everyday tasks. These studies have all used naturalistic tasks and document changes in terms of the numbers and types of errors, error detection and correction, rather than simply the proportion of task steps performed accurately. Nonetheless, these interventions have shown little benefit. Giovannetti, Bettcher, et al. (2007a) tested the impact of a user-centred condition that included environmental adaptations (placing objects in order of use) and a cue to error monitor (a bell with the words ‘check your work’ on it to encourage error-monitoring) on NAT performance in people with mild-moderate DAT. Although these adaptations improved performance (compared to a control condition) it was unclear which adaptation was responsible for the improved performance and long term benefits were not assessed. In a retrospective study that reanalysed the previous results, Bettcher et al. (2011a) found that the user-centred condition did not improve error detection or error correction. In another study, Brennan, Giovannetti, Libon, Bettcher, and Duey (2009) evaluated the efficacy of goal cues on NAT performance in people with mild-moderate dementia. Although, the goal cues reduced omissions, NAT performance remained in the impaired range and neither error detection nor correction of commission errors improved. Finally, in another study participants with dementia completed a 10 minute training session before each NAT task (Bettcher, Giovannetti, Libon, et al., 2011b), using verbal description, picture presentation of all the necessary task steps, video presentation reviewing all the task actions, and a pictorial quiz administered at the end of each training session. The training reduced total errors, and increased detection of errors, but did not improve error correction. Thus, the strategies aimed at enhancing error-monitoring in everyday tasks in people with dementia are limited and have generated minimal improvements.

1.4.5 Summary

Research into interventions that directly improve everyday task performance using naturalistic, sequential everyday tasks are limited and those studies which do use naturalistic tasks use a simplistic method for measuring improvement (number/proportion of accurate task steps performed). Strategies that aimed to enhance error-monitoring in naturalistic everyday tasks have indicated little benefit, but this may be due to a number of methodological limitations.

1.5 Aims and outline of thesis

This thesis reports a detailed analysis of everyday task performance in people with dementia, in order to inform interventions of everyday task performance. It builds on previous studies that only provided a single snapshot of functioning in the mild-moderate stage of dementia (Giovannetti et al., 2002a) and explores changes over time in a developing dementia. It develops previous error-monitoring taxonomies (Bettcher et al., 2008; Giovannetti et al., 2002b), in order to provide a more comprehensive documentation of everyday task performance in people with dementia. Finally, it briefly tests two behavioural strategies that might enhance everyday task performance in people with dementia. Throughout the thesis the emphasis is on a meticulous analysis of the complexity of actions executed in implementing an everyday task, and the capacity of people with dementia to monitor and correct emerging errors and performance errors. The overarching questions of this thesis are:

1) What is the evidence that people with dementia can effectively monitor for errors in everyday task performance and how does this change over time as dementia develops?

2) How can everyday task performance be improved in people with dementia?

1.5.1 Thesis summary

1.5.1.1 Study 1 - Age related changes in error-monitoring of an everyday task.

Study 1 documented error-monitoring (including checking) in young and older adults performing a novel everyday task and explored the impact of reducing cognitive resources on errors and error-monitoring. The novel everyday task developed for this study involved participants remembering two novel tea-making routines, performing the two routines concurrently and in a limited time-frame. Participants performed the task under two conditions of increasing complexity – a standard condition (as above) and a dual-task condition (same as standard, but with an added dual task) - in order to limit cognitive resources further. It was hypothesised that older adults would perform worse than young adults, due to the decline in global cognitive resources associated with healthy ageing and in a condition that limits cognitive resources further (i.e. dual-task condition), young adults would perform like older adults in a standard (i.e. single task) condition. It was predicted that older adults would make more errors compared to younger adults overall, reflecting age-related cognitive decline. Reduced cognitive resources in the dual-task condition would elicit more errors and reduce error-monitoring for both age-groups compared to the standard condition. *Study 1* found that older adults engaged in more checking than young adults, and this was reduced when cognitive resources reduced in the dual-task condition. However, checking had no impact on task accuracy.

1.5.1.2 Study 2 - Error-monitoring in an everyday task in people with Alzheimer-type dementia: Observations over 5 years of performance decline.

Using a comprehensive error-monitoring taxonomy (developed in *Study 1*) *Study 2* explored error-monitoring of an everyday task in four individuals with dementia over 5 years, using secondary observational archive data from Rusted and Sheppard (2002) of four people with dementia making tea in their own kitchens, according to their own routine. *Study 2* aimed to establish whether a) people in the early stages of DAT retain error-monitoring skills comparable with healthy older adults (as documented in *Study 1*), and b) there was a common pattern of change in error-monitoring over time across these four individuals with dementia. It was anticipated that the participants with dementia would increase error-monitoring over time, to sustain their performance; this would provide an explanation for the previous evidence that routine activities are maintained well into the dementia (Rusted & Sheppard, 2002), and establish a clear time-frame for changes in error-monitoring capacity to guide development of interventions to enhance awareness and reduce errors in everyday tasks. It was found that participants with dementia did not effectively monitor their performance.

1.5.1.3 Study 3a - Can verbal instruction enhance recall of everyday tasks and error-monitoring in people with dementia of the Alzheimer-type?

Study 3a used data drawn from unpublished observational data from Rusted and Sheppard (2002), whereby four participants with dementia were observed for five years in their own homes, completing three tea-making conditions: performed-recall (they made tea themselves); instructed-recall (they instructed the experimenter on how to make tea); and verbal-recall (they described how to make tea). The aim of *Study 3a* was to determine if the failures in error-monitoring seen in *Study 2* were present when participants with dementia were required to verbally instruct a third party to execute the routine. By maintaining the schema through instruction, activation of the action observation network through observing another's actions during instruction, and using a goal-directed task (optimising recall of the organisation/sequence of actions), it was anticipated that: 1) instructed-recall and performed-recall conditions would be comparable in terms of task accomplishment and the number of errors made; 2) the instructed-recall condition would promote more efficient error-monitoring; 3) sequence/anticipation errors would be reduced in the instructed-recall condition. It was found that participants performed well in the instructed-recall condition, but error-monitoring was not improved. It was believed that the observation of the task unfolding in front of the participants was responsible for the good performance, however, the contribution of the verbal element of instructing could not be ruled out.

1.5.1.4 Study 3b - Can self-explanation help people with dementia perform an everyday task? A pilot study.

Leading on from the results of *Study 3a*, *Study 3b* investigated the direct effects of verbalising on everyday task performance in a pilot study. Four participants with mild-moderate dementia were monitored in their own homes and observed making tea according to their own routines for three years. The aim was for tea-making routines to initially be established prior to errors emerging in their tea-making and to determine the nature of verbalisations that they made normally. A verbal self-explanation manipulation was introduced in the third year of the study when participants were beginning to decline in their everyday functioning. Self-explanation was found to increase the time it took participants to complete the task, but it did not improve everyday task performance or error-monitoring. This implied that in *Study 3a*, verbal instruction alone was not solely responsible for the good performance in the instructed-recall condition and perhaps the observational element of instructing another played an important role.

1.5.1.5 Study 4a – Observational learning of a novel everyday task in people with dementia.

In *Study 4a* the potential for observational learning was explored in people with mild-moderate dementia. It was anticipated that participants would perform better in the observational learning condition. Furthermore, due to the affordances that objects trigger (Tipper, 2010), it was hypothesised that the motor memory for the hand gestures required for selecting target items would be primed through observation. Thus, it was anticipated that in the observational learning condition, errors involving distractors that share the same hand gesture as the target objects (compatible distractors) were more likely, than distractors involving a different hand gesture as the target objects (incompatible distractors). Observational learning was found to improve task performance, but did not affect the type of distractors selected.

1.5.1.6 Study 4b – Can observational learning facilitate further learning over time in people with dementia? A pilot study.

In *Study 4b* three participants from *Study 4a* were followed up to determine if further observational learning sessions could encourage further learning or at least sustain learning over time. These three participants were given three additional sessions of observational learning over a period of five weeks. It was posited that savings in relearning might provide a more sensitive measure of the impact of observational learning. It was found that, although observational learning improved task performance short term within each session, repeated trials did not continue to develop with repeated training sessions over a longer period of time.

2 Studies

2.1 Study 1 – Age related changes in error monitoring of an everyday task

2.1.1 Abstract

The process of *checking* in an everyday task, in order to ensure error prevention/error correction, has not been systematically documented in relation to everyday action errors. This is surprising, given that studies of everyday task performance in people with dementia suggest poor error monitoring (error detection/correction). The present study documented age related changes in errors and error monitoring behaviours, including the novel variable of checking (verbal/non-verbal gestures indicating active task monitoring), in an everyday task. In a 2 x 2 mixed-subjects design (n = 57), young and older adults performed a tea-making task under standard and dual-task conditions. Error rates were similar across age-groups and conditions. The dual-task condition reduced verbal checking and increased microslips (initiation and termination of an error before the error is completed) for both age-groups, when compared to the standard condition. In the standard condition, older adults engaged in more verbal checks than young adults, but this was not associated with improved task accuracy. Thus, both age-groups do engage in checking during an everyday task, but this checking had little impact on task accuracy. Consequently, checking may not be a necessary part of performance accuracy. Future studies should investigate whether enhanced awareness would make monitoring more effective.

2.1.2 Introduction

Everyday activities, such as tea making and teeth brushing, are familiar tasks that are normally performed with ease. Tiredness and distraction can cause errors on these tasks (Reason, 1990), as can brain damage and disease (Humphreys & Forde, 1998). Individuals with dementia are prone to everyday action impairment. Studies of error monitoring in people with dementia (Bettcher et al., 2008; Giovannetti, Libon, & Hart, 2002b) show that this patient group are less likely to notice and correct their errors than healthy older adults. Bettcher and Giovannetti (2009) argue that errors of action may be unavoidable and that research should focus not on error prevention, but instead on the ability to quickly and accurately detect and correct errors (error-monitoring). This highlights the potential for behavioural strategies that aid error monitoring in people with dementia.

Action errors are measured using ‘naturalistic action sequences’: learned and habitual sequences of movements, required in achieving a goal (Schwartz et al., 2002a). Action errors are categorized into errors of omission (when a step or subtask is never performed) or commission (when a task step is inaccurately performed or an extra off-task step is performed) (Schwartz et al., 1998). Studies have shown that action errors are widespread in neurological groups and that the distribution of error types appears similar across patient groups, specifically they make more errors of omission (left hemisphere stroke: Buxbaum, 1998; dementia: Giovannetti et al., 2002a, 2002b; right hemisphere stroke: Schwartz et al., 1999) than their age-matched counterparts. Schwartz and colleagues (2002) argue that action errors in neurological patients may be an exaggeration of the slips of memory and distraction that happen in healthy individuals (Norman, 1981; Reason, 1990).

Error monitoring refers to the responses to an error (i.e. error detection, explanation and correction; (Bettcher & Giovannetti, 2009; Blavier et al., 2005). Behavioural studies examining error monitoring in people with dementia are limited. In a naturalistic task, Giovannetti and colleagues (2002b) reported that patients with mild to moderate dementia were less aware of their errors and corrected a significantly smaller proportion of action errors, compared to healthy controls (20% vs. 73% for healthy controls). Additionally, neither error detection, nor correction scores were significantly correlated with neuropsychological measures, dementia severity or the total number of action errors committed.

In a follow-up study, Bettcher and colleagues (2008) investigated microslips. These corrections were considered to reflect auto-control processes, because they occur before the error is fully completed (Giovannetti, Schwartz, & Buxbaum, 2007b). Bettcher and colleagues (2008) reported that, while their participants with dementia corrected most of the errors they detected (75.8%), even with the inclusion of microslips they detected only one third of their total errors (32.7%), whereas controls detected 73% of their errors. Most corrections in the dementia group were microslips; if the error was actually completed, it was unlikely to be corrected.

The aforementioned studies focused on error detection and error correction. Few studies, however, have sought to investigate the active monitoring or *checking* in an everyday task through which the participant ensures error prevention and/or error detection. To our knowledge, only three studies to date (Bettcher, Giovannetti, Libon, et al., 2011b; Brennan et al., 2009; Giovannetti, Bettcher, et al., 2007b) have examined checking behaviour, and all focused on older adults with dementia. Using the Naturalistic Action Task (NAT) under conditions that manipulated the amount of task support (e.g. by spatially ordering the items required for the task, by providing a cue to check performance). Cueing reduced commission errors, but not omission errors (Giovannetti et al., 2007a), whilst spatial ordering alone produced no benefits (Bettcher et al., 2011b). Explicit cues that restated the task goals were effective in prompting participants to check their work, and did reduce omission errors (Brennan et al., 2009). However, this improvement was interpreted as not clinically meaningful, because the cues did not shift performance from the impaired to unimpaired range of the NAT scoring system. The authors concluded that failure to monitor task progress may not be the primary cause for everyday action deficits in a dementia population (Brennan et al., 2009).

The predominant model of action impairment, the *resource model* (Buxbaum, 1998; Giovannetti, Libon, Buxbaum, et al., 2002a; Schwartz et al., 1999; Schwartz, 2006b; Schwartz et al., 1998), suggests that goal maintenance required for accurate task implementation is resource demanding, and thus errors are likely to occur when cognitive resources are limited, either through age related change, brain damage, disease or distraction.

Patient studies support the resource model (Buxbaum, 1998; Giovannetti et al., 2002a; Schwartz, 2006; Schwartz et al., 1998, 1999). Firstly, patients with high rates of omission errors also have high rates of commission errors (Schwartz, 2006; Schwartz et al., 1998), suggesting that a single construct of resource capacity may be responsible for impairments on outwardly distinct components of performance (Giovannetti et al., 2008). Secondly, different patient groups have shown nearly identical distributions of error types (mostly omissions), suggesting that action errors reflect a general cognitive impairment and not a particular neuropsychological profile (see Schwartz, 2006, for a review). Thirdly, everyday action performance appears strongly linked to measures of global cognitive functioning, rather than specific cognitive processes (Buxbaum, 1998; Giovannetti et al., 2002a; Schwartz et al., 1999, 1998). Further support for the resource model is provided by Rusted and Sheppard (2002), who monitored the breakdown of an everyday routine (tea-making) over a six year period of a developing dementia. Again, omissions were the most common error type in this population and increased as dementia severity limited available resources.

More recently, however, results have led researchers to reconsider the resource theory. Giovannetti and colleagues (2007b) compared healthy participants performing a complex Coffee Challenge under a novel task condition, compared to a dual-task condition (in which the task was well-learned, but had an added divided-attention component). The resource theory would predict a similar pattern of errors in each condition, because the conditions are comparable in terms of resource limitations. Omission errors were frequent in the novel condition, while in the divided attention condition the rate of commission errors was high and omissions were rare. Additionally, Giovannetti and colleagues (2002b) and Bettcher and colleagues (2008) found no relation between dementia severity and number of errors, which again contradicts the predictions made by the resource model. Finally, Giovannetti and colleagues (2008) reported in a sample of 70 dementia participants, that omission errors were predicted by tests of general dementia severity (i.e. MMSE) and episodic memory performance, whilst commissions were predicted by measures of executive control and working memory. The data suggest independent contribution to action-based memory from two processes: episodic memory is essential to schema selection, remembering task goals and which steps have been completed; while executive control abilities are needed for smooth sequential execution of task steps and target object selection. In a dementia population, errors of omission dominate, as anticipated in a population experiencing significant global cognitive impairment and episodic memory deficits. Where executive control impairments exist or co-exist, commission errors will be observed. Giovannetti et al. (2008) did not explore error monitoring, but their explanation would imply that this would be compromised in the executive-impaired group only.

The present study explored whether global cognitive resource or executive control resources better predict errors and error monitoring in an everyday task in non-demented individuals. Using a comprehensive error and error monitoring taxonomy, we compared performance of young and older adults on a naturalistic Tea-making Task (TT) developed to complement the Coffee Challenge task (Giovannetti et al., 2007b). Participants carried out the TT under standard and dual task conditions. According to the resource theory, in a condition that limits cognitive resources (i.e. a dual task condition) we would expect young adults to perform like older adults in a standard (i.e. single task) condition. We predicted that older adults would make more errors compared to younger adults, reflecting age-differences in global cognitive resources. Reduced resources in the dual condition would elicit more errors for both age-groups. Additionally, we document checking behaviour during an everyday task and whether this changes with age. Critically, we anticipated less monitoring in the dual condition compared to the standard condition, reflecting executive resource limitations imposed by the dual-task, and that older adults would experience greater disruption to monitoring capacity than their younger counterparts

2.1.3 Methods

2.1.3.1 Ethical Approval

Ethical approval was obtained from the University of Sussex Schools of Psychology and Life Sciences Research Ethics Committee. Informed consent was taken from each participant prior to data collection.

2.1.3.2 Participants

Twenty-nine older adult participants (aged 57–80 years; 16 females) were recruited from the general community, staff and alumni of the University of Sussex. Twenty-eight young adult participants (19-35 years; 15 females) were recruited from the University of Sussex psychology subject pool. For a mixed-subjects design, the sample size (n = 57) provided sufficient power (.96) to detect a small effect size (.25) when alpha (p value) was set to .05 (Erdfelder, Faul, & Buchner, 1996).

2.1.3.3 Measures

2.1.3.3.1 Naturalistic Tea-making Task (TT)

All participants carried out the TT, which was performed in a kitchen and filmed for subsequent observational analysis. The TT is an adaptation of the Coffee Challenge (Giovannetti et al., 2007b). It comprises two conditions: standard and dual.

Standard condition. Participants are presented with objects needed to make two cups of tea, along with eight distractor objects. They are required to make two cups of tea for two fictitious people ('Jack' and 'Jill'), who have different and specific tea requirements (see Appendix A1 for the objects used in the TT). Participants are instructed to make the cups of tea as quickly as possible, and are encouraged to interleave the steps required for the two teas. They are asked to avoid touching the objects until they need to use them. Participants are encouraged to say when they think they have made an error or when they are unsure that what they were doing was right, so that error monitoring can be coded. Participants are encouraged to ask questions about the task and instructions before the task begins, but not during the task.

Dual condition. Participants are required to complete the same task while simultaneously performing the *Oral Trail Making Task* (OTMT; Ricker & Axelrod, 1994). The OTMT requires participants to generate a verbal sequence of alternate letters and numbers (e.g. A1, B2, C3....). Participants are not permitted to stop one task to carry out the other (in such cases, participants are prompted to 'carry on' or 'keep going'), unless it is to verbalize an error. If participants reach the end of the alphabet they start the alphabet again, but continue the same number sequence (e.g. A27).

2.1.3.3.2 Neuropsychological measures

The National Adult Reading Test (NART; Nelson, 1982) is a vocabulary test, which provides an estimate of verbal IQ.

Trail Making Task A and B (TMT; Army Individual Test Battery, 1944) is a measure of executive processing, requiring visual-conceptual and visuo-motor tracking. The TMT ratio (TMT-B/TMT-A) provides a good indicator of executive functioning (Arbuthnott & Frank, 2000). It also controls for age and education (Lamberty, Putnam, Chatel, Bieliauskas, & Adams, 1994) and thus can be compared between young and older adults.

The Digit Symbol Substitution Test (DSST; Wechsler, 1987) is a pen and paper test of psychomotor performance and measures speed of information processing.

The Map Test of Everyday Attention (Map-TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996) is a visual search task measuring sustained attention.

2.1.3.4 Procedure

Informed consent was first taken, followed by the neuropsychological measures and finally the TT. The standard condition of the TT was always completed before the dual condition. This was to ensure that the dual condition always included practice effects, making it consistent amongst all participants. Finally, participants were debriefed and thanked for their participation.

2.1.3.5 Data coding for errors and error monitoring

The Noldus Observer software (Version 5.0; Noldus Information Technology, 2003) was used to code performance on the TT from digital video.

2.1.3.5.1 Errors

Errors were coded using the error taxonomy developed by Giovannetti et al. (2007b) for the Coffee Challenge. Errors were coded as either commissions or omissions. Following Giovannetti et al. (2007b), commissions were broken down into specific error types: when a task step was performed incorrectly (i.e. anticipation, perseveration, substitution, quantity) and when an off-task step was performed (i.e. action addition). Omissions were recorded when a task step was completely omitted. See Appendix A2 for the error taxonomy.

2.1.3.5.2 Error monitoring

An error monitoring taxonomy (modelled on Bettcher et al., 2008) was used to analyse error correction, microslips and checking behaviour (see Appendix A3). In contrast to Bettcher et al. (2008), microslips were coded as an independent category, and were not included as errors and corrections. Additionally, a novel *checking* category was added to capture any verbal or non-verbal indication that the participant was monitoring their performance.

2.1.3.5.3 TT performance speed

The TT performance speed for each participant in each condition was recorded in seconds.

2.1.3.6 Inter-rater reliability

The error taxonomy has previously shown to have high inter-rater reliability (Giovannetti et al., 2007b), as has the error-correction and microslip component of the error monitoring taxonomy (Bettcher et al., 2008). Inter-rater reliability of the novel *checking* category was established across two raters (SB and another lab member) using Cohen's Kappa analysis. A Kappa of .62 ($p < .0001$) indicated substantial agreement (Landis & Koch, 1977).

2.1.4 Data analysis

All data were analysed using IBM Statistics 20. For demographic data, independent samples *t*-tests were carried out. Effect sizes were reported using Pearson's correlation coefficient (*r*). Age-group x condition mixed design ANOVAs were conducted on all main variables and Bonferroni corrections were applied. Effect sizes were reported using partial eta squared (η^2). Correlations were calculated using Spearman's Rho (some variables were non-parametric). *P* values of below .05 were considered statistically significant. All data has been reported to two decimal places, except where borderline *p*-values were found. In which case these were reported to three decimal places

2.1.5 Results

2.1.5.1 Preliminary Analyses

2.1.5.1.1 Demographic and neuropsychological characteristics of the sample

Young and older adults were comparable on years of education, TMT ratio scores and Map-TEA (all *p*s > .05). Older adults had a significantly higher NART estimated IQ than the younger adults ($p < .0001$), but young adults performed better in the DSS compared to older adults ($p < .0001$; see Table 1.1).

Table 1.1. Mean averages (*M*) and standard deviations (*SD*) of demographic and neuropsychological variables

Variable	Older adults (*n* = 29) *M* (*SD*, range)	Young adults (*n* = 28) *M* (*SD*, range)	*t (df)*	*p* (2-tailed)	Effect sizes
Age	67.86 (5.72, 57-80)	24.64 (4.79, 19-35)	*N/A*	*N/A*	*N/A*
IQ	122.61 (3.20, 114-127)	118.01 (5.57, 105.6-128)	3.81 (42.79)	.00	.50
Education	17.81 (3.07, 10-26)	17.46 (2.24, 13-21)	.49 (55)	.63	.07
TMT ratio	2.08 (.63, 1.05-3.69)	2.25 (.67, 1.40-3.48)	.98 (55)	.33	.13
Map-TEA	10.76 (2.97, 4-17)	11.61 (2.10, 4-15)	1.07 (55)	.29	.14
DSST	48.48 (9.18, 29-66)	64.57 (11.38, 45-89)	5.89 (55)	.00	.62

Note. IQ = NART estimated IQ; Education = Years of education; TMT ratio = Trails B/Trails A; Map-TEA = Map Test of Everyday Attention; DSST = Digit Symbol Substitution Test.

2.1.5.1.2 TT performance speed

TT performance speed did not differ across conditions or age-group and there was no significant condition x age-group interaction (all *F*s < 1). Conclusively, this analysis demonstrates that neither age-group had a speed of performance advantage that might have led to a variation in error rate between age-groups.

2.1.5.1.3 Secondary task performance

The rate of OTMT responses per minute was calculated. On average young adults made 14.25 OTMT responses per minute (SD = 3.61) and older adults made 14.10 OTMT responses per minute (SD = 3.57); this difference was not significant, $t(55) = .16$, $p > .05$. Thus, any age-group difference in TT performance in the dual condition cannot be explained by difference in digit generation time (and by implication, difference in working memory load).

2.1.5.2 Principal Analyses: Errors and Error Monitoring

2.1.5.2.1 Errors

Errors were low across all participants (see Table 1.2). Contrary to prediction, there was no significant main effect of age-group or condition on total errors and no significant interaction (all *F*s < 1). In terms of the main categories of errors, commissions were more common than omissions, regardless of age-group or condition, with substitutions being the most common type of commission in both age-groups and both conditions. Regarding errors of omission, there was no significant main effect of age-group or condition, and no significant interaction (all *F*s < 1). Similarly with respect to commission errors, there was no significant main effect of age-group or condition and no significant interaction (all *F*s < 1).

Table 1.2. Mean averages (*M*) and standard deviations (*SD*) of main error and error monitoring variables.

	Young adults		Older adults	
Errors/error monitoring variables	Standard *n = 28* *M* (*SD*)	Dual *n = 28* *M* (*SD*)	Standard *n = 29* *M* (*SD*)	Dual *n = 29* *M* (*SD*)
Omissions	0.46 (0.74)	0.5 (0.88)	0.59 (1.09)	0.72 (0.75)
Commissions	1.68 (1.76)	1.54 (1.55)	2.48 (2.10)	2.24 (2.39)
Total errors	2.14 (2.17)	2.04 (2.06)	3.07 (2.45)	2.97 (2.63)
Microslips	0.54 (0.64)	1.11 (1.10)	0.62 (0.68)	0.97 (1.38)
Verbal checks	1.57 (1.26)	0.64 (0.83)	4.00 (6.05)	1.34 (2.79)
Non-verbal checks	1.82 (1.85)	1.46 (1.40)	1.55 (1.33)	1.59 (1.40)
Total checks	4.32 (2.50)	2.11 (1.71)	5.55 (6.38)	2.93 (3.16)
Proportion of errors corrected	*n* = 22* 0.18 (0.27)	*n* = 22* 0.57 (0.79)	*n* = 25* 0.23 (0.26)	*n* = 26* 0.27 (0.33)
TT performance speed (seconds)	331.73 (76.53)	333.41 (90.77)	383.55 (75.06)	356.72 (60.24)

*Participants who made no errors were not included in this analysis.

2.1.5.2.2 Error monitoring

Verbal checks. Verbal checks were significantly more frequent in the standard condition, than the dual condition across both age-groups ($F[1, 55] = 17.77$, $p < .001$, $\eta^2 = .25$). There was a significant age-group x condition interaction ($F[1, 55] = 4.12$, $p = .047$, $\eta^2 = .07$), with older adults making more verbal checks than young adults in the standard condition ($t[30.51] = -2.11$, $p = .04$, 2-tailed), but no difference in the dual condition ($t[55] = -1.28$, $p > .05$, 2-tailed). The main effect of age-group just missed the .05 level of significance ($F[1, 55] = 21.89$, $p = .058$, $\eta^2 = .06$), reflecting a non-significant trend for older adults to make more verbal checks than young adults overall (regardless of condition).

Non-verbal checks. There was no significant main effect of condition or age-group and no significant interaction (all *F*s < 1).

Microslips and error-corrections. There was a significant main effect of condition on microslips ($F[1, 55] = 6.62$, $p = .02$, $\eta^2 = .11$), with more microslips made in the dual condition than in the standard condition for both age-groups. There was no significant main effect of age-group on microslips ($F < 1$), and no significant age-group x condition interaction ($F < 1$). The proportion of errors corrected was calculated for those who made errors (see Table 1.2); there was no significant main effect of condition or age-group, and no significant interaction (all *F*s < 1).

2.1.5.3 Supplementary Analyses

2.1.5.3.1 Qualitative breakdown of verbal checks

To investigate verbal checks further, a coding scheme was developed for qualitative analysis of verbalizations (see Appendix A4). Thus, checks were classified as: schema checks (SC; recalling or attempting to recall the task steps and/or task goal); reflective implementations (RI; reflecting, evaluating and planning the task at hand); practical checks (PC; any comment indicating technical clarification or a matter of fact statement). All statements were rated independently by two coders (SB, JR); Kappa was 0.78 ($p < .0001$), indicating a substantial agreement (Landis & Koch, 1977). Remaining inconsistencies were agreed through discussion.

Verbal checks occurred almost exclusively in the standard condition. In this condition, there was a significant main effect of age-group ($F[1, 55] = 6.34$, $p = .02$, $\eta^2 = .10$), with older adults making more RIs than young adults. There were no significant differences between older and younger adults on schema checks or on practical checks (all *F*s < 1). See Table 1.3.

Table 1.1. Mean averages (*M*) and standard deviations (*SD*) of verbal check categories.

	Young adults		Older adults	
Verbal check	Standard	Dual	Standard	Dual
categories	*n = 28*	*n = 28*	*n = 29*	*n =29*
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
SC	0.36 (0.56)	0.00 (0.00)	0.90 (0.37)	0.28 (1.13)
RI	0.39 (0.69)	0.25 (0.52)	2.55 (4.46)	0.83 (1.56)
PC	0.82 (0.86)	0.32 (0.55)	0.55 (0.91)	0.24 (0.95)

Note. SC = Schema check; RI = Reflective implementation; and PC = Practical check

Following significant group differences on verbal checks and microslips, Spearman's Rho (r_2) correlations were carried out to determine any associations between verbal checks (specifically SCs, RIs and PCs), errors (omissions and commissions) and microslips. Only significant correlations are reported here (r_2 range of non-significant correlations = -.19-.21, all *p*s > .05). Schema checks and reflective implementations in both conditions correlated with commissions in the dual condition (SCs and RIs in standard: r_2 = .57, $p <$ .001; r_2 = .33, p = .014; SCs and RIs in dual: r_2 = .51, $p <$ .001; r_2 = .384, p = .003). Microslips in the standard condition correlated with reflective implementations in the dual condition (r_2 = .32, p = .015). Similarly, microslips in the dual condition correlated with schema checks (r_2 = .43, p = .001) and reflective implementations (r_2 = .39, p = .003) in the standard condition, and schema checks (r_2 = .35, p = .008) and reflective implementations (r_2 = .32, p = .04) in the dual condition. This hints that microslips and verbal checks might be measuring the same construct (i.e. error monitoring), but that neither effectively reduced commission errors.

2.1.5.3.2 Relationship between TT performance and neuropsychological measures

Spearman's Rho correlation (r_2) was conducted between the TMT ratio (a measure of executive functioning), DSST (a measure of speed of processing), Maps-TEA (a measure of sustained attention) and errors/error monitoring outcome variables across all participants regardless of age-group (see Appendix A5). TMT ratio only correlated significantly with commissions in the dual condition (r_2 = .39, $p <$ .001, 2-tailed), suggesting that poorer executive function is related to higher commissions. Good performance on the DSST was associated with fewer commissions in the standard condition ($r_2 = -.30$, $p < .05$, 2-tailed) and more practical checks in the dual condition ($r_2 = .27$, $p < .05$, 2-tailed). This suggests that speed of processing may also provide a proxy measure of executive competence. Additionally, performance in the Maps-TEA was associated with fewer reflective implementations in both conditions, suggesting that sustained attention was associated with reduced need to externalise online monitoring of the task.

2.1.6 Discussion

Building on previous studies (e.g. Bettcher et al., 2008; Giovannetti et al., 2007b), this study presents a comprehensive analysis of errors and error monitoring behaviours by healthy young and older adults in a naturalistic task.

Consistent with the resource model, distribution of error types was similar across age-groups and across conditions. For both young and older adults errors of commission were more common than omission errors. Contrary to expectations, older adults did not make more errors than young adults. The results are in line with studies reporting that healthy controls tend to be low error producers and produce mostly errors of commission (Schwartz, 2006). The error pattern observed in the older adults performing the TT when resources were limited differed from reported errors in people with dementia, who make mostly omissions (Giovannetti, Libon, Buxbaum, et al., 2002a; Ramsden, Kinsella, Ong, & Storey, 2008; Rusted & Sheppard, 2002). Therefore, limiting the cognitive resources of older adults did not induce an error profile that modelled participants with dementia. The number of errors made in the present sample was surprisingly low, considering the complexity of the task, even when the secondary load (the OTMT) was added. The resource model would anticipate more errors when cognitive resources are limited (Schwartz et al., 1998), but this was not observed in our sample. Notably, the exceptionally good performance in the dual condition was not achieved by taking extra time: there was no difference in performance speed between conditions in either age-group. The dual condition always followed the standard condition and practice effects may have reduced the dual-task impact. Although there were no changes in the task accuracy, however, we did observe a difference in monitoring behaviours, which is discussed later.

Giovannetti et al. (2008) suggested that participants with dementia could be either omissive, commissive, or have a mixed pattern of everyday action impairment, as evidenced by different neuropsychological measures predicting different error categories in people with dementia: omissions were predicted by global cognitive ability and episodic memory; commissions were predicted by deficits in executive functioning. The present study explored this model for healthy adults without dementia: for both young and older adults, the dominance of commission errors implies that the task requires and engages executive skills. Imposing a concurrent working memory task, however, did not increase commissions further.

Verbal checks occurred exclusively in the standard condition; older adults made more RIs than young adults; and there were no differences between SCs and PCs between age-groups. We suggest that RIs represent on-line planning and evaluation of the task at hand, and provide here an external index of executive engagement. The tendency for older adults to verbalize RIs is consistent with active monitoring to hold attention on task – a shift away from automatic executive engagement to more conscious executive engagement. This is supported by the inverse relationship between sustained attention and RIs – the poorer attentional focus, the higher the need for active monitoring. In the standard condition, commissions were associated with a slower speed of processing, and in the dual condition, with poorer executive functioning (the latter supporting Giovannetti et al., 2008). These results suggest that different domains may be engaged under different task conditions to minimise errors of commission.

Three measures of monitoring were recorded: error corrections, checking behaviours and microslips. Surprisingly, there was no difference in the proportion of errors corrected between young and older adults, contradicting the notion that age related resource limitations might be a limiting factor in error correction. There was also no difference (for either age-group) in the proportion of errors corrected under standard or dual conditions.

The literature regarding error correction in older adults has reported mixed findings. In a serial choice reaction time task, older adults detected and corrected as many of their errors as younger adults, but they needed additional time (Rabbitt, 2002). In the present study, older adults did not require more time to maintain an error correction rate equivalent to their younger counterparts. Band and Kok (2000) found that task complexity rather than time restrictions determined older adults' error corrections, but our study was unable to support these findings.

A key finding in the present study was that both young and older adults do engage in active *checking* during performance of an everyday task, but this checking had little impact on task accuracy. First, for both groups, verbal checking was reduced significantly when the dual condition limited cognitive resources, likely reflecting use of the oral OTMT. However, actual errors did not increase for either group, suggesting that verbal checks were not a necessary part of performance accuracy even when they were used. In fact, verbal checks (schema checks and reflective implementations particularly) across all participants correlated with errors of commission in the dual condition. This suggests that verbal checks are ineffective in reducing errors. Second, older adults made more verbal checks (specifically RIs) than young adults. Again, eliminating RIs in the dual task condition did not affect performance accuracy, which suggests that verbal checks did not improve error detection/correction. Third, all participants adjusted to resource reduction with an increase in microslips. Thus, as verbal checking decreased, monitoring continued in a less overt form (microslips), and error rates did not change - an interpretation supported by the observed correlation between verbal checks in the standard condition and microslips in the dual condition across all participants. Brennan and colleagues (2009) found a similar pattern of data in a dementia population, where failure to monitor was not related to action deficits. Our data suggest that monitoring is similarly uncorrelated with action errors in older adults without dementia.

Previous studies show that action errors were related to unawareness of errors in dementia (Giovannetti et al., 2002b) and head injury participants (Hart, Giovannetti, Montgomery, & Schwartz, 1998). This study suggests that healthy adults, even though they make use of overt monitoring as they perform an everyday task, do not use it as a route to improve accuracy. Awareness of errors is a prerequisite for effective training, and a number of studies have begun to explore awareness in dementia in relation to cognitive rehabilitation (Marková, Clare, Wang, Romero, & Kenny, 2005). Clare, Wilson, Carter, Roth, and Hodges (2004) demonstrated that awareness of memory difficulties in a dementia sample predicted outcome of a cognitive rehabilitation intervention. In an earlier paper, the same authors reported that a higher level of awareness (Clare, Wilson, Carter, Roth, & Hodges, 2002b) was associated with better outcomes for cognitive rehabilitation interventions in early dementia.

There were a number of limitations in this study. First, there were, overall, few error and error monitoring behaviours. A design with a more complex everyday task could address this. Second, the dual condition always followed the standard condition; this may have reduced errors under the dual condition. Randomising the order of condition and controlling for the order of condition effects in the analysis could overcome this in future studies. Third, the oral aspect of the OTMT may have hindered verbal checking. Future research could employ a non-verbal secondary task. Fourth, the sample predominantly comprised university students, staff and alumni; thus, higher than average education and IQ might have explained the exceptionally good performance in the everyday task.

Despite these limitations, this study, using a comprehensive taxonomy of active error monitoring, demonstrated that for older adults overt monitoring of performance might have little impact on task accuracy. Future studies should investigate whether enhanced awareness or training would make monitoring more effective. This knowledge would certainly aid the development of more effective behavioural strategies to promote maintenance of everyday task performance by people with failing memory, including dementia.

2.2 Study 2 - Error-monitoring in an everyday task in people with Alzheimer-type dementia: observations over 5 years of performance decline.

2.2.1 Abstract

Research suggests that, although everyday action errors increase significantly with dementia progression, accomplishment of the task remains high, even in severe dementia. We used archive observational data charting progressive decline in everyday task performance to explore error-monitoring over a 5-year period in four people with dementia. None of the participants showed effective error-monitoring during their execution of their established tea-making routine: over five years and into more severe stages of dementia, errors increased, but there was no reactive increase from our participants in error-monitoring. Training to error-monitor routine tasks may be an appropriate target for further study.

2.2.2 Introduction

One of the diagnostic criteria for dementia is impairment in everyday task performance (American Psychiatric Association, 2013). Error taxonomies that categorize the external manifestation of errors (see Appendix A2 for an example, developed by Balouch & Rusted, 2013) have been used to assess the everyday functioning of individuals from a variety of different clinical populations (Buxbaum, 1998; Giovannetti, Libon, Buxbaum, & Schwartz, 2002a; Kessler, Giovannetti, & MacMullen, 2007; Ramsden, Kinsella, Ong, & Storey, 2008; Rusted & Sheppard, 2002; Schwartz et al., 1999; Schwartz, 2006). Research shows that people with dementia are high error producers and produce mostly errors of omission (Giovannetti et al., 2008; Giovannetti, Libon, Buxbaum, et al., 2002b; Ramsden et al., 2008; Rusted & Sheppard, 2002), whereas healthy controls are low error producers and produce mostly errors of commission (Giovannetti, Schwartz, & Buxbaum, 2007; Schwartz, 2006). Giovannetti et al. (2008) suggested that people with dementia can have either an ‘omissive’ or ‘commissive’ pattern of everyday impairment, in terms of the types of errors they produce - omissions reflect global cognitive decline and episodic memory impairments, whilst commissions reflect executive control and working memory impairments. They also suggested that action-additions (or off-task commissions - see Seidel et al., 2013), distinct from omissions and commissions reflect the inability to inhibit actions from other tasks (Bailey, Kurby, Giovannetti, & Zacks, 2013; Giovannetti et al., 2008; Seidel et al., 2013).

Bettcher and Giovannetti (2009) suggested that everyday task errors in people with dementia may be unavoidable and that research focused on error-monitoring (which they define in terms of detection and correction of an error) may produce more helpful outcomes. Studies measuring the electrophysiological responses to an error (that is, brain event related potentials - ERP) have consistently shown that error detection and error correction are separate entities. ERP studies also confirm that older adults have significantly smaller and slower ERP responses to an error than younger adults (Band & Kok, 2000; Falkenstein et al., 2000; Mathewson et al., 2005; Nieuwenhuis et al., 2002). Behaviourally these studies show increased error rates, slower reaction times and greater post-error slowing in older adults. In one study, older adults corrected more of their errors than young adults, but only in simple task conditions (Band & Kok, 2000). Error-monitoring is further compromised in people with dementia: while they still generate ERP responses, these are smaller and slower than those of age-matched controls. Behaviourally, in these lab-based tasks, people with dementia perform worse than age-matched controls, as evidenced by slower reaction times, increased error rates (Ito & Kitagawa, 2005; Mathalon et al., 2003) and fewer corrections (Ito & Kitagawa, 2005).

Naturalistic behavioural studies of error-monitoring have focused on a more detailed characterization of these behavioural indices. Giovannetti et al. (2007) developed the Coffee Challenge, in which healthy young adult participants were required to make two cups of coffee, following predefined routines as quickly as possible, without making any errors. The task was performed under conditions of increasing complexity in order to induce errors and in turn error-monitoring. Error detection (measured by corrections and verbal/non-verbal exclamations) was high in all conditions; it increased significantly when the task became more familiar, but did not change when the task became more complex. The results confirmed that healthy young adults are efficient error-monitors, even under conditions of high complexity. Using a similar Tea-making Task, Balouch and Rusted (2013; *Study 1*) reported that older adults error-monitored just as well as young adults in the everyday task. Older adults were more inclined to verbally check their performance, but these verbal checks did not impact error rate, suggesting that they reflected a lack of confidence, rather than an adjunct to error-monitoring.

Very few behavioural studies to date have explored everyday task error-monitoring in people with dementia. Giovannetti and colleagues (2002b) explored awareness (or detection) and error correction in people with dementia and healthy older adults, carrying out the Multi-Level Action Task-Short Version (MLAT-S; comprises three everyday tasks). The participants with dementia were aware of and corrected a significantly smaller proportion of their errors than healthy age-matched controls. In a subsequent study, (Bettcher et al., 2008) examined error-correction and microslips (correction of an error before the error is complete). Participants with dementia corrected only a quarter of their total errors (25%), whereas controls corrected 69% of their errors. Most corrections in the dementia group were microslips – the more time that elapsed after the error, the less likely it was for the error to be corrected. However, ambiguities in the scoring of these detections preclude conclusions regarding the dementia group's 'awareness' of their errors; it is possible that awareness was overestimated.

In summary, both ERP and naturalistic studies suggest that error-monitoring does occur in people with dementia (at least in terms of error detection and correction), but they are significantly compromised compared to healthy age-matched controls. Additionally, the coding system used by previous studies (Bettcher et al., 2008; Giovannetti et al., 2002b) may have overestimated error detection. Furthermore, these cross-sectional designs provide data only for a single snapshot of error-monitoring, in participants with mild-moderate dementia and in a managed task. Surprisingly little is known about how error-monitoring changes over time as the dementia progresses and becomes more severe. If people with dementia do error-monitor, then interventions aimed at enhancing effective error-monitoring could be developed. Effective error-monitoring, through awareness and correction of errors, could lead to fewer hazards, greater independence and reduced caregiver burden; thus, would certainly be a worthwhile field of research. Such interventions may involve reducing cognitive load through external memory aids, increasing awareness through self-monitoring, or activation of the motor engram for the task through (for example) observational cueing. Understanding whether and how error-monitoring changes over time as the dementia develops is a prerequisite for timely introduction of an intervention, and the anticipated timeframe of its potential effectiveness.

In a unique longitudinal study, Rusted and Sheppard (2002) documented everyday task performance change in a group of individuals with dementia of the Alzheimer-type (DAT) over a 6 year period, filming the routine (tea-making) in the home setting at regular intervals from when the participants were in the mild-moderate stage of DAT and thus tea-making abilities were still intact. This small dataset provides a rarely obtained window on change within dementia in a naturalistic setting. Here we report error-monitoring data drawn from the Rusted and Sheppard (2002) archive of data (not coded in the original study), to establish whether a) people in the early stages of DAT retain error-monitoring skills comparable with healthy older adults (as documented by Balouch & Rusted, 2013; *Study 1*), and b) there was a common pattern of change in error-monitoring over time across these four individuals with DAT. We anticipated that the participants with DAT would increase error-monitoring over time, to sustain their performance; this would provide an explanation for the previous evidence that routine activities are maintained well into the dementia (Rusted & Sheppard, 2002), and establish a clear time-frame for changes in error-monitoring capacity to guide development of interventions to enhance awareness and reduce errors in everyday tasks.

2.2.3 Methods

2.2.3.1 Design

A retrospective study was carried out, analysing longitudinal archive data of individual case studies of people with DAT, spanning five years from Rusted and Sheppard's (2002) original study.

2.2.3.2 Ethical approval

Ethical approval for the original study was obtained from the local Health Authority Ethics Committee and by the University of Sussex Ethics Committee. It included the consent of the volunteers to store and re-analyse the video footage beyond the original study. For the present study ethical approval was obtained from the Schools of Psychology and Life Sciences Ethics Committee, University of Sussex to reanalyse the archived data.

2.2.3.3 Participants

Only the data from participants with sessions available over at least three years were included in the present study. This comprised 4 of the original group of 9 participants from Rusted and Sheppard (2002). Rusted and Sheppard (2002) recruited participants from the community on the basis that they had a clinical diagnosis of probable Alzheimer's disease as classified by the Cambridge Examination for Mental Disorders of the Elderly (CAMDEX) test battery (Roth, Huppert, Tym, & Mountjoy, 1988). The diagnosis of DAT was made by the consultant psychogeriatricians from the local medical centres at the time and was based on: clinical interviews with patient and family; computed tomography (CT) scans showing significant atrophy; Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) scores of below 26; exclusions of vascular dementia (according to Hachinski Ischaemic Scale, Hachinski et al., 1975), cognitive decline associated with systemic illness, and history of psychiatric problems. All participants lived at home with a spouse or carer and were either in the mild or mild-moderate stage of DAT at the outset (see Table 2.1).

Table 2.1. Case study background data and number of sessions in each stage of dementia severity.

Case	Sex	Age at outset	Dates in study	MMSE at outset	Mild[1]	Mild-moderate[1]	Moderate[1]	Severe[1]
AH	M	71	Apr 1991-Dec 1994	19	0	10	9	9
TL	M	67	Jan 1991-Jul 1995	18	0	7	6	7
DB	F	81	Nov 1992-Jan 1996	18	4	4	4	1
FM	M	83	Oct 1992-Sep 1997	18	18	2	0	0

[1]Number of sessions in each stage of dementia severity.

2.2.3.4 Procedure and measures used in Rusted & Sheppard (2002)

Tea-making was the everyday task used as the experimental model, comprising several independent actions needed to achieve the goal (e.g., to make a cup of tea). At recruitment, participants' individual tea-making routines were still intact; they made tea in their own homes as part of their daily activities and had been doing so for many years prior to the study taking place. Therefore, each participant's tea-making routine was well established. Initially participants carried out preliminary sessions that established their individual protocol for their tea-making routine. Each participant's unique tea-making protocol was used to measure errors and change over time.

At recruitment and all subsequent sessions, the MMSE was used to establish cognitive status over time. After the preliminary sessions all participants completed sessions at intervals that varied between 12 weeks (initially) and 4 weeks (towards the end of the study) for up to five years. The participants made tea in their own kitchens, according to their own normal routines. All sessions were filmed and it is this video footage that has been re-coded and analysed for the purposes of this study.

2.2.3.5 Grouping of sessions

Due to the variable numbers of sessions for each participant, and due to the differences in rate of decline over the five-year study, the sessions were grouped into stages of dementia severity based on National Institute for Health and Clinical Excellence (NICE, 2011) guidelines and the MMSE scores: mild = 26-21, mild-moderate = 20-15, moderate = 10-14, severe < or = 9. However, FM's MMSE scores remained fairly consistent throughout the study; thus, his data were grouped by year.

2.2.3.6 Data coding

The Noldus Observer Version 5.0 (Noldus Information Technology, 2003) software was used to code all errors and error/monitoring behaviours, using the error/error-monitoring taxonomy developed by Balouch and Rusted (2013; *Study 1*). See Appendices B1 and B2 for the error and error-monitoring taxonomies, respectively.

An accomplishment score was calculated to encompass the actions that the participant performed correctly. For each protocol action that was correctly completed a point was given, regardless of errors. Therefore, if an incorrect action was corrected, then the participant was awarded a point for the associated action. The accomplishment score was converted into a percentage of each participant's tea-making protocol for analysis. Further details on this scoring procedure are in Appendix B3. The accomplishment scoring system was based on that of the Naturalistic Action Test (NAT; Schwartz et al., 2002).

All data were coded by the first author and a research assistant. A Kappa analysis of the coded data revealed a high inter-rater reliability for two coders (Kappa = .90, $p < .0001$).

2.2.4 Data analyses

Each case study was analysed separately. Where variables violated assumptions of normality and homogeneity of variance, transformations or non-parametric analyses were used accordingly. Descriptive data are reported as means (*M*) and standard deviations (*SD*) throughout. ANOVAs with polynomial contrasts were performed on all parametric data

(Jonckeere's tests for non-parametric data) to identify any significant trends across the different stages of dementia severity (four levels: mild, mild-moderate, moderate, and severe) or across years in study for FM (five years). Where Jonckeere's test was not significant, Kruskall Wallis was performed to identify significant dementia stage effects, and every significant main effect was followed up by Mann-Whitney tests (Bonferroni corrections were applied accordingly). Repeated measures ANOVAs were conducted on omissions, commissions and action-additions at each stage of dementia (or year for FM) to determine any significant differences in error-type distribution. One-tailed *p*-values are reported, except where stated. Effect sizes are reported as omega squared (ω^2), with values of 0.01, 0.06 and 0.14 representing small, medium and large effects, respectively (Kirk, 1996) and Pearson's correlation coefficient *r*, with values .10, .30 and .50 representing small, medium and large effects, respectively (Cohen, 1988).

2.2.5 Results

2.2.5.1 AH case study

AH experienced three stages of dementia during the course of this study: mild-moderate, moderate and severe.

Accomplishment score

On average across sessions, AH correctly accomplished 97% of his tea-making protocol in the mild-moderate stage, which decreased to 83% in the moderate stage and down to 73% in the severe stage. This was a significant linear trend, $F(1, 25) = 10.16$, $p < .01$, $\omega^2 = 0.23$ (see Figure 2.1).

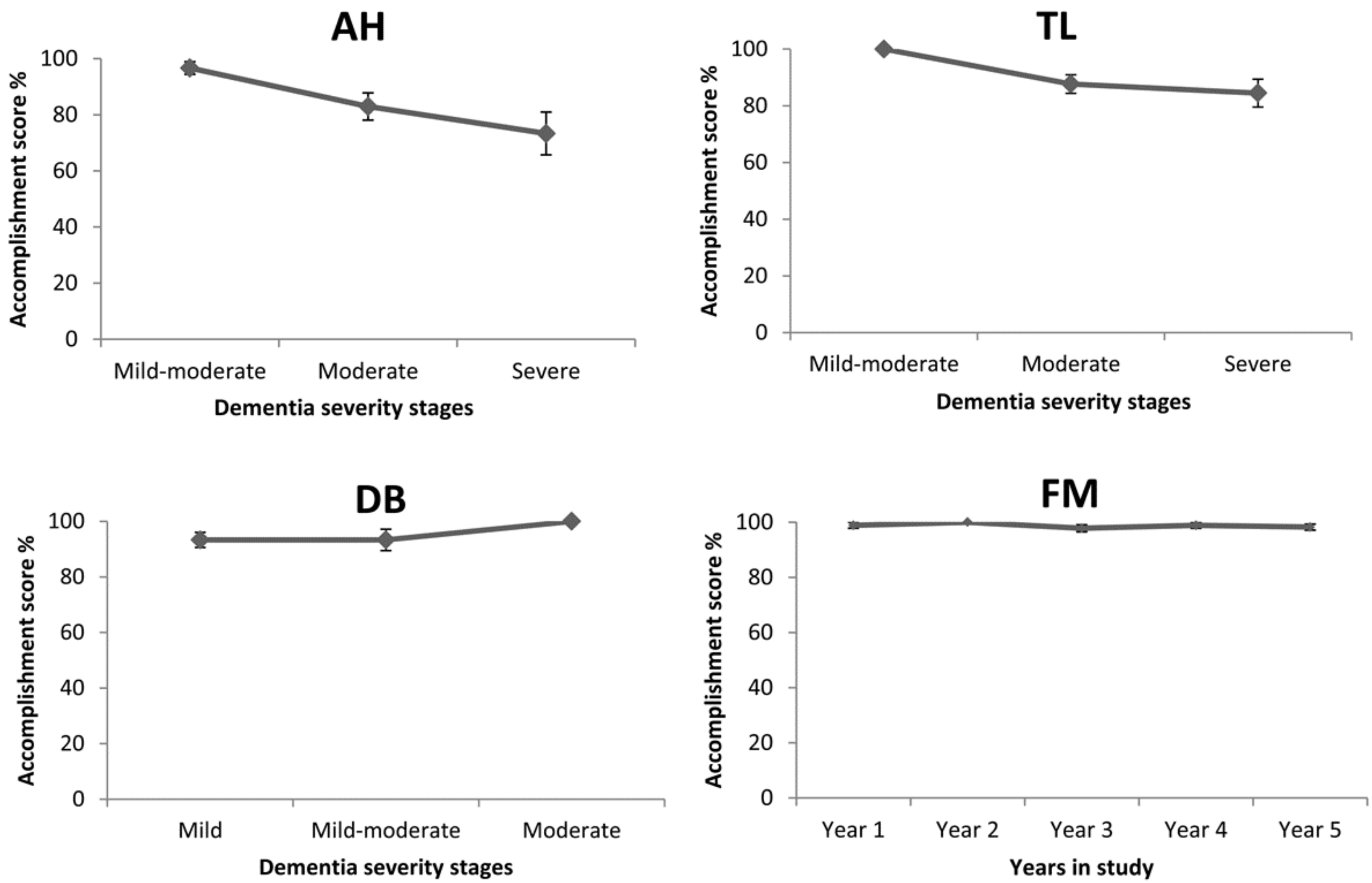


Figure 2.1. Mean accomplishment score across stages of dementia for case studies AH, TL and DB, and across years for FM (error bars are +/- 1 SEM).

Errors

As dementia severity increased there was a significant positive linear increase in omissions, $J = 71.00$, $z = 2.37$, $p < .05$, $r = .45$, but not in commissions or action-additions (all *p*s < .01; see Figure 2.2).

In the mild-moderate stage of dementia, there was a non-significant trend for AH to make more commissions than omissions, $F(1, 9) = 3.51$, $p = .09$, and action-additions, $F(1, 9) = 4.01$, $p = .08$. In the moderate stage, AH made similar numbers of omissions, commissions and action-additions, $p > .05$. Finally, in the severe stage, omissions and commissions were evenly distributed, but both were significantly higher than action-additions (omission > action-additions: $F[1, 8] = 10.75$, $p < .05$, $r = .75$; commissions > action-additions: $F[1, 8] = 5.73$, $p < .05$, $r = .65$).

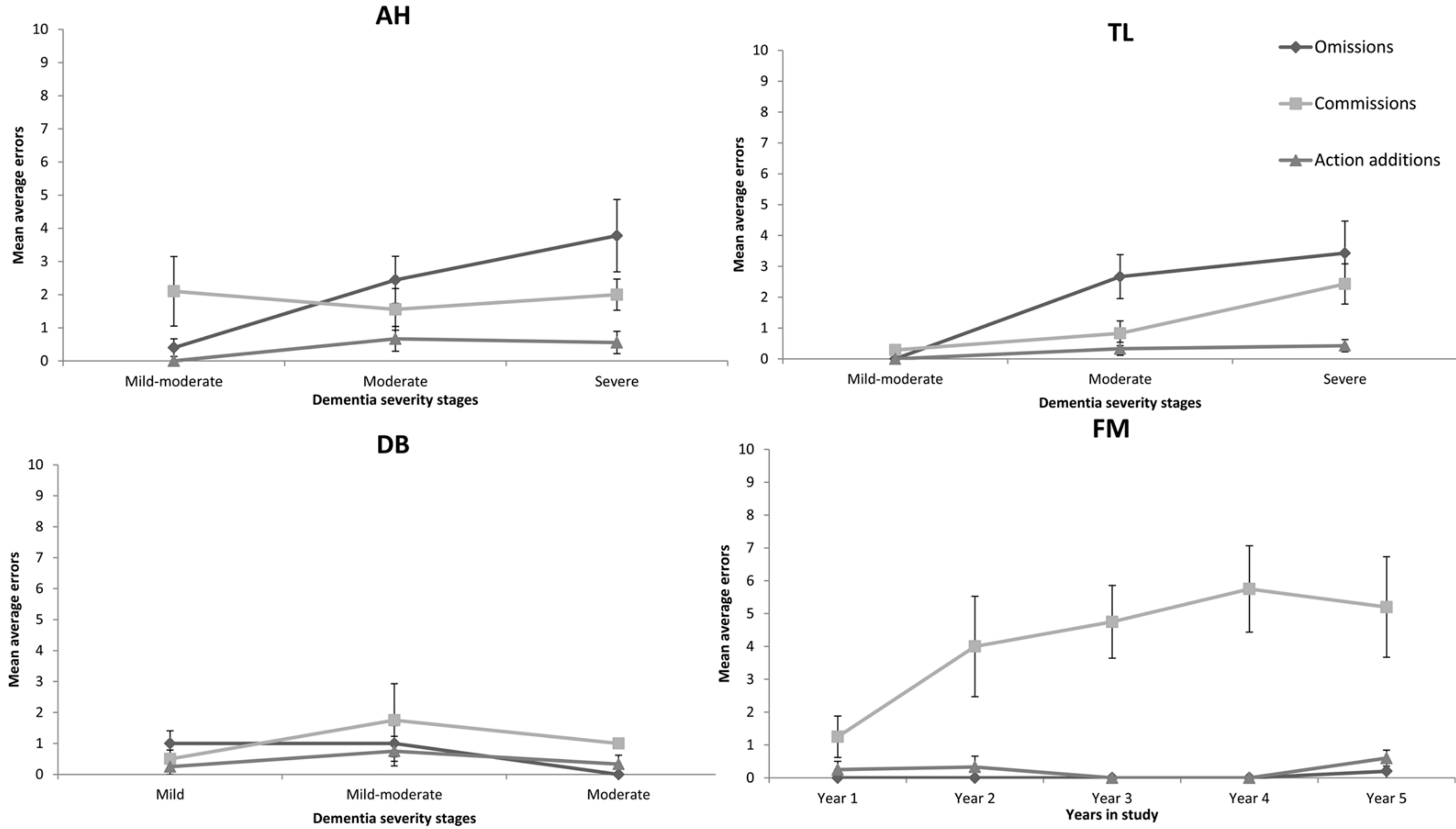


Figure 2.2. Mean errors across stages of dementia severity for case studies AH, TL and DB, and across years for case study FM (error bars are +/- 1 SEM).

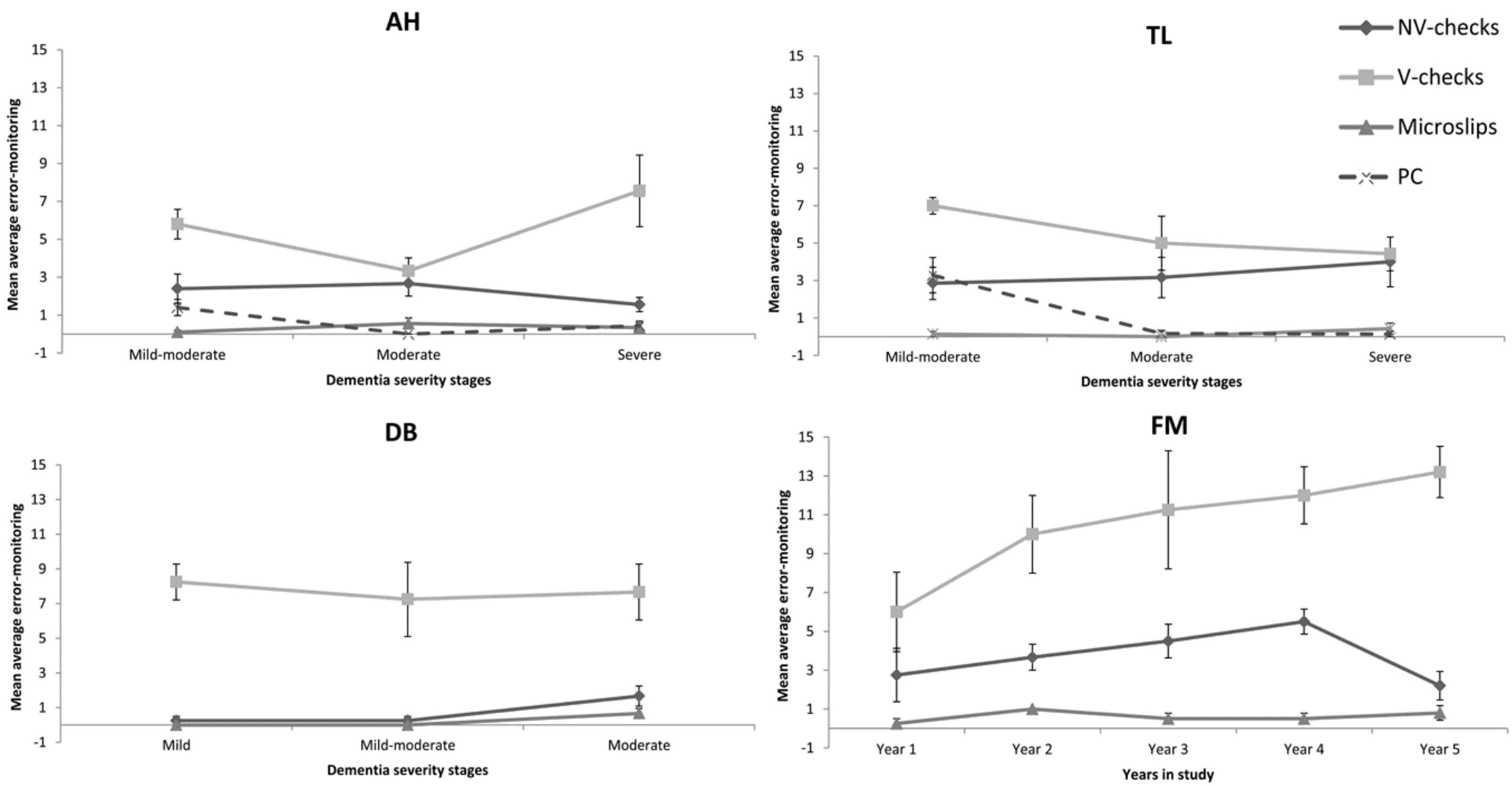
Qualitative review of action errors

Across the 28 sessions, AH most consistently failed on two particular task steps in his tea-making routine: locating and putting the milk in the cup (11 sessions for each: obviously adding the milk to the cup cannot be performed without locating the milk first, so these actions are related), and putting the sugar in the cup (13 sessions). Interestingly, the milk error involved omission, while the sugar error was one of commission.

Error-monitoring

AH was error-monitoring, even into the severe stage of dementia, but these were mostly verbal checks. AH's verbal checks decreased in the moderate stage of dementia, but increased again in the severe stage, indicating a significant quadratic trend, $F(1, 25) = 4.93$, $p < .05$, $\omega^2 = 0.12$. Practical checks (PC) were the only verbal check sub-category to change, declining significantly with dementia severity, $H(2) = 8.35$, $p < .05$: PCs decreased significantly from mild to moderate dementia, $U = 21.00$, $p < .05$, $r = -.24$, reaching floor, such that there was no further change in the severe phase, $U = 18.50$, $p > .05$. AH made some non-verbal checks, but these did not change significantly with dementia progression, $p > .05$. Checking had little impact on error rate (see Figure 2.3).

AH made very few microslips and this did not change as dementia progressed, $p > .05$ (Figure 2.3). AH corrected 19% of his total errors in the mild-moderate stage, 8% in the moderate and 6% in the severe stages, but this was not a significant change, $p > .05$.



Note. NV = non-verbal; V = verbal. Verbal checks include schema checks (SC), reflective implementations (RI) and practical checks (PC). PCs are also included separately on the figure for AH and TL, because it was the only verbal check to show a significant change.

Figure 2.3. Mean error-monitoring across stages of dementia for case studies AH, TL and DB, and across years for FM (error bars are +/- 1 SEM).

2.2.5.2 TL case study

Similar to AH, TL also experienced three stages of dementia severity: mild-moderate, moderate and severe.

Accomplishment score

TL's accomplishment score never fell below 100% in the mild-moderate stage; it decreased significantly to 88% in the moderate stage and only dropped to 85% in the severe stage. The linear trend was significant, $J = 26.50$, $z = -2.92$, $p < .01$, $r = -.65$, but only the difference between mild-moderate and moderate was significant, $U = 3.50$, $p < .01$, $r = -.64$, not the difference between moderate and severe stage, $p > .05$. See Figure 2.1.

Errors

There were significant linear trends for both omissions, $J = 107.50$, $z = 2.99$, $p < .01$, $r = .67$ and commissions, $J = 104$, $z = 2.75$, $p < .01$, $r = .62$, and a non-significant trend for action-additions, $J = 86$, $z = 1.81$, $p = .07$, $r = .40$. Thus, as dementia severity increased, so too did the average number of omissions, commissions and action-additions (see Figure 2.2).

In the mild-moderate stage, there was no significant difference between omissions, commissions and action-additions, $p > .05$. In the moderate stage, omissions were more dominant than commissions and action-additions (omissions > commissions: $F[1, 5] = 11.42$, $p < .05$, $r = .84$; omission > action-additions: $F[1, 5] = 8.45$, $p < .05$, $r = .79$), but no significant difference between commissions and action-additions, $p > .05$. In the severe stage, omissions and commissions were evenly distributed ($p > .05$), but both significantly higher than action-additions (omission > action-additions: $F[1, 6] = 7.56$, $p < .05$, $r = .75$; commissions > action-additions: $F[1, 6] = 7.64$, $p < .05$, $r = .75$).

Qualitative review of action errors

Across TL's twenty sessions he consistently failed on three particular task steps in his tea-making routine: warming the teapot (5 omissions), using the tea-cosy appropriately (9 omissions), and putting the tea in the teapot (commissions in 5 sessions). There were 6 actions that TL completed correctly throughout all his sessions. Those actions related to checking kettle for water, filling the kettle, adding the milk and preparing the crockery and teaspoons appropriately.

Error-monitoring

TL was error-monitoring throughout the course of the study, but, like AH, these were mostly verbal checks. Verbal checks significantly decreased with dementia progression, $J = 39.50$, $z = -1.91$, $p < .05$, $r = -.43$. PCs were the only verbal check category that changed significantly with dementia severity: as dementia severity increased, average PCs decreased, $J = 29$, $z = -2.95$, $p < .01$, $r = -.66$. TL made some non-verbal checks, but these did not change significantly as his dementia progressed, $p > .05$ (see Figure 2.3). TL's checking had no impact on error rate (see Figure 2.3).

Microslips were rare throughout all stages of dementia, $p > .05$ (see Figure 2.3). TL did not correct any of his errors in the mild-moderate stage, but corrected 19% of his errors in the moderate stage and 20% in the severe stage, but this was not a significant change, $p > .05$.

2.2.5.3 DB case study

DB experienced the first three stages of dementia (mild, mild-moderate and moderate). Although, DB was in the severe stage of dementia in her very last session, it was excluded from the analysis, because there was only one session in that stage. Additionally, one of the sessions in the moderate stage was excluded from analysis, due to uncharacteristic and extreme errors in the session.

Accomplishment score

There was no significant change in the accomplishment score for DB over the course of the study, $p > .05$; the mean accomplishment score never dropped below 93% (see Figure 2.1).

Errors

Although DB made errors, she did not make as many as AH and TL. Surprisingly, there were no significant effects of dementia severity on any of the error categories (all *p*s > .05). Additionally, DB made similar numbers of omissions, commissions and action-additions across all stages of dementia (all *p*s > .05; see Figure 2.2).

Qualitative review of the actions

As reported above, DB did not make many errors over the course of 11 sessions. Emerging errors were on two task steps: warming the teapot (4 omissions), and commissions in locating the teabag (3 sessions).

Error monitoring

Like AH and TL, DB sustained some error-monitoring throughout the course of the study, mostly verbal checks. However, verbal checks did not change with dementia progression, $p > .05$ (see Figure 2.3). Non-verbal checks and microslips were very rare throughout DB's sessions, but there was a significant positive linear trend for both of these, non-verbal checks: $F[1, 8] = 6.61$, $p < .05$ $\omega^2 = 1.55$; microslips: $F[1, 8] = 9.14$, $p < .05$, $\omega^2 = -1.48$. However, both microslips and non-verbal checks only began to emerge in the moderate stage of dementia towards the end of the study and in the earlier stages these were at floor. It is unclear if DB had made more microslips and non-verbal checks in the earlier stages, whether these would have increased significantly with dementia severity. Thus, these significant trends must be downplayed and interpreted with caution.

DB corrected 8% of her errors in the mild stage of dementia, none of her errors in the mild-moderate stage and 17% of her errors in the moderate stage, but this was not a significant change, $p > .05$.

2.2.5.4 FM case study

FM commenced the study with an MMSE that placed him in the mild dementia phase. Despite monitoring over 5 years, he did not progress in his dementia over this period. Therefore, his data provide an index of the effect of time in the absence of dementia progression. FM's data were analysed by years in study (5 years), but must be interpreted with caution due to the low number of sessions in each year.

Accomplishment score

Throughout the course of the study, FM accomplished at least 98% of his original established tea-making routine in the course of the study. There was no significant effect of time on his accomplishment score (see Figure 2.1).

Errors

Commissions dominated FM's errors and were significantly higher than action-additions, $F(1, 19) = 38.97$, $p < .0001$, $r = .82$. An omission occurred only once throughout the whole study (see Figure 2.2). Despite FM's dementia not progressing significantly over the course of the study, his commissions increased significantly over time, $F(1, 15) = 5.80$, $p < .05$, $\omega^2 = 3.02$.

Qualitative review of tea-making actions

Across 20 sessions, FM's commission errors mostly involved switching on the kettle (11 sessions), locating the saucer (10 sessions) and stirring the tea (10 sessions). Actions involved with checking the kettle for water, putting the tea in the teapot, and locating the milk were errorless throughout the course of the study.

Error-monitoring

Like the other participants, FM made mostly verbal checks compared to any other error-monitoring variable, and these increased significantly over time, $F(1, 15) = 6.89$, $p < .05$, $\omega^2 = 0.16$. On closer inspection, schema checks (SC) increased significantly over time and there was a non-significant trend for reflective implementations (RI) to increase over time (SC: $F[1, 15] = 6.11$, $p < .05$, $\omega^2 = 0.42$; RI: $F[1, 15] = 4.23$, $p = .06$), not PCs ($p > .05$). These seem to be in line with the increase in errors over time.

Non-verbal checks were the second most common sign of error-monitoring and there was a significant quadratic trend over time: non-verbal checks increased steadily between Years 1-4, then in Year 5 they decreased dramatically, $F(1, 15) = 6.03$, $p < .05$, $\omega^2 = 0.20$.

Microslips were very rare and did not change over time, $p > .05$ (see Figure 2.3). There was a non-significant quadratic trend for proportion of errors-corrected: corrections increased in the second year and then decreased steadily in later years, suggesting that awareness of errors was highest in the second year of the study, $F(1, 14) = 3.41$, $p = .09$. FM did not correct any of his errors in the first year, 34% in the second year, 19% in the third year, 13% in the fourth year, and 10% in the fifth year.

2.2.5.5 Supplementary analysis: correlations between key dependent variables

In order to investigate the relationships between the key dependent variables, we performed Spearman's Rho correlations (r_2; data did not meet all assumptions of normality). Correlations were performed on accomplishment score, omissions, commissions (including action-additions), microslips, non-verbal checks, verbal checks, and proportion of errors corrected for each participant regardless of dementia stage. We anticipated that accomplishment score would correlate negatively with omissions, due to the fact that the accomplishment score is virtually the inverse of omissions. The results are as follows:

For AH, TL and DB, when their omissions increased, the accomplishment score decreased significantly: r_2 range = .98 to -1.00, all ps < .001; all 1-tailed. Additionally, as AH's commissions increased, so too did his microslips, $r_2 = .38$, $p = .048$, 2-tailed; as TL's omissions increased, so too did his commissions, $r_2 = .47$, $p = .04$, 2-tailed; finally, as DB made more non-verbal checks, she also corrected more of her errors, $r_2 = .71$, $p = .02$, 2-tailed. There were no other significant correlations (all ps > .05). Spearman's Rho indicated no significant correlations for FM's data (all ps > .05).

2.2.6 Discussion

This study explored a unique dataset to gain insight into error-monitoring by people with dementia under naturalistic conditions of a typical everyday task. Tea-making was chosen as the experimental model, because, like other activities of daily living, it is goal-directed, requires actions performed in a sequential order, and is organised into several sub-goals (Cooper & Shallice, 2000; Rusted & Sheppard, 2002). Furthermore, the same kind of errors that we observed in tea-making have been observed in other everyday tasks too (see Bettcher & Giovannetti, 2009, and Schwartz, 2006, for reviews). Therefore, our findings regarding error-monitoring should map emerging problems in other everyday tasks too.

The data were acquired for four participants who were regularly visited over a period of five years. Three showed progression in dementia, as evidenced by decreasing MMSE scores, over the course of the study (AH, TL and DB), whilst one (FM) did not. We first summarise the results of the decliners, and then consider the participant who remained stable over the period of the study.

The decliner participants showed signs of error-monitoring, mostly in the form of verbal checks, even into the severe stage of dementia. This verbal checking, however, appeared unrelated to error rate, because errors were still being made even when checking was occurring. Microslips and corrections were very rare, even in the mild stage of dementia. All three participants showed very similar patterns of error-type. Omissions and commissions were much more frequent than action-additions. Omissions and commissions were evenly distributed at each stage of dementia for all of our participants, although TL displayed significantly more omissions than commissions in the moderate stage of dementia.

In the participant who did not progress in his dementia (FM), we observed that errors of commission dominated other error-types and these increased significantly over time despite the stable MMSE scores. The initial pattern of low commissions maps onto performance seen in healthy adults (Balouch & Rusted, 2013; *Study 1*), and the subsequent increase appears consistent with the onset of pathological change (indeed, the final two sessions observed registered a decline in FM's MMSE scores, but these two sessions were not sufficient to group separately). The results from our decliners would suggest that FM's omission errors would rapidly match the commission errors as the dementia progressed. Also, marking FM as a participant with an emerging dementia, FM's verbal checking (particularly SCs and RIs) and non-verbal checking increased over time, while non-verbal checking decreased dramatically in the last year. Corrections were rare, and like the other participants, these decreased over time. Like the other participants, microslips were rare, even though FM was cognitively less impaired than the other volunteers, as evidenced by the MMSE scores. These results suggest that cognitively FM was declining over time, but the MMSE was not sensitive enough to pick up these changes. The increase in FM's verbal checking suggests that FM may have been attempting to externalise working memory, but, as with the other participants, this strategy had little effect on error rate, which increased regardless.

Surprisingly, in none of our participants did we observe significant error-monitoring (in terms of microslips and corrections). These results differentiate the participants from healthy older adults, who do show effective error-monitoring even during complex tasks (Balouch & Rusted, 2013; Bettcher & Giovannetti, 2009). The results confirm previous cross-sectional research with people in the early stages of dementia (Bettcher et al., 2008; Giovannetti et al., 2008) and demonstrate that over a longitudinal time-frame, and into more severe stages of dementia, as errors increased, there was no reactive increase from our participants in error-monitoring. It would seem that the ability to implement error-monitoring deteriorates much earlier in people with dementia, possibly in the prodromal stage. Future research should explore this.

Critically, where previous studies of error-monitoring in people with dementia employed novel everyday tasks, such as the NAT/MLAT (e.g. Bettcher et al., 2008; Giovannetti et al., 2002b), our results provide evidence that error-monitoring is severely compromised in people with dementia, even in their own well-established everyday routines: error-monitoring impairment is not limited to new action sequences. Our participants did, however, maintain the appearance of error-monitoring - they continued through all sessions to check their work, both verbally and non-verbally. This checking had little impact on error rate. We found a similar result in healthy older adults (Balouch & Rusted, 2013; *Study 1*); we suggested that checking may reflect a lack of confidence in task performance or a social awkwardness (e.g. attempting to fill the silence), rather than an error-monitoring strategy per se.

The data reported here suggest that the ERP indices of error-monitoring that have been observed in people with mild-moderate dementia (Ito & Kitagawa, 2005; Mathalon et al., 2003) may not translate behaviourally into naturalistic tasks. By their nature, unfamiliar lab-based tasks (e.g. a lexical recognition paradigm and a picture name verification task) may be cognitively more taxing for people with dementia, and higher numbers of errors obviously provides more opportunity to employ error-monitoring strategies. It is possible that in familiar everyday tasks, the routinized execution that habitual tasks encourage indicate that error-monitoring is less likely to be engaged, and that errors are therefore missed. An alternative explanation for why these ERP indices did not translate into an everyday task in our participants with dementia (and related to our earlier discussion that checking was an ineffective error-monitoring strategy in people with dementia) could be due to diminished conscious awareness of errors. Previous ERP studies have shown that people with dementia exhibit ERP responses to an error, but show little behavioural indication that they have detected the errors, suggesting that neurally they may be ‘aware’ of their errors, but consciously they are not (Bettcher & Giovannetti, 2009). In support of this, we demonstrated that our participants appeared to error-monitor, through checking (even into the severe stage of dementia), but did not consciously detect their errors. Previous studies have shown that the anterior insula is more active during errors of which the participant is aware of the error, compared to unaware errors, in healthy adults performing lab-based cognitive tasks (Hester, Foxe, Molholm, Shpaner, & Garavan, 2005; Klein et al., 2007; Ullsperger, Harsay, Wessel, & Ridderinkhof, 2010). As a result, we expect decreased activation of the anterior insula in people with DAT during everyday task errors (when compared to age-matched controls). However, due to the impracticalities of electroencephalogram use in everyday tasks, future research could implement magnetoencephalography, in order to provide greater mobility during an everyday task. This lack of error awareness has been discussed as a possible target for interventions (Bettcher et al., 2011b; Brennan et al., 2009).

We explored possible relationships between our everyday task performance indices. For all our decliners, as their accomplishment on tea-making decreased, their omissions increased. However, our decliners showed individual differences on other correlations that we explored. This suggests that with dementia progression, individual differences in strategies used may become more apparent.

We observed that our declining participants largely made similar numbers of omissions and commissions throughout all stages of their dementia. Action-additions were very rare amongst all our participants. Giovannetti et al. (2008) suggested that people with dementia could exhibit either ‘omissive’, ‘commissive’ or ‘mixed’ everyday action impairment, with action-additions (reflecting inability to inhibit other task schema) a third distinct component (Giovannetti et al., 2008, 2012; Seidel et al., 2013). The omissive-commissive model suggests that as cognitive capacity declines, people with dementia will be more prone to omissions, whereas those with executive dysfunction will be more prone to commissions (Giovannetti et al., 2008). Our decliners showed a 'mixed' pattern of everyday action errors - neither omissions nor commissions predominated, but both were dominant over action-additions. Interestingly, this error pattern did not change over time as the dementia progressed. The omissive-commissive model would predict that as global cognitive functioning declines, omissions become more commonplace. Although, AH and TL's omissions increased significantly with dementia progression, they did not outnumber commissions. Additionally, DB's error rates did not increase with dementia progression. Therefore, our findings do not support this model's prediction. The model derived from studies comprising only participants with mild and mild-moderate dementia, however, and it is possible that it is more relevant to dementia in the earlier stages, and may need to be modified to predict errors in a developing dementia.

In line with data reported in Rusted and Sheppard (2002), the tea-making actions that our participants omitted as their dementia progressed were mostly non-essential actions (e.g. warming the teapot), whilst essential actions (e.g. using a teabag) were retained even in the severe stage of dementia. Rusted and Sheppard (2002) attributed this to the hierarchical organisation of memory structures or mental representations of everyday activities; as memory declines, the less important actions become more susceptible to degradation. This fits the omission error pattern, but not the tea-making actions that were performed inaccurately (i.e. commissions). Commissions occurred for both essential and non-essential tea-making actions and this remained the case even as the dementia progressed. Giovannetti et al. (2008) suggested that commissions are a result of executive functioning impairments, which appears to fit with these findings, because the quality of commission errors, such as perseverations and anticipations, seem to occur due to lapses in working memory causing the individual to forget their position in the task, regardless of whether the associated action is key or non-key.

For all participants, once an action became problematic it continued to be problematic throughout the developing dementia; errors were not random or sporadic. This is interesting, and qualitatively different from other neuropsychological profiles, such as action disorganization syndrome and frontal apraxia that show no particular pattern or consistency in the types of actions that are affected by errors (Schwartz et al., 1995; Schwartz, Reed, Montgomery, Palmer, & Mayer, 1991). Perhaps actions that are found to be problematic in the earlier stages of dementia could be reinforced through auditory or visual cues that support memory explicitly by reducing cognitive load (see Rusted & Moniz-Cook, 2013, for a review), increasing awareness through self-monitoring, or activation of the motor engram for the task through observational cueing. The effectiveness of such an intervention would need to be tested in future research.

Our results may provide a challenge for traditional theories of hierarchical everyday tasks (e.g. Cooper & Shallice, 2000). The interactive activation network (IAN; a hierarchical computational model by Cooper & Shallice, 2006; Cooper & Shallice, 2000) accurately simulates error types that are observed in people with dementia, such as omissions, anticipations and action-additions, but is unable to simulate increase in the quantity of errors (observed in our study as dementia progressed) by introducing greater noise into the system (attempting to mimic global cognitive decline). An alternative computational model of everyday action, the connectionist model of a sequential recurrent network (SRN; Botvinick & Plaut, 2006; Botvinick & Plaut, 2002, 2004) has successfully produced omissions, anticipations, perseverations, substitutions and action-additions and errors increase with greater disruption to the model, better supporting our findings.

We acknowledge limitations to our study. Firstly, our data is drawn from longitudinal observation of a group of four people with dementia. Although this is a very small sample, the detailed tracking of an everyday task over an extended time-frame provides a rarely available observational dataset through which to address change within dementia. Thus, our study provides a rich longitudinal account of everyday task performance in people with a developing dementia, which has never been carried out before. It sets the scene for future studies, providing a protocol for detailed exploration of everyday task performance. Secondly, although, widely popular, the MMSE is a very crude measure of cognitive performance and may not be sensitive to subtle changes in cognitive functioning (Nieuwenhuis-mark, 2010; Tombaugh & McIntyre, 1992). Thus, our measure of trajectory of decline is an estimate only. Methodological shortcomings in the original study also limit the interpretation of our analyses. The data relate only to performance in people with dementia, and the addition of a healthy control sample would have allowed age- versus disease-related change to be separately assessed. Also, the lack of neuropsychological measures taken in the original study has limited the interpretation of our analyses, with respect to both mechanism and process.

In conclusion, the present study offers a detailed longitudinal account of functioning in an everyday task in four people with dementia. The results of the analysis suggest that memory for everyday tasks remains remarkably resilient to disruption, even in the severe stages of dementia, despite poor error-monitoring skills. Omission and commission errors dominate and proliferate as performance declines. Importantly, errors are not sporadic or disorganised, but recur in the same points of the individual's routine. We suggest that this important observation may offer a potential target point for interventions designed to sustain the personalised routine for longer.

2.3 Study 3a - Can verbal instruction enhance the recall of an everyday task and promote error-monitoring in people with dementia of the Alzheimer-type?

2.3.1 Abstract

People with dementia of the Alzheimer-type (DAT) have difficulties with performing everyday tasks and error awareness is poor. Here we investigated whether recall of actions and error monitoring in everyday task performance improved when they instructed another person on how to make tea. In this situation, both visual and motor cues are present, and attention sustained by the requirement to keep instructing. The data were drawn from a longitudinal study recording performance in four participants with DAT, filmed regularly for five years in their own homes, completing three tea-making conditions: performed-recall (they made tea themselves); instructed-recall (they instructed the experimenter on how to make tea); and verbal-recall (they described how to make tea). Accomplishment scores (percentage of task they correctly recalled), errors and error-monitoring were coded. Task accomplishment was comparable in the performed-recall and instructed-recall conditions, but both were significantly better than task accomplishment in the verbal-recall condition. Third person instruction did not improve error-monitoring. This study has implications for everyday task rehabilitation for people with DAT.

2.3.2 Introduction

A deterioration of everyday task performance is one of the diagnostic criteria for dementia/major neurocognitive disorder (American Psychiatric Association, 2013), with dementia of the Alzheimer-type (DAT) being the most common, followed by vascular dementia (VaD) and mixed dementia, respectively (Brunnström, Gustafson, Passant, & Englund, 2009). People with dementia make significantly more errors than age-matched controls when carrying out everyday tasks, their errors increase with greater dementia severity and they tend to produce mostly errors of omission (a task step/action is completely omitted; (Giovannetti et al., 2008; Giovannetti et al., 2002a; Ramsden et al., 2008; Rusted & Sheppard, 2002).

Bettcher and Giovannetti (2009), suggested that errors may not be prevented in this population, and therefore the management of such errors, or error-monitoring, may be a more viable target for research. Error-monitoring is typically referred to as the detection and correction of errors (see Bettcher & Giovannetti, 2009, for a review). Studies which have explored error-monitoring in people with dementia have found that they error-monitor far less than age-matched controls during everyday task performance, whether performance is assessed in a cross-sectional (Bettcher et al., 2008; Giovannetti et al., 2002a) or in a longitudinal (Balouch & Rusted, 2014; *Study 2*) design.

One study employed verbal description, picture presentation and video presentation of the task, in order to strengthen recall of the task schema (Bettcher et al., 2011a), reporting that errors were reduced and error detection increased. These results are promising for rehabilitation, but despite detecting errors, error correction did not increase with this training method. Another study in a patient with action disorganisation syndrome (Bickerton, Humphreys, & Riddoch, 2006) showed that verbal strategies can reduce errors and enhance error-monitoring – in this case, the verbal strategy was to learn a mnemonic.

In the present study, we ask whether error monitoring and error correction would improve if task performance was made a more overt and 'conscious' process by requiring the person to observe and instruct another person on the task script and so take on an outsider's perspective? In this situation, in addition to the participants engaging with the schema through instructing a third person, they also have the visual cues of the third person carrying out the task actions in front of them. This requirement should both maintain activation of the task schema and increase awareness of the task. According to Schwartz (2006), high error producers (e.g. people with dementia) find it increasingly difficult to select the target schema due to severe cognitive resource limitations. Thus, the schema or task representation may still be intact, but the schema and its associated actions may not be sufficiently active. In this situation, other distractions/schemas may capture attention, leading to attention failures that allow the target schema to become *deactivated*. From this, we can infer that errors could be detected (and consequently corrected) if the target schema is *maintained in an activated state* by encouraging strategies that sustain the task schema, such as verbalising the script of the task.

Third person instruction is an interesting proposition for a cognitively impaired person to undertake for a number of reasons. First, it requires the instructor to take on the role of the performer and anticipate/reflect on the performer's actions as they are carried out. As a result, they would need to coordinate their own schema with the actions of the person being instructed in reference to a common goal, making them more mindful of their own schema script. Second, this strategy would encourage joint attention (a shared focus of two individuals on an object or task). Joint attention is widely studied in developmental psychology (see Striano & Reid, 2006, for a review), but recently dementia care research has shown an interest in it too (Astell et al., 2010; Sävenstedt, Zingmark, Hydén, & Brulin, 2005). The two latter studies show that people with dementia are capable of engaging in joint attention and can benefit from dementia care interventions that utilise joint attention. Third, the mere act of verbalising the task script may make participants more aware and mindful of the task schema. However, this is yet to be tested in people with dementia. In the present study we examine whether people with dementia error-monitor more when they increase their engagement (through instructing another person) with the task schema, and more effectively complete the task.

Observing another person's actions is thought to activate the 'mirror neuron system' (MRN; di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996; Rizzolatti & Craighero, 2004), or more broadly the 'action observation network' (AON; Cross, Kraemer, de C. Hamilton, Kelley, & Grafton, 2009; Grèzes, Armony, Rowe, & Passingham, 2003; Jenkins, Brooks, Nixon, Frackowiak, & Passingham, 1994; Sakai, Ramnani, & Passingham, 2002): a discrete set of neural regions that are active when observing and when performing actions. However, *doing* the task normally provides optimal encoding of action phrases. First, a wide body of research has shown that a list of unrelated action phrases are recalled better when the participant performs the actions (subject-performed tasks, SPTs), rather than when they verbally process them (verbal task, VTs) - this is known as the enactment effect (Earles, 1996; Engelkamp, 1998; Engelkamp & Zimmer, 1994; Knopf, Mack, Lenel, & Ferrante, 2005). Second, when participants are asked to watch the researcher perform the actions with imaginary objects and later recall them (experimenter-performed tasks, EPTs), they recall more action phrases than the VT condition, but fewer action phrases than the SPT condition (Engelkamp & Dehn, 2000; Mulligan & Hornstein, 2003). However, studies of the enactment effect normally focus on the encoding of action *phrases*, rather than the retrieval of action *sequences*, which is where our interest lies. To this effect, Steffens (2007) found that in a goal-directed sequence of actions, observing those actions was just as effective as performing those actions, in terms of free recall of the objects used in the task and the participants' performance of that task. In addition, organisation of the actions was better recalled after observation, rather than enactment. Steffens (2007) explained that during the enactment of a sequence of actions, the bigger picture can often be missed; whereas during the observation of a sequence of actions, by taking an outsider's perspective, it is easier to see the missing pieces. In support of the notion that sequential action is recalled better than unrelated actions, Hutton, Sheppard, Rusted, and Ratner (1996) showed that in people with mild-moderate DAT, sequential goal-directed actions were recalled better than unstructured actions. Therefore, one would assume that watching and instructing a third person carry out a goal-directed task (such as tea-making), could particularly target sequence errors.

The data reported here is derived from archive data (Rusted & Sheppard, 2002) from participants with DAT carrying out various tea-making tasks in their own homes at regular intervals for up to 6 years. In the original study, the participants took part in three tea-making tasks: a) participants made tea according to their own routines in their own kitchens (performed-recall condition); b) the participants instructed the experimenter on how to make tea in their own kitchen according to their own routine (instructed-recall condition); and c) the participants verbally recalled how to make a cup of tea (according to their own routine), without actually making the tea or having the visual cues present (verbal-recall condition). The instructed-recall condition constitutes unpublished data from this archive and provides the data for the current study. In the original study (Rusted & Sheppard, 2002), participants with DAT showed preserved memory for tea-making in the performed-recall condition, compared to the verbal-recall condition, even into the severe stage of dementia, but errors of omission increased significantly with dementia severity. In a more refined analysis of that data, Balouch and Rusted (2014) reported that error monitoring in the performed-recall condition remained poor. Here we consider whether similar failures in error-monitoring occur when they are verbally instructing a third party to execute the routine. By maintaining the schema through instruction, activation of the mirror neuron system through observing another's actions during instruction, and using a goal-directed task (optimising recall of the organisation/sequence of actions), we anticipated that: 1) instructed-recall and performed-recall conditions will be comparable in terms of task accomplishment and the number of errors made; 2) the instructed-recall condition will promote more efficient error-monitoring; 3) sequence/anticipation errors will be reduced in the instructed-recall condition.

The opportunistic data used in this study, not only provides a step towards exploring the effects of externalising the task schema in participants with DAT, but it also documents this effect longitudinally up to 5 years in a developing dementia, allowing us to study the changes that occur with dementia progression.

2.3.3 Methods

2.3.3.1 Design

Longitudinal, observational, case-study data previously collected by Rusted and Sheppard (2002) was utilised for this study. The two experimental conditions were performed-recall and instructed-recall conditions, where task accomplishment, errors and error-monitoring behaviours were compared. The verbal-recall condition was used as a baseline for the accomplishment score when visual and motor cues were not present.[1]

2.3.3.2 Ethical approval

Ethical approval for the original study was obtained from the local Health Authority Ethics Committee and by the University of Sussex Ethics Committee. It included the consent of the participants to store and reanalyse the video footage beyond the original study. For the present study, ethical approval was sought from the Schools of Psychology and Life

[1] Data from the performed condition published elsewhere (Balouch & Rusted, 2014).

Sciences Ethics Committee, University of Sussex to reanalyse the archived data.

2.3.3.3 Participants

Only the data from participants with a substantial number of sessions available in both experimental conditions were included in the present study. This comprised 4 participants with full datasets from Rusted and Sheppard (2002). Rusted and Sheppard (2002) recruited participants from the community on the basis that they already had a clinical diagnosis of probable Alzheimer's disease as classified by the Cambridge Examination for Mental Disorders of the Elderly (CAMDEX) test battery (Roth et al., 1988). The clinical diagnosis was made by the consultant psychogeriatrician from the local medical centres at the time and was based on clinical interviews, Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) scores below 26 and CT scans showing significant cerebral atrophy. Exclusions included vascular and mixed dementia (vascular and AD), cognitive decline associated with systemic illness, and a history of psychiatric problems. All participants lived at home with a spouse or carer. All participants were either in the mild or mild-moderate stage of dementia at the outset (see Appendix C1).

2.3.3.4 Procedure and measures used in Rusted and Sheppard (2002)

Participants were visited in their own homes by the original researchers (Rusted & Sheppard, 2002) and all data collection took place in the participants' homes with their spouses present. Tea-making was the everyday task used in each condition, which comprised several independent actions needed to achieve the goal (i.e. to make a cup of tea). At recruitment, participants' individual tea-making routines were still intact; participants made tea in their own homes as part of their daily activities and had been doing so for many years prior to the study commencing. Therefore, each person's tea-making routine was well established at the beginning of the study. Initially participants carried out preliminary tea-making sessions that determined their individual protocol for their tea-making routine. Any deviations from each individual's unique protocol was used as a basis to measure errors.

At recruitment and all subsequent sessions, the MMSE was used to measure cognitive status over time. After the preliminary sessions, all participants completed sessions at intervals that varied between 12 weeks (initially) and 4 weeks (towards the end of the study) for up to five years. At each session the participant made tea under three different conditions: performed-recall (participant made tea in his/her own kitchen following his/her own normal routine), instructed-recall (participant, seated in his/her own kitchen, verbally instructed the experimenter on how to make a cup of tea in his/her own kitchen according to his/her own routine), and verbal-recall (participant, seated in the living room, described "in as much detail as possible" how he/she made a cup of tea in his/her own kitchen). In the instructed-recall condition the instructions to the participant were: "Give me instructions to tell me exactly how to make a cup of tea, so that I can make a cup for you, exactly the way you would do it yourself. Don't go too fast, because I have to keep up. I'm going to do everything as and when you tell me to do it."

The order of the conditions was counterbalanced at each session. All sessions were filmed and it is with this video footage that further analysis has been made possible for the purposes of the current study.

2.3.3.5 Data Coding

The Noldus Observer Version 5.0 was used to code all errors and error/monitoring behaviours. All errors were coded according to the error and error-monitoring taxonomy developed by Balouch and Rusted (2013, 2014). Errors were coded when a task step was recalled incorrectly (perseveration, anticipation/sequence, quantity, substitution, location and tool errors), when an off-task step was recalled (i.e. action addition), and when a task step was completely omitted (i.e. omission). All errors, apart from omissions, were summed as a single score of commission errors. Corrections, microslips (initiation and termination of an error before the error is completed) and checking behaviour (verbal and non-verbal) during tea-making were also coded, indicating error-monitoring. For the instructed-recall condition, a further category was added to the taxonomy to capture all the instances when the participant intervened, i.e. when the participant did not verbalise the instructions and instead carried out the actions himself/herself (see Appendix C2 for the error-monitoring taxonomy and the coding of interventions).

All data were coded by the first author and a trained research assistant. A Kappa analysis of the coded data revealed a high inter-rater reliability for two coders (Kappa = .90, $p < .0001$).

The percentage of actions recalled correctly from individual protocols was calculated for each session in each condition, to form an *accomplishment score.* The equation for calculating the accomplishment score (modelled on (Schwartz et al., 2002) was (number of actions in protocol) – (number of omissions) – (number of uncorrected substitutions) – (number of uncorrected tool errors).

2.3.3.6 Grouping of sessions

Sessions were grouped into stages of dementia severity (DAT-stage from hereon) based on NICE guidelines (NICE, 2011), using the MMSE scores: mild = 26-21, mild-moderate = 20-15, moderate = 10-14, severe <= 9. This resulted in data across three DAT-stages (mild-moderate, moderate and severe) for one participant (AH), and across two stages of dementia (mild-moderate and moderate) for two participants (TL and DB). However, one participant's (FM) MMSE scores remained relatively unchanged (mostly in the mild category) over the five year period of the study; thus, his data was included as a control for time with sessions grouped by year (see Appendix C1 for grouping of sessions).

2.3.4 Data analysis

Each participant's data was analysed separately using SPSS; each session, or replication, was entered as a separate case and replications grouped by dementia stage. The three conditions (performed-recall, instructed-recall and verbal-recall) were repeated measures at each replication. In this format, ANOVAs and MANOVAs were performed to compare outcomes across conditions separately for each volunteer.

To test the first prediction, accomplishment was analysed using 2-way ANOVAs, with DAT-stage (2 or 3 levels: mild-moderate, moderate, and for AH severe; or year for FM: 5 levels for each year) and condition (3 levels: performed-recall, instructed-recall and verbal-recall) as the independent-variables. Key error variables (commissions and omissions) were analysed using 2-way MANOVAs. The variables were DAT-stage and condition (2 levels: performed-recall and instructed-recall). All significant MANOVAs were followed up with 2-way ANOVAs, followed by contrasts as appropriate. Bonferroni corrections were applied accordingly. For the second prediction, error-monitoring variables (proportion of errors-corrected, microslips, non-verbal checks and verbal checks) were analysed using the same procedure. Finally for the third prediction, 2-way ANOVAs (condition x DAT-stage/year) were conducted on anticipation errors, followed by appropriate contrasts, with Bonferroni corrections. *P* was significant at the .05 level and all *p* values are reported as 1-tailed, unless otherwise stated. The effect sizes are reported for all significant main effects (where two groups are compared) and all significant contrasts, using Pearson's Correlation Coefficient (*r*); whereby .10 is a small effect, .30 is medium, and .50 is large (Cohen, 1988).

2.3.5 Results

Means (*M*s) and standard deviations (*SD*s) across all dependent variables for each individual volunteer are summarised in Appendix C3.

2.3.5.1 Prediction 1: Instructed-recall and performed-recall conditions will be comparable in terms of task accomplishment and the number of errors made

Task accomplishment. See Figures 3a.1-4 for accomplishment scores across DAT-stages for each participant.

Case AH. There was a significant main effect of condition on accomplishment, $F(2, 36) = 406.13$, $p < .0001$, with no significant difference between performed-recall and instructed-recall conditions, $p > .05$, but both these conditions were significantly higher than the verbal-recall condition, $F(1, 18) = 412.97$, $p < .0001$, $r = .98$; $F(1, 18) = 1007.09$, $p <$

.0001, $r = .99$, respectively. A significant main effect of DAT-stage on accomplishment, $F(2, 18) = 6.03$, $p = .01$, revealed that accomplishment declined as dementia became more severe, but this did not interact with condition, $p > .05$. When interventions were excluded from the instructed-recall condition and the ANOVA was conducted again: the significant main effect of condition remained, $F(1.38, 24.89) = 89.26$, $p < .0001$, but instructed-recall was significantly lower than performed-recall, $F(1, 18) = 13.16$, $p < .0001$, $r = .65$, but significantly higher than verbal-recall, $F(1, 18) = 73.61$, $p < .0001$, $r = .90$.

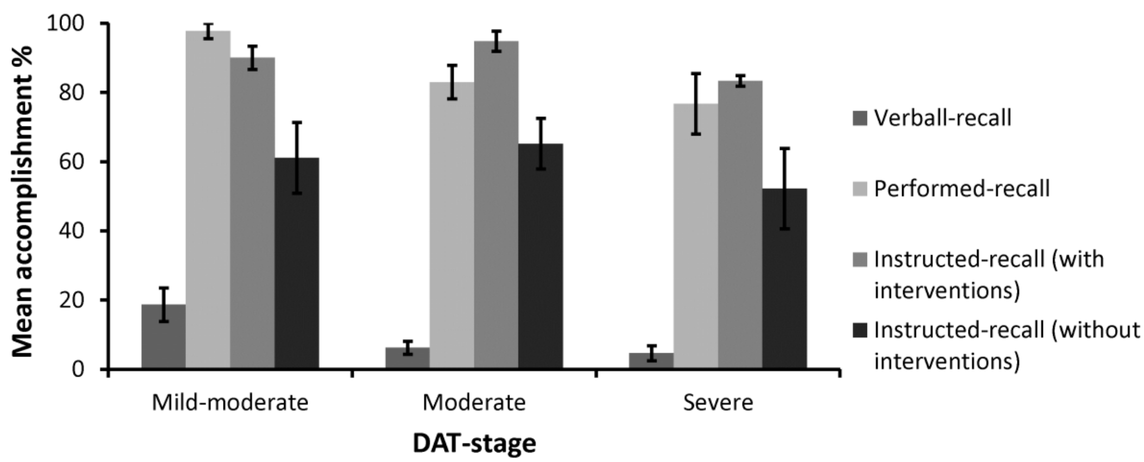


Figure 3a.1. AH's mean accomplishment % (error bars are +/-1 SEM) across DAT-stages, as a function of condition.

Case TL. There was a significant main effect of condition on accomplishment, $F(2, 10) = 387.02$, $p < .0001$, but in contrast to AH, TL's accomplishment score was significantly higher in the performed-recall condition, than the instructed-recall and verbal-recall conditions: $F(1, 5) = 12.62$, $p = .02$, $r = .85$; $F(1, 5) = 2004.38$, $p < .0001$, $r = 1.00$, respectively. However, similar to AH, the instructed-recall outperformed the verbal-recall, $F(1, 5) = 490.49$, $p < .0001$, $r = .99$. There were no significant effects of DAT-stage and no condition x DAT-stage interaction (all ps > .05). Although TL made interventions in the instructed-recall condition, these were not sufficient to increase accomplishment and bring it in line with the performed-recall condition.

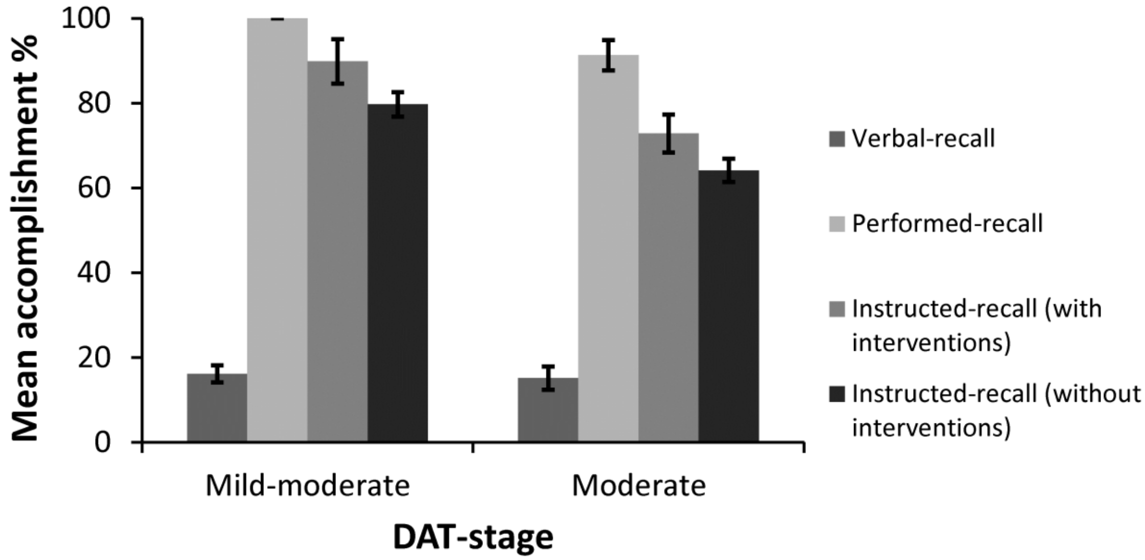


Figure 3a.2. TL's mean accomplishment % (error bars are +/-1 SEM) across DAT-stages, as a function of condition.

Case DB. There was a main effect of condition on accomplishment, $F(2, 10) = 136.14$, $p < .0001$. Similar to AH, DB's accomplishment score was comparable in performed-recall and instructed-recall conditions, $p > .05$, with both these conditions significantly higher than the verbal-recall condition: $F(1, 5) = 239.55$, $p < .0001$, $r = .99$; $F(1, 5) = 118.24$, $p < .0001$, $r = .98$, respectively. There was no significant effect of DAT-stage and no interaction (all ps > .05). After excluding the interventions from the instructed-recall condition, the ANOVA was conducted again, which showed a significant main effect of condition, $F(2, 10) = 197.24$, $p < .0001$: performed-recall was significantly higher than instructed-recall, $F(1, 5) = 163.87$, $p < .0001$, $r = .99$, and in turn, instructed-recall was significantly higher than verbal-recall, $F(1, 5) = 147.04$, $p < .0001$, $r = .98$.

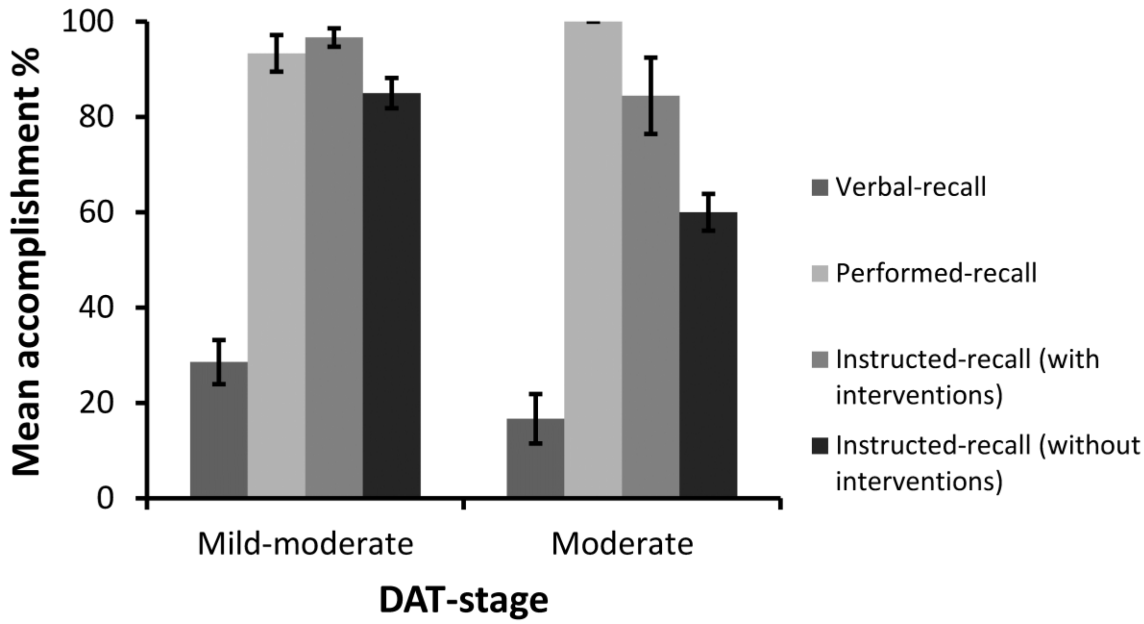


Figure 3a.3. DB's mean accomplishment % (error bars are +/-1 SEM) across DAT-stages, as a function of condition.

Case FM (control for time). The main effect of condition was significant, $F(2, 30) = 736.71$, $p < .0001$. Similar to AH and DB, FM showed comparable accomplishment scores in the performed-recall and instructed-recall conditions, $p > .05$, and accomplished significantly less in the verbal-recall condition: $F(1, 15) = 846.28$, $p < .0001$, $r = .99$; $F(1, 15) = 871.07$, $p < .0001$, $r = .98$, respectively. There was no significant effect of time and no significant condition x time interaction (all *p*s > .05). In an ANOVA that excluded interventions from the instructed recall condition, the main effect of condition was significant, $F(1.40, 20.96) = 511.48$, $p < .0001$. Performed-recall was significantly higher than instructed, $F(1, 15) = 6.40$, $p = .02$, $r = .55$, and in turn instructed-recall was significantly higher than verbal-recall, $F(1,15) = 452.74$, $p < .0001$, $r = .98$.

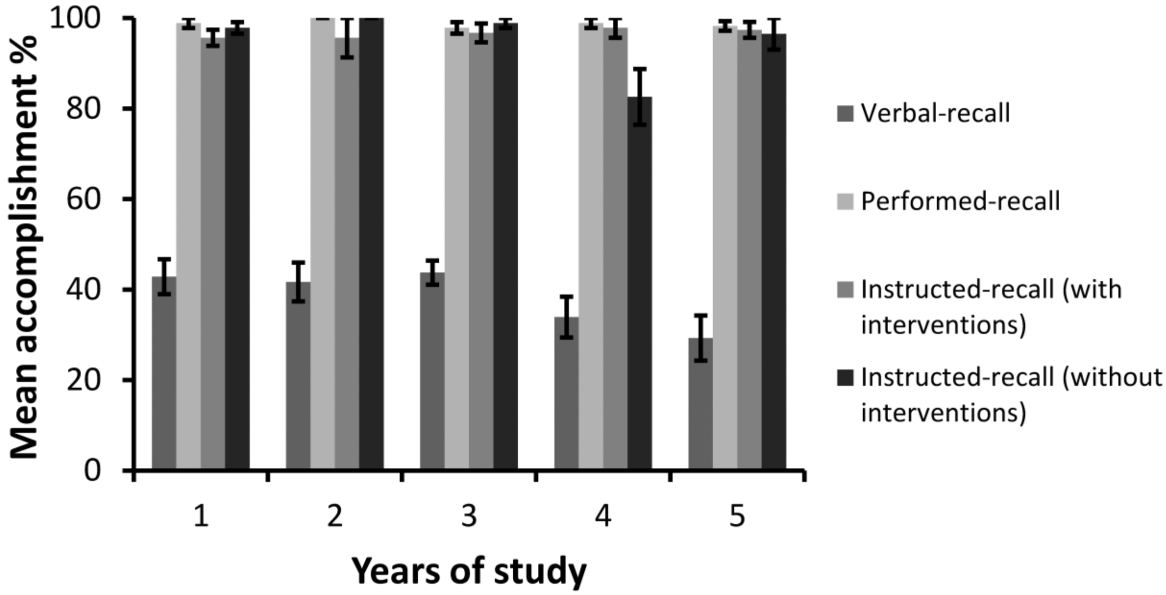


Figure 3a.4. FM's mean accomplishment % (error bars are +/-1 SEM) across time, as a function of condition.

Errors. There were individual differences in error patterns, with benefits of the instructed-recall condition only observed in AH.

Case AH. The MANOVA and subsequent ANOVAs revealed a significant condition x DAT-stage interaction on omissions only, $F(2, 18) = 4.40$, $p = .03$. There were fewer errors of omission in the instructed-recall condition than in the performed condition for the moderate and severe stages of dementia, but not for the mild-moderate stage (where few errors occurred). The MANOVA revealed no significant main effects of condition or DAT-stage on omissions (all *p*s > .05).

Case TL. The MANOVA and subsequent ANOVAs confirmed significant main effects of condition on both omissions, $F(1, 5) = 21.12$, $p = .01$, $r = .90$, and commissions, $F(1, 5) = 51.57$, $p < .0001$, $r = .95$, with more errors in the instructed-recall condition. The MANOVA revealed no main effect of DAT-stage, $p > .05$, but there was a significant condition x DAT-stage interaction, $V = .78$, $F(2, 4) = 7.26$, $p = .05$. Further ANOVAs revealed an interaction on commissions only, $F(1, 5) = 17.29$, $p < .0001$, $r = .88$:

commissions increased with dementia progression more dramatically in the instructed-recall condition, than the performed-recall condition.

Case DB. The MANOVA and subsequent ANOVAs revealed a significant interaction on omissions only, $F(1, 5) = 7.12$, $p = .04$, $r = .77$: showing that as dementia progressed omissions increased in the instructed-recall condition, but decreased in the performed-recall condition. There were no significant main effects of condition or DAT-stage on omissions, and although DB made commissions, the ANOVA revealed no significant results for commissions (all *p*s > .05).

Case FM (control for time). Omissions were rare for FM and thus excluded from his MANOVA. Although, FM made commissions, an ANOVA revealed no significant main effects of condition or time, and no interaction (all *p*s > .05).

2.3.5.2 Prediction 2: The instructed-recall condition will promote more efficient error-monitoring

Error-monitoring. Verbal checks were the most common type of error-monitoring variable across all participants, followed by non-verbal checks. Microslips and corrections were very rare; thus, excluded from the MANOVA.

Case AH. The MANOVA and subsequent ANOVAs revealed only a significant main effect of condition: AH made significantly fewer checks in the instructed-recall condition than the performed-recall condition: $V = .38$, $F(2, 17) = 5.22$, $p = .02$; non-verbal checks, $F(1, 18) = 8.10$, $p = .01$, $r = .56$; verbal checks, $F(1, 18) = 7.26$, $p = .02$, $r = .54$. There was no significant main effect of DAT-severity, and no significant interaction (all *p*s > .05).

Case TL. There was some evidence of decreased checking in the instructed-recall condition when compared to performed-recall, but the MANOVA revealed no significant main effect of condition, $p > .05$. Although, TL continued to use checking behaviours throughout the study and well into the moderate stage of dementia, there was no significant main effect of DAT-stage and no interaction (all *p*s $> .05$).

Case DB. Although DB made substantial numbers of checks (especially verbal checks), the MANOVA revealed no significant main effects of condition, DAT-stage, and no significant interaction (all *p*s $> .05$).

Case FM. The MANOVA and subsequent ANOVAs confirmed that FM made checks predominantly in the performed-recall condition: $V = .75$, $F(2, 14) = 20.69$, $p < .0001$; non-verbal checks, $F(1, 15) = 18.03$, $p < .0001$, $r = .74$; verbal checks, $F(1, 15) = 24.75$, $p = .00$, $r = .79$. There was a significant main effect of time on both non-verbal and verbal checks: $V = .90$, $F(8, 30) = 3.07$, $p = .01$; non-verbal, $F(4, 15) = 4.01$, $p = .02$; verbal checks, $F(4, 15) = 3.24$, $p = .04$, with checks generally increasing over time. However, there was no condition x DAT-stage interaction ($p > .05$).

2.3.5.3 Prediction 3. Sequence/anticipation errors will be reduced in the instructed-recall condition

Case AH. AH made significantly more anticipation errors in the instructed-recall condition, $F(1, 18) = 10.23$, $p = .01$, $r = .60$, but the ANOVA revealed no significant main effect of DAT-stage and no interaction (all *p*s $> .05$).

Cases TL, DB and FM. Anticipations were very rare for these participants, thus were not analysed.

2.3.5.4 Supplementary analyses: interventions

To determine if the number of interventions changed with dementia progression, we performed one-way ANOVAs on total interventions for each participant, with DAT-severity (or time) as the independent variable. The results showed no significant change in the number of interventions with dementia progression or over time for any of the participants (all *p*s $> .05$).

To explore the nature of interventions, we grouped interventions into three core action categories based on the types of actions included in the tea-making protocols: 1) 'change' (actions that changed the quality of an item, i.e. switching on the kettle, stirring the tea, and warming the teapot); 2) 'put' (actions that involve putting or placing an item into or onto another item); and 3) 'locate' (actions that involve searching for an item). The results are shown in Table 3a.1.

Again there were individual differences in the predominance of the various interventions, with AH's interventions consisting mostly of 'put' and 'locate' actions, DB and TL made mostly 'locate' interventions, while FM made few interventions of any type.

Table 3a.1. Mean average (+*SD*) intervention categories for each participant.

Participant	Change	Locate	Put
AH	0.71 (0.72)	1.71 (1.49)	2.05 (1.91)
TL	0.14 (0.38)	1.86 (1.95)	0.14 (0.38)
DB	0.13 (0.35)	1.88 (0.64)	0.38 (0.74)
FM	0.15 (0.49)	0.55 (0.89)	0.45 (0.95)

2.3.6 Discussion

The present study explored whether verbalising instructions during observed performance of an everyday task would improve recall and error monitoring in people with dementia. We anticipated that instructed-recall would improve retrieval of the required actions, and would be comparable in terms of task accomplishment and the number of errors made to performed-recall. We found that three of our four participants accomplished just as many of the task actions in the instructed-recall condition, as they did in the performed-recall condition, and they accomplished significantly more in these conditions than they did in the verbal-recall condition. Interestingly, although in the instructed-recall condition, participants used interventions to supplement their verbal recall, even without these interventions the instructed-recall outperformed the verbal-recall condition, suggesting potential benefits of overt verbalising when visual cues are present.

Furthermore, for the participant whose dementia progressed to the severe stage, instructed-recall continued to outperform the verbal-recall, suggesting that memory for an everyday sequence is best measured when supported by visual cues, than simply by verbal recall alone.

In terms of errors, the results revealed considerable individual differences. Indeed, while there were benefits to task accomplishment, and one of our participants showed decreased errors in the instructed-recall condition, for two of our participants there was an increase in commission errors in the instructed condition, which warrants further study. The fourth participant, who remained stable in the moderate stage of dementia until near to the end of the five years of study, made errors of commission throughout the study and very few omissions, but showed no change across conditions or time. These results suggest that verbal instruction may not benefit all individuals with dementia, and it is possible that the process of instructing may actually be an additional burden on cognitive resources that are already compromised in people with dementia. Therefore, cognitive capacity must inform behavioural strategies aimed at helping everyday task performance in people with dementia

We anticipated that the instructed-recall condition would promote more efficient error-monitoring than the performed-recall condition. Again, there were individual differences; for two of our participants, checking was highest in the performed-recall condition, but for the other two there was no change across conditions. Interestingly, all our participants continued to use checking behaviours throughout the task, well into the moderate and severe stages of dementia, but this did not reduce the number of errors, which increased with dementia progression. This result supports findings from our previous study (Balouch & Rusted, 2013) that found that healthy young and older adults use verbal and non-verbal checking behaviours in tea-making tasks, but that these behaviours were unrelated to error rate. These data all suggest that checking is not a useful means of error prevention/detection.

Finally, we anticipated reduced anticipation/sequence errors in the instructed-recall condition, because previous findings suggested that observing a sequence of goal-directed actions from an outsider's perspective benefits the recall of the organisation and sequence of the task actions (Hutton et al., 1996; Steffens, 2007). Of our four participants, only one produced sufficient anticipation errors for statistical analysis and this revealed fewer anticipation errors in the performed-recall condition, contrary to what we expected.

In Balouch and Rusted (2014), where we provided a more detailed analysis of change over time/dementia progression in the performed-recall condition, the participants showed a general decrease in accomplishment, increase in errors and individual differences in error-monitoring. In contrast, the present study shows that in the instructed-recall condition, there was little change over time in this condition and only the following changes were observed: TL's errors increased with dementia progression, AH's accomplishment declined with dementia progression and FM's checking increased over time.

In terms of recalling the various actions of the task and preventing errors, the instructed-recall condition was just as good as (if not better than) the performed-recall condition and was significantly better than the verbal-recall. Critically, this sometimes was achieved through interventions that helped them maintain the output of the task schema in the instructed-recall condition. Grinstead and Rusted (2001) found similar results in a study of mild-moderate DATs who were required to respond verbally to questions about an item's function: they found substantial deficits, when compared to controls, but the deficit was significantly reduced when participants were encouraged to provide information motorically, i.e. to act out the actions required to use the object. Grinstead and Rusted (2001) suggested that the knowledge of functional information is not degraded in DAT participants in the mild-moderate stage, but instead the deficit is apparent in the retrieval of this type of information. They suggested that the retrieval of functional information depends upon the mode that it was encoded into memory, i.e. motorically. In relation to our study, memory for everyday tasks is normally learned through performance of the task; thus, motoric retrieval, especially when cognitive resources are limited, is the most effective.

Interventions did not increase over time with dementia progression. This is surprising because one would expect more reliance on interventions as cognitive resources reduced with dementia progression. As mentioned earlier, when interventions were excluded from the analyses, the instructed-recall condition continued to outperform the verbal-recall condition. This suggests that interventions alone were not responsible for the good performance in the instructed-recall condition, but more likely, it was the presence of the visual cues in both performed-recall and instructed-recall conditions, that enhanced recall of the actions.

A wide body of research has shown that cortical motor areas are activated simply by observing actions, as well as performing actions (Cross, Kraemer, Hamilton, et al., 2009; di Pellegrino et al., 1992; Gallese et al., 1996; Grèzes, Armony, Rowe, & Passingham, 2003b; Jenkins et al., 1994; Rizzolatti et al., 1996; Giacomo Rizzolatti & Craighero, 2004b; Sakai et al., 2002). This implies that memory for everyday actions are activated through observing another person perform the actions. Two studies of observational learning in people with dementia learning a computerised motor-learning task (van Tilborg et al., 2011) and two everyday tasks (van Tilborg, Kessels, & Hulstijn, 2011) found promising results, but further investigation is required.

The competence of our volunteers in instructing another person on how to perform an everyday task was quite remarkable, given the poverty of their unsupported verbal-recall. In the verbal-recall condition, participants were instructed to ‘provide as much detail as possible’, but in pilot work it was clear that it was difficult to elicit highly detailed outputs. In the original study (Rusted & Sheppard, 2002) this issue was addressed with an analysis based on “key actions” of the individual protocols – these key actions closely mirrored the basic recall elicited in the verbal condition. A separate set of analyses comparing performed and verbal recall on the key action protocols revealed that performed-recall was still superior to verbal recall. Thus, we feel confident that it was the combined effect of verbal instruction, visual and motor cues that led to the superior recall in the instructed-recall condition when compared to the verbal-recall condition.

Seeing the static tea-making objects in the kitchen may also prompt the objects’ affordances, triggering the task schema. There is substantial evidence suggesting that this conversion from vision to action is automatic and takes place even when the person has no intention to act on a viewed object (see Tipper, 2004, for a review). For example, viewing a teacup activates the motor responses to grasp the cup, regardless of whether or not it was necessary to grasp the cup at any given point in time. Therefore, simply viewing tea-making objects in front of them is likely to have contributed to sustaining the schema in the instructed-recall condition.

Another reason why our participants performed well in the instructed-recall condition, may be due to the joint-attention aspect that this condition provided, which was absent from the performed-recall and verbal-recall conditions. In the instructed-recall condition, participants were required to interact with the experimenter in order to achieve the goal of tea-making, and this interaction forced participants to keep on task. The archive data analysed here do not allow us to disentangle the potential effects of joint-attention from the impact of visual and motor cues. Some researchers have already shown that joint-attention benefits patient-caregiver communication and relationships (e.g. Astell et al., 2010; Sävenstedt et al., 2005), but to our knowledge the role of joint-attention in performing everyday tasks in people with dementia has not been studied, and warrants attention.

The present data do not allow us to differentiate the separate contributions of verbal instruction, visual and motor cues. Further experimental studies that explore each of these processes separately, in larger sample sizes, are needed. This knowledge would certainly have implications for behavioural strategies to aid recall of everyday tasks in people with dementia. If visual and motor cues were found to be effective, then tasks could be re-learned through observation. In contrast, if verbal instruction was found to be more effective, then people with dementia could be encouraged to verbalise their actions step-by-step whilst carrying out day-to-day tasks.

In conclusion, the current study builds on Rusted and Sheppard’s (2002) original study and Balouch and Rusted’s (2014; *Study 2*) retrospective analysis of the archive data. Rusted and Sheppard (2002) documented the recall of the everyday task steps and the types of errors that emerged with dementia progression; concluding that recall of the task became degraded with dementia progression and errors of omission became more prominent as the disease progressed. Developing on this, Balouch and Rusted (2014; *Study 2*) documented errors and error-monitoring as dementia developed; concluding that error-monitoring was rarely observed. In the current study, we explored whether a verbal strategy (verbal instruction) could potentially aid the recall of the everyday task, enhance error-monitoring and reduce errors. We found that our four participants were able to verbally instruct surprisingly well and used verbal recall appropriately and fluently to instruct a third party in a tea-making activity. The presence of visual and motor cues appears to be fundamental to their sustained verbal recall of the task schema. Our study was an exploratory investigation that optimised detailed observational data, but focussed on just a small number of individual case studies. The data do show some benefits to instructed recall, in terms of task accomplishment, but there was no evidence for benefits to error-monitoring, or sequencing (i.e. anticipation) errors. In addition, our participants exhibited individual differences, making generalization of the impact and potential of the instructed-recall condition difficult. Our data explored changes longitudinally through at least two stages of dementia, and to our knowledge is the first study to do this. It provides a platform for further studies to explore the impact of verbal, observational and motoric strategies for people with dementia.

2.4 Study 3b - Can self-explanation help people with dementia perform an everyday task? A pilot study.

2.4.1 Abstract

Self-explanation involves verbally explaining, describing and interpreting how one is performing in a task and its benefit in helping people with dementia perform an everyday task has not been previously tested. Previously (*Study 3a*) a condition that involved participants with dementia instructing another person on how to make tea had positive results for recall of an everyday task. In the current pilot study, we directly measure the effects of a self-explanation strategy on four people with dementia performing a routine task (tea-making). As part of ongoing studies, these participants were monitored for two years to establish their tea-making routines prior to errors emerging in their tea-making and to determine the nature of verbalisations they made normally. The self-explanation manipulation was introduced in the third year of the study when participants were beginning to become impaired. The results from the self-explanation manipulation showed that participants took longer in this condition than at baseline, but there was no change in errors or accomplishment of the task. Self-explanation may not be a useful strategy for helping people with dementia perform an everyday task. Limitations are discussed.

2.4.2 Introduction

The 'think aloud' (TA) paradigm requires the participant to generate a subjective verbal account of his/her thoughts or inner speech, whilst performing a task. It is normally used as a tool to obtain rich qualitative data regarding the thought processes involved in problem-solving (Fonteyn, Kuipers, & Grobe, 1993), but may also have consequences for task performance. Some studies show that, apart from prolonging the time it takes for participants to complete tasks, TA has no reactive effect on cognitive tasks in young or older adults (e.g., Gilhooly, Phillips, Wynn, Logie, & Della Sala, 1999; Johnson, 1993; Perfect & Dasgupta, 1997). Interestingly, Fox and Charness (2010) found that older adults performed *better* under TA than a silent condition in the Raven's Progressive Matrices test (Raven, 1965), but comparable to a silent condition in a series of other cognitive measures.

Young adults did not benefit from TA in that study. In a meta-analysis, Fox et al. (2011) differentiated between a verbalisation strategy which is truly ‘thinking aloud’, and a strategy that requires the participant to verbally explain, describe or interpret how they were performing in the task (from here on, *self-explanation*). They found that when participants were asked to merely verbalise their thoughts during a task, their performance was unaltered, whereas performance *improved* for participants who used an explanatory strategy. The meta-analysis also confirmed that verbal strategy methods prolong the completion time of the task. In educational psychology, too, self-explanation has been found to improve understanding and enhance performance in children and students (Atkinson, Renkl, & Merrill, 2003; Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Michelene, Chi, De Leeuw, Chiu, & Lavancher, 1994; Neuman, Leibowitz, & Schwarz, 2000; Wong, Lawson, & Keeves, 2002). Chi et al. (1989) and Chi (2000) suggested that through self-explanation the participant generates inferences and repairs their own mental model. Furthermore, Fargier, Ménoret, Boulenger, Nazir, and Paulignan (2012) found that when healthy adults verbalised action-related words whilst performing a simple grasp and replacement task, their movements became faster than when they performed the task with unrelated action words or without verbalising. The authors concluded that language can be used to aid and refine overt motor behaviour.

Little is known, however, about how verbalisation can be used in a rehabilitative role for people with brain damage or other neuropsychological profiles, such as dementia. One exception to this was in a unique case-study that taught a verbal strategy to a person with action disorganisation syndrome, FK. Bickerton, Humphreys, and Riddoch (2006) taught FK a poem based on the steps involved in making a cup of tea (a task which he carried out with great difficulty). Immediately following poem training, FK’s task performance improved dramatically and error-monitoring (error detection and correction) was enhanced. Benefits of training did not, however, last across sessions and did not transfer onto other everyday tasks. Of note, however, the poem that FK used was a mnemonic strategy, which differs from a self-explanation strategy, in that a mnemonic requires intact episodic memory to implement, whereas self-explanation does not rely on memory as such.

Little research exists exploring the impact of verbalisation on everyday tasks in people with dementia, who also have difficulties with everyday tasks. Indirect evidence for the effects of verbalisation is reported in two recent studies (Balouch & Rusted, 2013, 2014): both healthy older adults and older adults with dementia made spontaneous verbalisations whilst performing everyday tasks (even into the severe stage of dementia), with the content indicating that they were using verbalisation to monitor the task. These verbalisations, however, did not improve error prevention or correction, and were subject to large individual differences.

In *Study 3a* of the current thesis, we presented data that explored the potential benefits of verbalisation on an everyday task in people with dementia. We found that when we asked participants to instruct another person on how to make tea in their own kitchen (instructed recall condition), they were able to instruct surprisingly well and the verbal recall of the task was comparable to when they made tea themselves (performed recall condition). They used interventions (i.e. physically moved away from their seats and preceded to carry out the task) to supplement their verbal retrieval. Therefore, verbalisation in the presence of visual and motor cues appeared to be beneficial in sustaining the recall of the task schema, although in that study it was not possible to separate the impact of verbalisation from the contribution of the visual and motor cues in attaining an appropriate degree of specificity in the verbal instruction.

In the current study, in a small group of participants with mild-moderate dementia, the effect of verbalisation on task performance was directly measured. Specifically, the potential of self-explanation was examined. Although spontaneous verbalisations may not habitually impact performance (Balouch & Rusted, 2013, 2014; *Studies 1* and *2*, respectively), the effect of self-explanation on task performance has not been tested previously in people with dementia. In this pilot study, participants were encouraged to explain each of their actions as they initiated it, rather than simply thinking aloud. Self-explanation, which is prompted by the experimenter, is differentiated from spontaneous verbalisations that the participant naturally produces when making tea in a naturalistic setting with no prompting. We evaluated the effects of self-explanation on errors, error-monitoring, accomplishment scores and time to complete the task. The participants in this study were monitored on a regular basis in their own homes for over three years. The aim of the longitudinal aspect of the study was to establish the participants' tea-making routine before errors began to emerge (in order for errors to be coded) and to document natural spontaneous verbalisations to establish what was normal before we applied the verbal manipulation. The aim was to implement the verbal manipulation at a point when errors were beginning to emerge.

2.4.3 Methods

2.4.3.1 Ethical approval

The study was approved by the National Research Ethics Service, Research Ethics Committee for Wales. Participants all had, and retained for the duration of the study, the capacity to provide informed consent. A personal consultee (a spouse in all cases) also confirmed consent at each session.

2.4.3.2 Design

This was a naturalistic, observational, design, reporting four case-studies of people with dementia carrying out an everyday task at regular intervals over a period of three years. The self-explanation manipulation was introduced in the last year of the longitudinal study, and was evaluated in a repeated measures design (condition: baseline and self-explanation).

2.4.3.3 Participants

Four participants (all male) were recruited in liaison with the Sussex Partnership NHS Foundation Trust Older People Mental Health Teams, from the local memory clinics. The participants were recruited based on the following inclusion criteria: clinical diagnosis of Alzheimer's disease (AD) or mixed dementia (AD and vascular dementia); mild-moderate impairment, based on a score of 16-26 on the Mini Mental State Examination

(MMSE; Folstein, Folstein, & McHugh, 1975); and capable of making a hot drink independently. Exclusion criteria included severe learning disabilities, history of head injury, recent alcohol or drug abuse (within one month), epilepsy, visual impairment, heart disease, and primary psychiatric illness. Participants were diagnosed, using DSM-IV criteria for dementia (American Psychiatric Association, 2000), by a consultant psychogeriatrician, on the basis of CT scan and the Addenbrook's Cognitive Examination Revised (ACE-R; Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006).

2.4.3.4 Measures and Procedure

Tea-making was used as the everyday task. At the outset all participants were independently making their own cups of tea, with individual routines comprising 11-12 actions, and these routines were used to assess subsequent changes in tea-making performance. Participants were visited in their homes by SB every two months for three years. At the initial and 6-monthly sessions a full neuropsychological battery and a quality of life measure was administered (see Appendix D for full list). At every session participants were filmed (using a handheld digital camera) making tea in their own kitchens according to their own routines. Prior to each tea-making session participants were given the following simple instructions: "Please make a cup of tea as you would normally make it". The tea-making footage was coded offline for errors and error-monitoring. Additionally, the MMSE was taken at each session to measure global cognitive status.

In the last 8 months of data collection, participants also completed the self-explanation condition. There were four tea-making trials per session: two trials under the self-explanation condition and two naturalistic "baseline" trials. In the self-explanation condition, participants were given the following instructions: "Please make a cup of tea as you would normally make it, but when you make the cup of tea, talk me through step-by-step what you are doing. So for instance, as you are switching on the kettle, say 'I am switching on the kettle' and so forth." Participants were asked to repeat the instructions back to the experimenter, and instructions were repeated if the participant did not understand. More complex instructions aimed at capturing the thought processes involved with planning and evaluating the task at hand (i.e. self-explanation) were avoided, however, in order to reduce the cognitive burden on participants. Pilot work revealed that the instructions selected for use in the study prompted verbalisations of the actions currently being executed and therefore were indicative of intention planning of the task at hand. The order of conditions was counterbalanced at each data collection time-point, across sessions and across participants. There was a 15 minute break between each trial, away from the kitchen, which included conversation with SB, drinking tea and the MMSE after the second trial. This was to minimise interference effects from one condition to another. All trials were filmed for offline coding.

2.4.3.5 Data coding

Errors, microslips, non-verbal checks, and corrections were coded using previous taxonomies (Appendices B1 and C2). In both the self-explanation and baseline conditions, all verbalisations were coded based on the verbal monitoring coding guide of Balouch and Rusted (2013; Appendix A4). Verbalisations were categorised as schema checks (SC: recalling or attempting to recall the task steps and/or task goal), reflective implementations (RI: evaluating, planning, and describing the task at hand) and practical checks (PC: a need for a practical or technical clarification or a matter of fact statement). The self-explanation condition was anticipated to elicit RIs. A Kappa analysis of the coded data revealed a high inter-rater reliability for two coders (Kappa = .89, $p < .001$). The accomplishment score and completion time were calculated as in *Study 3a*.

2.4.4 Data analyses

Data from the neuropsychological, quality of life and tea-making performance measures were reported on a yearly basis (years 1, 2 and 3). The results for the neuropsychological and quality of life measures are reported descriptively only (except MMSE, see below). The longitudinal data on tea-making performance and spontaneous verbalisations were analysed individually for each participant, whereby sessions (replications) were entered as ‘subject’ and grouped by year of study. The longitudinal data is reported descriptively, due to not meeting assumptions for statistical analyses. The data from the self-explanation manipulation was analysed using group data in 2 (condition: baseline and self-explanation) x 2 (time: 1 and 2) repeated measures ANOVAs on outcome variables that had substantial data (errors, completion time, accomplishment, RI, SC, and PC). Significant main effects and interactions were followed up with paired-sample *t*-tests. Multiple comparisons were controlled for using Bonferroni corrections.

2.4.5 Results

2.4.5.1 Case summaries

DH was a 76-year old high-functioning gentleman at the outset of the study. He lived at home with his wife. He was diagnosed with probable AD in 2005 and commenced the current study in October 2010. At recruitment, DH had scored 76 in the Addenbrooke's Cognitive Examination Revised (ACE-R; Mioshi et al., 2006; cut off for dementia is 88/100) and an MMSE of 26, placing him in a mild impairment range at the outset of the study. He was taking memory enhancers (cholinesterase inhibitors) prior to and throughout the study. His NART estimated IQ was 126 and he had 25 years of education.

NW was an 80-year old high functioning gentleman at the outset of the study. He lived at home with his wife. NW started developing short-term memory problems in 2007. He was diagnosed as having mild dementia (AD or mixed) a year prior to the study commencing, with an ACE-R of 83, and MMSE of 29. A clinical CT scan revealed generalised involution; sulci that were a little more pronounced in the frontal and peri-sylvian regions; and a minor degree of small vessel ischaemic change, but no acute lesion. He commenced in the current study in November 2010, at which time his MMSE was 19. He was on cholinesterase inhibitors prior to and during the study. His NART estimated IQ was 122 and he had 18 years of education.

DS was a high-functioning 81-year old gentleman at the outset of the study. He lived at home with his wife. DS was diagnosed with probable AD two years prior to the study commencing, with an ACE-R score of 75 and an MMSE of 25. He was on cholinesterase inhibitors prior to and during the study. He commenced in the current study in February 2011, with an MMSE score of 22 at recruitment, placing him in the mild dementia range at the outset. He had a NART estimated IQ of 118 and had 13 years of education.

NL was an 87-year old high functioning gentleman at the outset of the study. He lived at home with his wife. NL was diagnosed in 2009 with AD or mixed dementia. His records note a small cerebral vascular accident (CVA) in 2010, making the latter more likely. He began the current study in March, 2011. A CT scan in 2010 revealed no evidence of acute haemorrhage or infarction. There were involution changes consistent with age and a possible very small local infarct. He was not on any memory enhancer medication. He commenced the current study in March 2011. At recruitment he had an ACE-R of 75 and an MMSE of 22, placing him in the mild range of dementia. His NART estimated IQ was 123 and he had 13 years of education. NL had a number of physical problems including, hip replacement in 2001 and again in 2013. Despite all of this, NL remained remarkably resilient and cognitively did not appear to change substantially throughout the study.

2.4.5.2 Neuropsychological and quality of life changes over time

Figure 3b.1 shows that all participants' MMSE scores declined over time. The ANOVAs revealed significant main effects of Year for DS, $F(2, 13) = 17.77$, $p < .0001$, and NL, $F(2, 9) = 9.30$, $p = .006$, with planned contrasts confirming significant decreasing linear trends, $F(1, 13) = 33.57$, $p < .0001$, and $F(1, 9) = 14.30$, $p = .004$, respectively. Although, DH and NW's MMSE scores decreased over time, the main effect of Year just missed significance (DH: $F(2, 10) = 3.81$, $p = .059$; NW: $F(2, 11) = 3.71$, $p = .059$), but the planned contrasts indicated significant linear decreases (DH: $F(1, 10) = 7.24$, $p = .023$; NW: $F(1, 11) = 5.37$, $p = .04$). All participants, however, remained in the mild-moderate stage of dementia throughout the study.

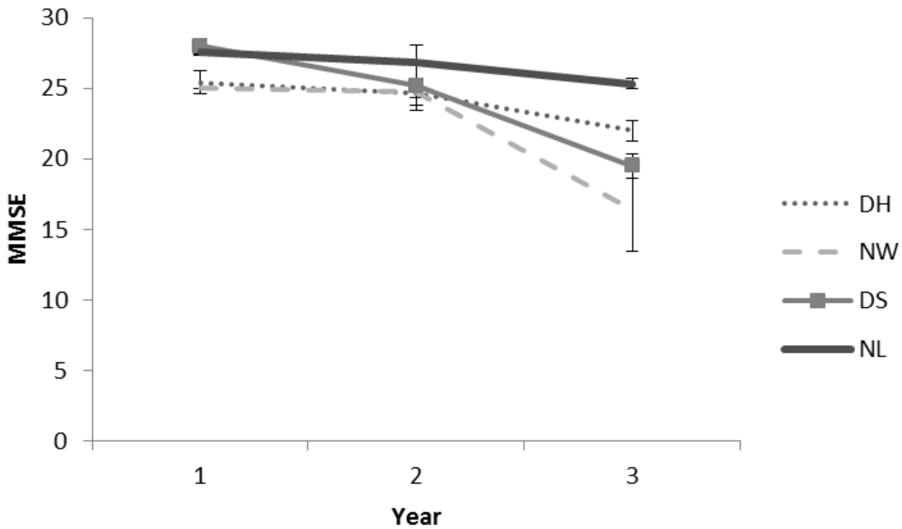


Figure 3b.1. Participants' MMSE scores over time (error bars are +/- 1 SEM).

Table 3b.1 summarises the neuropsychological data and quality of life measure taken over three years to determine change over time. Data is reported descriptively due to insufficient data for statistical analysis. All participants (except NL) declined in executive functioning (as measured by the FAS test; Spreen & Strauss, 1998), speed of processing (as measured by Digit Symbol Substitution; DSST; Wechsler, 1987) and sustained attention (as measured by the Map Test of Everyday Attention; Map-TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996) over time. Episodic memory (as measured by word recall; Rusted & Warburton, 1992) remained stable for all participants except DS, whose episodic memory declined. NL remained relatively stable in all cognitive measures. Self-reported cognitive failures (as measured by the Cognitive Failures Questionnaire; CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982) increased over time for all participants. The caregiver report of the participants' ability to carry out activities of daily living (as measured by the Instrumental Activities of Daily Living scale; IADL; Lawton & Brody, 1969) remained relatively stable for most (except DH who declined over time), but there were individual differences in functioning. Quality of life (as measured by Quality of Life in Alzheimer's Disease; QOL-AD; Logsdon, Gibbons, McCurry, & Teri, 1999) declined somewhat for all participants over the course of the study.

Of note, in the final year of the study, three participants were performing below the 10th percentile in FAS when compared to normative data in healthy people matched for age and years of education (Tombaugh, Kozak, & Rees, 1999), and DH performed in the 20th - 30th percentile in his final year. This shows that executive functioning was poor during the time when the self-explanation manipulation took place.

Table 3b.1. Mean averages (+*SD*) of neuropsychological data and other background measures

Participant/ Year	FAS	DSST	Word recall	Map-TEA	CFQ	IADL	QOL-AD
DH							
1	44.00 (2.83)	27.50 (4.95)	2.00 (1.41)	32.00 (12.02)	31.00 (1.41)	3.50 (0.71)	41.50 (0.71)
2	40.50 (0.71)	25.00 (2.83)	2.00 (0.00)	28.00 (11.31)	35.00 (2.83)	4.50 (0.71)	40.00 (1.41)
3	28.50 (7.78)	15.50 (3.54)	2.00 (1.41)	23.00 (11.31)	35.00 (1.41)	3.00 (0.00)	39.00 (1.41)
NW							
1	25.00*	18.00*	4.00*	6.00*	37.00*	5.00*	41.00*
2	28.50 (17.68)	17.50 (7.78)	2.50 (0.71)	17.00 (4.24)	44.50 (7.78)	4.50 (0.71)	38.00 (5.66)
3	17*	7*	3*	6*	65*	3*	38*
DS							
1	13.50 (0.71)	7.50 (2.12)	2.00 (0.00)	21.00 (11.31)	37.50 (4.95)	2.50 (0.71)	33.50 (0.71)
2	13.50 (2.12)	4.50 (2.12)	1.00 (0.00)	12.00 (2.83)	37.00 (9.90)	2.50 (0.71)	38.50 (3.54)
3	8*	3*	0*	9*	39*	3*	21*
NL							
1	31.33 (7.57)	29.00 (2.65)	3.67 (0.58)	27.50 (3.54)	35.00 (7.55)	5.67 (1.53)	35.00 (3.00)
2	28.00 (12.73)	22.00 (5.66)	3.00 (1.41)	25.50 (6.36)	45.50 (14.85)	4.50 (2.12)	29.50 (0.71)
3	21*	21*	4*	27*	44*	5*	26*

Note. *Actual score

2.4.5.3 Longitudinal tea-making performance and spontaneous verbalisation changes over three years

Table 3b.2 summarises the tea-making performance and spontaneous verbalisations over three years. There was insufficient data for statistical analysis, so data is reported descriptively.

Although there was no substantial increase for number of errors over time for any of the participants, NW and DS made most of their errors in year 3. NW's completion time increased considerably in year 3 and may indicate that he was beginning to find the task more difficult. Surprisingly, NL's completion time reduced over time. All participants verbalised frequently when they were making tea. These mostly consisted of reflective implementations, and the frequency of these did not change substantially over time.

Table 3b.2. Mean averages (+ *SD*) of tea-making performance and spontaneous verbalisation (SC, RI, PC*) data over three years for each case-study.

Participant/year	Errors	Accomplihment %	Completion time (seconds)	Microslips	Errors-corrected %	Non-verbal checks	SC	RI	PC
DH									
Year 1	0.80	98 (4)	242.53	0.80 (1.10)	25 (50)	0.80 (.84)	0.40	2.00	0.20
N = 5	(0.45)		(66.32)				(0.55)	(0.71)	(0.45)
Year 2	0.00	97 (5)	276.56	1.67 (1.53)	N/A	2.33	1.00	2.33	1.33
N = 3	(0.00)		(40.51)			(0.58)	(0.00)	(1.53)	(2.31)
Year 3	0.80	96 (5)	214.54	0.00 (0.00)	17 (29)	1.40	1.40	3.60	0.80
N = 5	(0.84)		(54.90)			(1.14)	(1.67)	(1.95)	(0.84)
NW									
Year 1	1.25	96 (8)	359.74	0.25 (0.50)	50 (58)	0.25	1.00	6.75	0.00
N = 4	(0.50)		(60.87)			(0.50)	(0.82)	(4.50)	(0.00)
Year 2	0.75	100 (0)	268.55	1.50 (2.38)	25 (35)	0.75	0.50	7.00	1.75
N = 4	(0.96)		(72.28)			(1.50)	(1.00)	(4.16)	(1.50)
Year 3	3.17	96 (7)	481.91	0.17 (0.41)	7 (10)	0.17	1.83	4.00	2.00
N = 6	(2.64)		(160.46)			(0.41)	(0.98)	(2.28)	(1.55)
DS									
Year 1	0.20	100 (0)	245.50	0.20 (0.45)	0 (0)	0.80	1.00	4.20	0.20
N = 5	(0.45)		(89.48)			(0.84)	(1.00)	(2.68)	(0.45)
Year 2	0.60	100 (0)	212.43	0.60 (1.34)	0 (0)	0.40	1.80	0.80	1.00
N = 5	(1.34)		(63.63)			(0.55)	(1.10)	(1.10)	(1.41)
Year 3	2.00	92 (11)	261.17	0.33 (0.52)	6 (13)	0.50	1.83	3.33	0.33
N = 6	(1.67)		(75.20)			(0.55)	(1.17)	(2.50)	(0.52)
NL									
Year 1	0.17	99 (3)	204.76	0.00 (0.00)	0 (0)	0.33	0.00	3.67	0.83
N = 6	(0.41)		(54.07)			(0.52)	(0.00)	(1.75)	(0.98)
Year 2	1.00	92 (12)	198.54	0.00 (0.00)	0 (0)	3.50	0.00	1.50	2.00
N = 2	(1.41)		(28.93)			(0.71)	(0.00)	(0.71)	(1.41)
Year 3	0.25	100 (0)	156.00	0.25 (0.50)	0 (0)	0.75	0.00	0.75	0.25
N = 4	(0.50)		(16.05)			(0.96)	(0.00)	(0.50)	(0.50)

Note: RI = reflective implementation, SC = schema check, and PC = practical check; *N* = number of sessions

2.4.5.4 Self-explanation manipulation

In the final 8 months of the study the effect of self-explanation on tea-making performance was evaluated. The longitudinal data indicated that all participants were showing declining cognitive resources, and that participants were continuing to use spontaneous verbalisation. DH participated in four sessions in the verbal manipulation; DS participated in six, NL in four and NW in two.

In each session participants made tea under two conditions: baseline and self-explanation. For each session, participants completed two tea-making trials in each condition; one practice and one actual trial; the latter was included in the analysis. MMSE scores did not change over the 8 month timeframe during which these session replications occurred (they remained in the mild-moderate range). One-way repeated measures ANOVAs (condition: baseline and self-explanation) were conducted on group data for each of the following variables: errors, accomplishment score, completion time (to assess tea-making performance) and reflective implementations (RI), schema checks (SC) and practical checks (PC) (to assess the verbalisations). Error-monitoring was rare, thus was not analysed. Although the sample size was small, ANOVA constituted the most robust statistical test to apply to this data (Schmider, Ziegler, Danay, Beyer, & Bühner, 2010). Table 3b.3 summarises the mean performance measures.

The results show that in the self-explanation condition, participants took significantly longer to complete the task, $F(1, 3) = 13.38$, $p = .035$. Numbers of errors and accomplishment scores were consistent across conditions (both ps > .05). Participants made significantly more RIs in the self-explanation condition than in the baseline condition, $F(1, 3) = 19.29$, $p = .022$, and RIs were the most prominent verbalisation, indicating that they adhered to the instructions in the self-explanation manipulation. There was a trend for participants to make more SCs in the self-explanation condition, than in the baseline condition, SC: $F(1, 3) = 6.37$, $p = .086$. PCs were rare and were not affected by condition ($p > .05$).

Table 3b.3 Mean averages (+ *SD*) for the self-explanation manipulation

Time/condition	Errors	Accomplishment %	Completion time (seconds)	RI	SC	PC
Baseline	2.06 (2.07)	91.67 (10.22)	242.84 (168.64)	1.75 (1.59)	1.06 (.82)	0.94 (0.83)
Self-explanation	2.79 (2.98)	93.28 (6.51)	358.06 (199.96)	12.79 (4.30)	3.11 (2.35)	0.83 (0.67)

2.4.6 Discussion

The current study explored the effect of self-explanation on everyday task performance in four participants with mild-moderate dementia. It was motivated in part by the impact of verbalisation achieved in the previous study (*Study 3a*). This suggested that verbalising the sequence of actions required in an everyday activity, whilst carrying out the activity, may aid the continuity and ordering of the actions required to complete the task correctly. Our assessment compared verbalisations that were continuous throughout the task, had a self-explanation content and had been prompted by the experimenter, with verbalisations that were spontaneous, sporadic and had not been guided by any instructions. Other than increasing the time it took to make tea, self-explanation did not affect everyday task performance. These results suggest that a self-explanation intervention may not be suitable for people with dementia, and would not aid everyday task performance.

A closer look at the types of verbalisations that participants made showed that they tended to make mostly reflective implementations, rather than schema checks or practical checks, regardless of whether they were in the self-explanation manipulation or in their normal tea-making sessions. Reflective implementations included any verbalisation that indicated planning, evaluating and describing one’s actions in the present moment, similar to Chi et al.'s (1994) definition of self-explanation. Thus, more complex instructions that require the participant to vocalise planning and evaluating in the self-explanation condition were not needed in this study and if used may have unnecessarily burdened the participants beyond their competence. While the self-explanation strategy significantly increased the number of RIs, this increased ‘monitoring’ of the task did not lead to any change in errors made.

Previous literature found that self-explanation improved performance in healthy volunteers (Chi et al., 1994; Chi, 2000; Chi et al., 1989), however these benefits did not appear to translate to people with dementia performing an everyday task in the present study. The increased task completion time we observed in our volunteers was also reported in healthy individuals (Fox et al., 2011).

The current findings have implications for the interpretation of *Study 3a* of this thesis. In *Study 3a* participants with dementia took part in an instructed-recall condition, where they were required to instruct the experimenter on how to make tea. In this condition they performed surprisingly well and it was discussed that this may have been due to the combined effect of the verbal, visual and motor cues present in the instructed-recall condition, and not to the verbal element of instruction alone. To clarify, the instructed-recall condition consisted of more elements than simply verbalising. In fact viewing the task from a third person perspective and taking on an outsider's perspective, may have been helpful in recalling the task steps. Observing actions has repeatedly been shown to improve the learning of action-based tasks (Black & Wright, 2001; Cross, Kraemer, de C. Hamilton, et al., 2009; Rizzolatti & Craighero, 2004) and this is explored as a potential memory aid in people with dementia in *Studies 4a* and *4b*.

It is possible that verbalisation strategies may be of limited benefit for our participants with dementia, because of difficulties in language production; for instance word finding difficulties are common (McKhann et al., 2011), word fluency and naming are impaired, even in the early stages of the disease (Verma & Howard, 2012). Furthermore, in the self-explanation manipulation of this study, participants were required to verbalise simultaneously with performing the actions. This dual-task aspect of the manipulation may have created an extra burden on cognitive resources that are already limited. In fact, previous research shows that people with dementia have a specific impairment in dual-tasks (Foley, Kaschel, Logie, & Sala, 2011). A strategy that used fewer resources, such as observation of actions, may be a better avenue for future research.

A number of limitations are recognised in the present study, which would need addressing in future research. Firstly, the sample size was too small to robustly interpret the findings from this study. This important limitation is fully acknowledged by the author, and is viewed as a pilot study for future large scale studies. Secondly, the participants did not progress beyond the mild-moderate stage of dementia; hence errors were limited in the everyday task performance. Errors did occur, however, and were not eliminated in the self-explanation condition. Testing at a point when competence was still good, but not quite perfect, minimised the potential confound of word-finding difficulties, so it is possible that the potential impact of self-explanation was accurately measured at the optimal time in the course of the disease. Thirdly, due to the low sample size it was not possible to differentiate between the potential for self-explanation as a strategy to affect people with different neuropsychological profiles differently. For example, Giovannetti and colleagues (2008) found that people with dementia, who showed different error patterns in everyday tasks reflected different neuropsychological profiles. They found that participants who made mostly errors of omission had episodic memory deficits and participants who made mostly errors of commission had executive functioning deficits. This suggests that different neuropsychological profiles may benefit differently from the self-explanation strategy. It is plausible that participants with executive functioning impairments may not find a self-explanation strategy of benefit, due to the strategy relying on working memory (e.g. they would need to hold their position in the task sequence in working memory and plan what they need to do next). All participants showed deficits in executive functioning in the final year of the study when the self-explanation strategy took place, which may explain why it did not aid their performance.

Notwithstanding these limitations, the results provide a novel first exploration into the potential use of self-explanation strategies to enhance everyday task performance in people with dementia. The results suggest that self-explanation does not aid recall of an everyday action sequence of participants with dementia when the participants are performing the task themselves. The benefit to the instructed recall condition in *Study 3a* may have been due to observing the actions from a third-person perspective in that condition. The specific contribution of observing another person's actions are tested in *Studies 4a* and *4b*.

2.5 *Studies 4a and 4b.*

2.5.1 Abstract

In people without dementia, there is strong evidence showing that passive observation of a sequence of actions aids acquisition of those actions. The present study assessed the impact of observational learning of an everyday task in participants with dementia. In a within-subjects design, nineteen participants with mild-moderate dementia were required to learn a novel tea-making task under two conditions: observational learning (experimenter demonstrated actions; participant watched) or verbal instruction (experimenter verbalised the instructions; participant listened). Three trials were completed under each condition; performance was filmed and coded for accomplishment, duration, errors and error-monitoring. The main findings were that compared to verbal learning, observational learning improved accomplishment of task steps, reduced errors and produced quicker completion of the task. A further follow-up study was conducted with three participants to determine if the benefits of observational learning could be sustained over time or facilitated relearning. No longer term benefits were evident, however. Implications for clinical rehabilitation are discussed.

2.5.2 Study 4a - Observational learning of a novel everyday task in people with dementia.

2.5.2.1 Introduction

People with dementia have difficulties performing everyday tasks (Jalbert et al., 2008). Studies of everyday task performance in people with dementia, employing aids such as environmental adaptations and goal cues, have yielded mixed results (e.g. Giovannetti et al., 2007a; Bettcher, Giovannetti, Klobusicky, et al., 2011a; Brennan, Giovannetti, Libon, Bettcher, & Duey, 2009; Bettcher, Giovannetti, Libon, et al., 2011b). Observational learning, however, is an understudied area of intervention for people with dementia performing everyday tasks.

In people without dementia, there is strong evidence showing that passive observation of a sequence of actions aids acquisition of those actions (Black & Wright, 2001; Cross, Kraemer, Hamilton, Kelley, & Grafton, 2009; Stefan et al., 2005; Vogt, 1995; Jenkins, Brooks, Nixon, Frackowiak, & Passingham, 1994; Sakai, Ramnani, & Passingham, 2002; Grezes, Armony, Rowe, & Passingham, 2003). It is widely suggested that this is a consequence of the 'mirror neuron system' - the neural mapping of the human motor system, which mirrors the actions of others at observation (Rizzolatti & Craighero, 2004). Electroencephalogram (EEG) studies have shown that movement and observation share the same neural pathways (Gestaut & Bert, 1954; Cochin, Barthelemy, Lejeune, Roux, & Martineau, 1998; Muthukumaraswamy, Johnson, & McNair, 2004; Pineda, 2005; Lisek & Kalaska, 2004; Mattar & Gribble, 2005), and brain imaging studies show that these pathways are activated by the act of observing another person's actions (Rizzolatti & Craighero, 2004). Indeed, behavioural studies have shown that learning a sequence of actions through passive observation can be just as effective as learning through enactment, both in multiple trial (Cross et al., 2009; Vogt, 1995) and single trial studies (Steffens, 2007).

Additionally, there is evidence that simply seeing a static object provides information about the action required to use it (affordance), e.g. a door knob affords twisting and a chord affords pulling (Tipper, 2010). This conversion from vision into action appears to be automatic, even when the observer has no intention of using the viewed object (Tipper, 2004, for a review). However, attention appears to guide this action simulation process and it is important for attention to be oriented to the parts of the object or body that are relevant to action. These internal motor representations are more active when action is observed, rather than viewing static objects, and is more likely to result in overt simulation of that behaviour (Tipper, 2010). Thus, it appears that learning a task through observation is better when actions involving objects are observed

Balouch and Rusted (under review; *Study 3a*) reported a longitudinal case study of volunteers with dementia of the Alzheimer-type (DAT), who were filmed making tea in their own kitchen for a period of up to 5 years. The DAT volunteers were competently able to instruct the experimenter on how to make tea in their own kitchen (instructed-recall condition), just as well as when they made tea themselves in their own kitchens (performed-recall condition). Both these conditions were superior to when the participants verbally described the step-by-step actions of how to make tea, seated away from the kitchen (verbal-recall condition). The surprising capability of the volunteers in the instructed-recall condition suggested that the participants were making use of dynamic visual cues (through seeing the task unfold in front of them) and that these activated motor cues –intervening with the task themselves when they got stuck with the instruction.

Studies exploring observation as an aid to learning in people with dementia are limited. One study showed that people with DAT were able to learn a computerized motor-learning task via observational learning and that this method was better than guidance, whereby the trainer physically guided the participants hands to the correct targets (van Tilborg et al., 2011). This study did not use a naturalistic everyday task, however, so it is difficult to draw any conclusions on how this would apply in the real world. In another study, van Tilborg et al. (2011) taught people with DAT two novel everyday tasks, over a number of trials, under two different conditions: implicit (the experimenter demonstrated how to perform the task, whilst the participant observed) and explicit (the experimenter verbalized instructions on how to perform the task, whilst the participant listened) learning.   Although learning occurred in both conditions, neither condition was better than the other. This may have been due to differences in the amount of cognitive effort required between conditions, to the errorless learning regimen employed, or to lack of sensitivity of the measures for assessing task learning. Certainly, observational learning of an everyday task in people with dementia is an area that appears to warrant further research.

To interrogate the effects of observational learning on everyday tasks, the present study investigated the effectiveness of observation on learning of a novel everyday task in people with dementia. Previous studies show that people with dementia are impaired in error-monitoring (Balouch & Rusted, 2014; Bettcher et al., 2008; Giovannetti et al., 2002b), and previous efforts to encourage error-monitoring have found little benefit (e.g. Bettcher et al., 2008; Brennan et al., 2009), with the exception of a study that involved an observational component (video presentation) as part of an extended verbal and visual combination approach (Bettcher et al., 2011b). Overall, we expected more task steps to be recalled, fewer errors and less time to complete the task in the observed condition. Additionally, due to the affordances that objects trigger (Tipper, 2010), we examined whether the motor memory for the hand gestures required for selecting target items was primed through observation. If this were the case, we expected to see more errors involving distractors that share the same hand gesture as the target objects (compatible distractors), than distractors involving a different hand gesture as the target objects (incompatible distractors).

2.5.2.2 Methods

2.5.2.2.1 Ethical approval

Ethical approval was granted by the National Research Ethics Committee for Wales. Informed consent was taken from all participants and strict measures were taken to ensure participants with dementia had the capacity to make an informed decision before consent was taken.

2.5.2.2.2 Participants

Nineteen participants were recruited from memory clinics and day centres in East Sussex, U.K. with a diagnosis of Alzheimer's disease (AD), vascular dementia (VaD) or mixed dementia (i.e. DAT and VaD). Participants were diagnosed by a neurologist or geriatrician within the Sussex Partnership NHS Foundation Trust and all participants met the DSM-IV criteria for dementia (American Psychiatric Association, 2000). Inclusion criteria for the study were: mild-moderate impairment, based on a score of 11-25 (as suggested by Perneczky et al., 2006) on the Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975); stabilized medication at the time of recruitment (at least 6 months); and capable of making a hot drink independently. Exclusion criteria were: dementia that was not due to AD or VaD, severe learning disabilities, history of head injury, recent alcohol or drug abuse (within one month), epilepsy, visual impairment, colour blindness, cortical stroke, heart disease, and primary psychiatric illness.

2.5.2.2.3 Design

The 2 x 3 within-subjects design consisted of two conditions (verbal and observed) and three trials in each condition. The order of conditions was counterbalanced between participants.

2.5.2.2.4 The Modified Tea-making Task (MTT)

The novel MTT is based on the Tea-making Task (TT) devised by Balouch and Rusted (2013), and requires the participant to learn a novel tea-making routine. The participant is presented with an array of objects for making tea on a worktop or table in a kitchen setting and knowledge of the objects is checked prior to the task commencing. The experimenter administers the step-by-step instructions for the tea-making routine either verbally or by performing the actions (depending on the condition). The participant must remember these instructions and make the tea according to those instructions immediately following the instructions. In the verbal condition, the step-by-step instructions for the tea-making routines are verbally administered and the experimenter points to the objects as s/he names those objects. In the observed condition, the step-by step actions are performed by the experimenter (no words are spoken) whilst the participant observes. The time taken to administer both modes of instruction is standardised across conditions and across participants. Each participant performs three trials in each condition in immediate succession. In both conditions, the instructions are given twice before the first trial, once before the second trial and once before the third trial. Once the instructions are given, the experimenter does not remind participants of the instructions during the task. If participants ask the experimenter for reminders of the tea-making routine, the experimenter uses prompts such as: “Just do what you can remember from my instructions”.

The layout of the task objects is randomised for each trial to ensure that learning derives from mode of instructions (verbal or observed) and not recall or proximity of object location. There are two parallel tea-making routines, one for each condition, to avoid practice effects from condition to condition. For each tea-making routine there are 9 target objects, 5 of these have matched distractor objects (one compatible distractor and one incompatible distractor) making a total 10 distractor objects in each routine. The compatible distractor shares the same action or hand gesture to use/lift/grip as the target item (e.g. the same action is required to lift two cups that differ only in colour). In contrast, an incompatible distractor requires a different action or hand gesture to use than the target object (e.g. a different hand grip would be required for two cups that vary in size and shape). Please see Appendix E1 for the MTT guide.

2.5.2.2.5 Neuropsychological measures

The Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). A measure of global cognitive status.

The National Adult Reading Test (NART; Nelson, 1982). A vocabulary test that provides an estimate of IQ.

Trail Making Task A and B (TMT; Army Individual Test Battery, 1944). A measure of executive processing, requiring visual-conceptual and visuo-motor tracking.

The Digit Symbol Substitution Test (DSST; Wechsler, 1987). A measure of psychomotor performance and speed of information processing.

The Map Test of Everyday Attention (Robertson et al., 1996). A visual search task measuring sustained attention.

Controlled Oral Word Association Test (or “FAS” test; Spreen & Strauss, 1998). A verbal fluency measure of executive functioning.

Word recall. A ten item word list matched on frequency and imagery ratings and used to measure episodic memory (Rusted & Warburton, 1992).

2.5.2.2.6 Procedure

Testing took place in day centres, memory clinics or participants' homes. Data collection was spread out over two sessions to reduce fatigue and avoid interference effects from one condition to another. The sessions were approximately 1-4 weeks apart. In the first session, informed consent was taken, along with demographic details and the following cognitive measures: MMSE, NART, Trails A and B. This was followed by the MTT in either the verbal or observed condition (order of conditions was counterbalanced between participants, as was order of the two parallel MTT routines). In the second session, informed consent was taken again for the dementia group, followed by the remaining neuropsychological measures in the following order: Map-TEA, FAS, word recall, and DSST. The MTT was administered last. The MTT was filmed using a small handheld digital camera in order to code task performance off-line.

2.5.2.2.7 Data coding

Performance on the MTT was coded using the Noldus Observer Version 5.0 software (Noldus Information Technology, 2003). Errors were coded as in Appendix E2 and error-monitoring was coded as in Appendix A3. All data was coded by the first author and a trained research assistant. A Kappa analysis of the coded data revealed a high inter-rater reliability for two coders (Kappa = .90, $p < .0001$).

The accomplishment score indicated the number of MTT actions the participant completed, regardless of sequence and repetition of those actions, and it credits the participants for corrections. The accomplishment score was calculated for each trial using the following formula: (number of tea-making actions in routine) – (total omissions) – (total uncorrected substitutions). This was then converted into a percentage. The completion time for each MTT trial was also documented in seconds.

2.5.2.3 Statistical Analyses

Learning was assessed using two-way repeated-measures ANOVAs (condition 2 levels – verbal and observed; trial 2 levels – trial 1 and 3) on the accomplishment score, task completion time and all key error and error-monitoring variables (only variables that yielded sufficient data). To determine differences between the number of compatible and incompatible substitutions, a three-way repeated-measures ANOVA was conducted (condition 2 levels – verbal and observed; trial 2 levels – trial 1 and trial 3; substitution 2 levels – compatible and incompatible). Significant main effects and interactions were followed up with appropriate contrasts and one-way ANOVAs. *P* was significant at the .05 level and all *p* values are reported as 1-tailed, unless otherwise stated. The effect sizes are reported for all significant (or near to significant) results, using Pearson's Correlation Coefficient (*r*), whereby .10 is a small effect, .30 is medium, and .50 is large (Cohen, 1988).

2.5.2.4 Results

2.5.2.4.1 Demographic and neuropsychological data

Table 4a.1 contains means (*M*s) and standard deviations (*SD*s) for background and neuropsychological data. There were 14 females and 5 males. Twelve participants were diagnosed with DAT, 2 with VaD and 5 with mixed dementia.

Table 4a.1. Demographic and neuropsychological data.

	Age	**Education**	**MMSE**	**NART IQ**	**Trails B/A**	**DSST**	**Map TEA**	**FAS**	**Word recall**
***M* (*SD*)**	82.47 (4.71)	11.47 (3.02)	19.26 (3.46)	109.52 (9.44)	3.32 (1.29)	15.00 (7.80)	16.28 (10.39)	19.79 (10.44)	1.68 (.95)
N	19	18	19	**19**	**14**	**19**	**18**	**19**	**19**

2.5.2.4.2 Preliminary analyses

Appendices E3 and E4 depict the descriptive data for all dependent variables. Only variables that generated sufficient data were included in the statistical analyses, namely: completion time, accomplishment score, total errors, omissions, commissions, compatible substitutions, incompatible substitutions, non-verbal checks, schema checks, reflective implementations and practical checks.

We explored possible order of condition effects (e.g. verbal-observed, observed-verbal) on our dependent variables, prior to the main analyses. ANOVAs, with order of condition as the between-subjects factor, revealed that the verbal-observed order generated better on accomplishment, omissions, and total errors (all *p*s $< .05$). There were, however, no trial x condition x order-of-condition, condition x order-of-condition and no trial x order-of-condition interactions (all *p*s $> .05$) and so order was not considered further.

2.5.2.4.3 Tea-making accomplishment score and completion time

There were no significant main effects of condition or trial on accomplishment score (all *p*s > .05), but there was a significant condition x trial interaction, $F(1, 18) = 8.60$, $p = .01$, $r = .57$, as can be seen in Figure 4a.1. In the observed condition, participants' accomplishment score increased significantly from trial 1 to trial 3, $F(1, 18) = 5.98$, $p = .03$, $r = .50$, whilst in the verbal condition there was no change ($p > .05$). Although there was no significant difference between the conditions in the first trial ($p > .05$), by the third trial participants accomplished significantly more in the observed condition than in the verbal condition, $F(1, 18) = 5.58$, $p = .03$, $r = .49$.

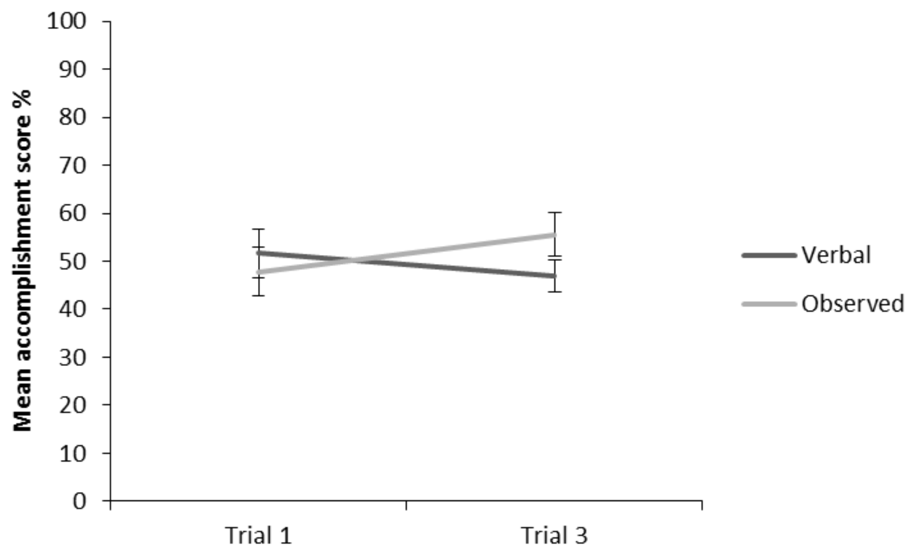


Figure 4a.1. Mean accomplishment scores (%) in trials 1 and 3 in each condition and standard error of the mean bars.

There was a condition x trial interaction effect on completion time, $F(1, 18) = 11.00$, $p < .001$, $r = .62$, and main effects of condition, $F(1, 18) = 9.43$, $p = .01$, $r = .59$, and trial, $F(1, 18) = 13.86$, $p < .001$, $r = .66$: participants were quicker to complete the task in the observed condition, than the verbal condition overall. In the verbal condition participants speeded up with increased trials, whereas in the observed condition they were consistently fast (see Figure 4a.2).

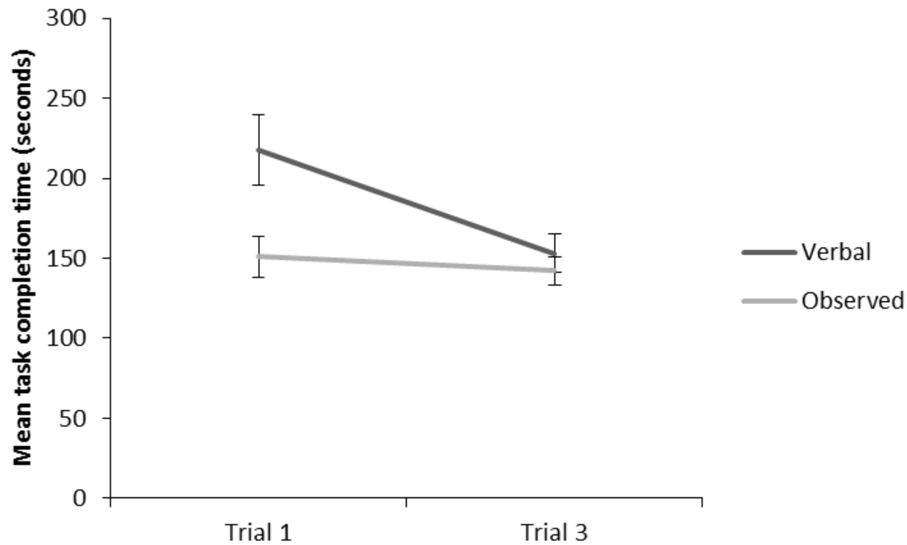


Figure 4a.2. Mean task completion time (in seconds) in trials 1 and 3 in each condition and standard error of the mean bars.

2.5.2.4.4 Errors

Total errors. There was no significant condition x trial interaction effect and no main effect of trial on total errors ($p > .05$), but there was a significant main effect of condition, with significantly more errors in the verbal condition than the observed condition, $F(1, 18) = 4.42$, $p = .05$, $r = .44$ (medium effect size), as can be seen in Figure 4a.3.

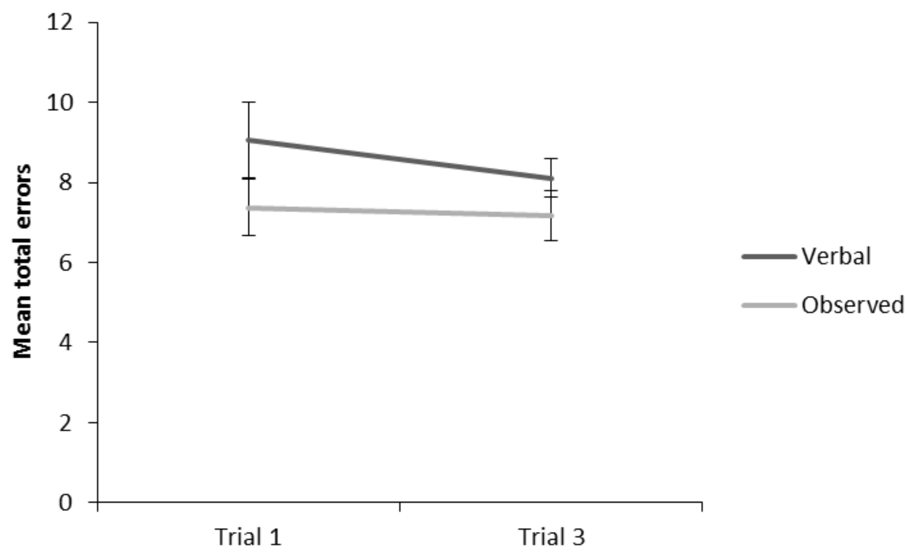


Figure 4a.3. Mean total errors in trials 1 and 3 in each condition and standard error of the mean bars.

Omissions. There was no significant condition x trial interaction and no significant main effect of condition on omissions (all *p*s > .05), but there was a significant main effect of trial, *F*(1, 18) = 4.65, *p* = .05, *r* = .45, with omissions decreasing from trial 1 to trial 3.

Commissions. There was a non-significant main effect of condition on commissions, *F*(1, 18) = 3.55, *p* = .08, *r* = .41 (with a medium effect size), indicating more commissions in the verbal condition than the observed. However, there was no significant condition x trial interaction and no main effect of trial on commissions (all *p*s > .05).

Compatible and incompatible substitutions. There was a non-significant trend (with a medium effect size) for a condition x trial interaction effect on compatible substitutions, *F*(1, 18) = 3.83, *p* = .07, *r* = .42, with participants' compatible substitutions reducing from trial 1 to trial 3 in the observed condition, but not in the verbal condition. However, there were no main effects of condition or trial (all *p*s > .05). Similarly, incompatible substitutions yielded no significant results and there were comparable numbers of compatible and incompatible substitutions, regardless of condition or trial (all *p*s > .05).

2.5.2.4.5 Error-monitoring

There was a non-significant trend for a condition x trial interaction effect on schema checks, $F(1, 18) = 3.19$, $p = .09$, $r = .39$, a significant main effect of trial on schema checks, $F(1, 18) = 7.66$, $p = .01$, $r = .55$, but no significant effect of condition ($p > .05$): schema checks reduced significantly across trials, and this decline was steeper for the verbal condition; schema checks in the observed condition remained relatively low across trials. There was no significant condition x trial interaction on reflective implementations ($p > .05$); there was a significant main effect of trial, $F(1, 18) = 6.45$, $p = .02$, $r = .51$, with reflective implementations decreasing across trials, and a non-significant trend for participants to make more reflective implementations in the verbal than in the observed condition, $F(1, 18) = 3.91$, $p = .06$, $r = .42$. Practical checks yielded no significant condition x trial interaction ($p > .05$), but there was a significant main effect of trial, $F(1, 18) = 5.43$, $p = .03$, $r = .48$ and a significant main effect of condition, $F(1, 18) = 10.21$, $p = .01$, $r = .60$: practical checks decreased across trials for both conditions, but occurred mostly in the verbal condition. There was no significant effect of condition, trial or condition x trial interaction on non-verbal checks (all *p*s > .05).

2.5.2.4.6 Correlations with neuropsychological measures

Studies have shown that omissions are normally associated with measures of episodic memory and global cognitive functioning, whilst commissions are associated with measures of working memory and executive functioning (Giovannetti et al., 2008, 2012; Seidel et al., 2013). In order to determine whether episodic memory and executive control were associated with total number of omissions and commissions, respectively, Pearson's *r* correlations were performed on the following cognitive measures: MMSE, word recall, Trails B/A (higher ratios indicated worse executive functioning), FAS, Map TEA, and DSST. Higher word recall, indicating better episodic memory, was associated with fewer omissions in the observed condition only, at a trend level, $r = -.37$, $p = .06$. Lower MMSE scores, indicating poorer cognitive status, were associated with higher commissions in both conditions (verbal: $r = -.68$, $p < .001$; observed: $r = -.45$, $p = .03$). Higher DSST scores, indicating better speed of processing, were associated with fewer commissions in the verbal condition only, $r = -.38$, $p = .05$, whilst higher FAS scores, indicating better executive functioning, were associated with fewer omissions in the verbal condition, $r = -.48$, $p = .02$. Trails B/A and Map TEA, measuring executive functioning and sustained attention respectively, did not correlate with omissions or commissions (all *p*s >.05).

2.5.2.5 Discussion

Observational learning, but not verbal instruction, improved the accomplishment scores of our participants over three trials. In addition, our volunteers made significantly fewer errors and were quicker at completing the task after *observing* the task steps than they did after *listening* to the step-by-step instructions. Notably, no volunteers achieved one hundred percent performance on the novel tea-making task. It is possible that we may have seen an increased benefit from observational learning if there had been more trials, though this has to be balanced against potential fatigue effects. Additionally, it is unclear whether the observational learning benefits that we observed in this study would be retained over time. Ultimately, this would be vital if we are to inform a potential intervention. To establish the extent and value of observational learning, we extended the study in a small group of volunteers who participated in the first phase, to examine the longer term benefits that might accrue through observational learning of an everyday task in people with dementia. In a follow-up study we examined observational learning over 6 weeks in three participants with DAT.

2.5.3 Study 4b - Can observational learning facilitate further learning over time in people with dementia? A pilot study.

2.5.3.1 Introduction

In order for an intervention to be of clinical and practical significance it is essential for it to work beyond the initial training stage. Evidence shows that memory rehabilitation in people with DAT can indeed be effective (De Vreese, Neri, Fioravanti, Belloi, & Zanetti, 2001). To our knowledge the long-term effects of observational learning have not been investigated. Therefore, the current study followed a subset of participants from the previous study with three additional sessions of observational learning over a period of 6 weeks. The additional sessions not only tested the residual memory of the previous observational leaning sessions, but they also retrained the same tea-making routine each time. *Savings* in relearning might provide a more sensitive measure of the impact of observational learning.

2.5.3.2 Methods

2.5.3.2.1 Participants

Only two male participants from the previous study volunteered to receive further visits. A third male participant was recruited from a local memory clinic. All three participants had been involved with the research team for over 3 years; thus, a relationship had already been established with the participants, that might optimise outcomes (Abrisqueta-gomez et al., 2004). See Table 4b.1 for participant demographics. Full informed consent was taken from all participants and their spouses (personal consultees).

Table 4b.1. Participant demographics and neuropsychological data.

Participant	Age	Sex	MMSE	Diagnosis	Anticholinesterase inhibitors	NART IQ
NL	88	Male	28	AD or mixed	None	123
DS	83	Male	23	AD	Aricept	118
DH	78	Male	21	AD	Aricept	126

2.5.3.2.2 Procedure and measures

All sessions took place at the participants' homes with their spouses present. The observed session from the previous study (which always followed the verbal session for all participants in this study) was used as baseline. All participants were given the MTT tea-making routine to learn (routine 2, see Appendix E1; baseline session). Two days later, participants received another observed session (session 1), but this time they had a residual trial prior to the three learning trials. The residual trial tested their memory of the tea-making routine from the prior session, before volunteers were retrained on the routine again. Two days later, the same procedure was repeated (session 2). Four weeks after session 2, the final session (session 3) was administered with exactly the same format as sessions 1 and 2. All tea-making trials were filmed for subsequent coding using the same coding scheme as before (Appendices E2 and A3).

2.5.3.3 Data Analysis

The accomplishment score, total errors and completion time provided our indicators of learning. For the baseline session, trials 1 and 3 are reported. For the remaining sessions only the residual trial and trial 3 are reported. Due to the case-study nature of this study, this data is reported descriptively only. The full dataset is reported in Appendix F.

2.5.3.4 Results

Participant DS was unavailable for session 3 due to unforeseen circumstances; thus, his data only includes baseline, and sessions 1-2.

2.5.3.4.1 Accomplishment scores

DS accomplished substantially less than the other two participants throughout the study. Baseline accomplishment scores were relatively high for all three participants (trial 1: *M* = 69.70%, *SD* = 13.89; trial 3: *M* = 72.73%, *SD* = 24.05), compared to the average scores in the group data from the observed condition of the previous study (trial 1: *M* = 47.85%, *SD* = 22.24; trial 3: *M* = 55.50%; *SD* = 22.24). Participants' accomplishment scores overall appeared relatively stable over time (see Figure 4b.1).

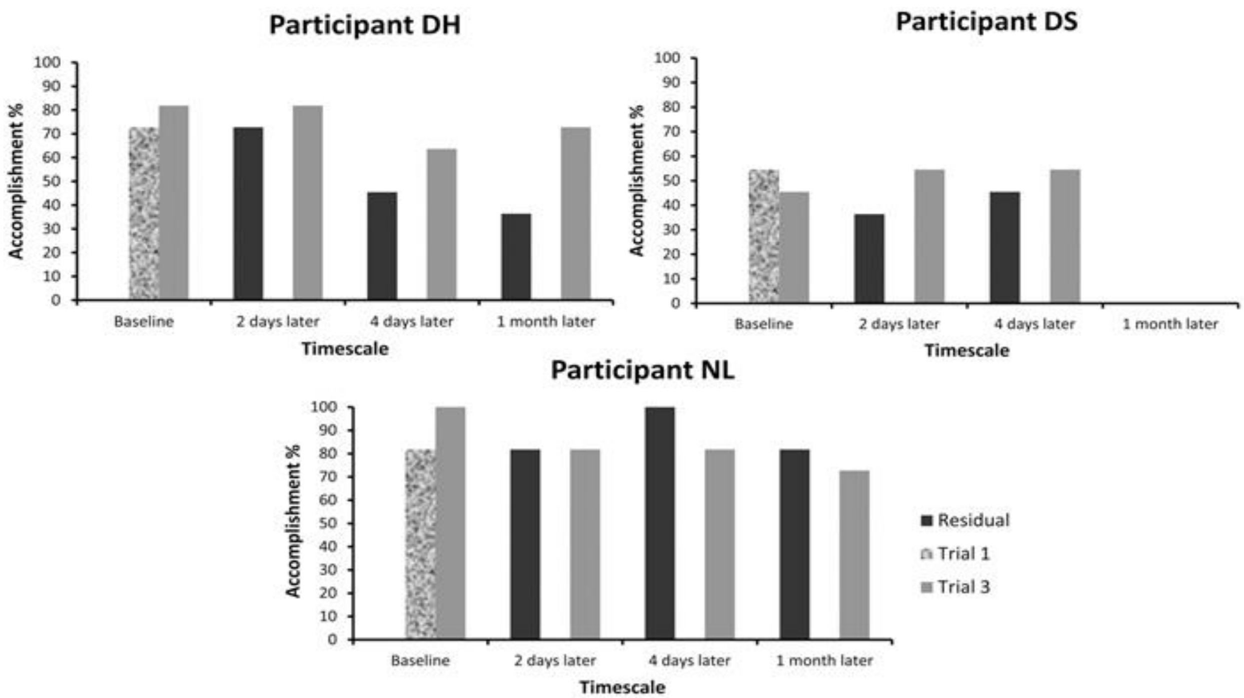


Figure 4b.1. Individual accomplishment scores across sessions. Baseline sessions on the figure depict the first (trial 1) and the last (trial 3) trial of the first acquisition session; follow-up sessions depict the residual trial (test for residual memory) and final relearning trials (trial 3).

2.5.3.4.2 Total errors

Participant DS made substantially more errors than the other participants. For all participants, within each session, total errors reduced in trial 3 compared to earlier trials. More long term, however, there appears to be no substantial change in total numbers of errors (see Figure 4b.2).

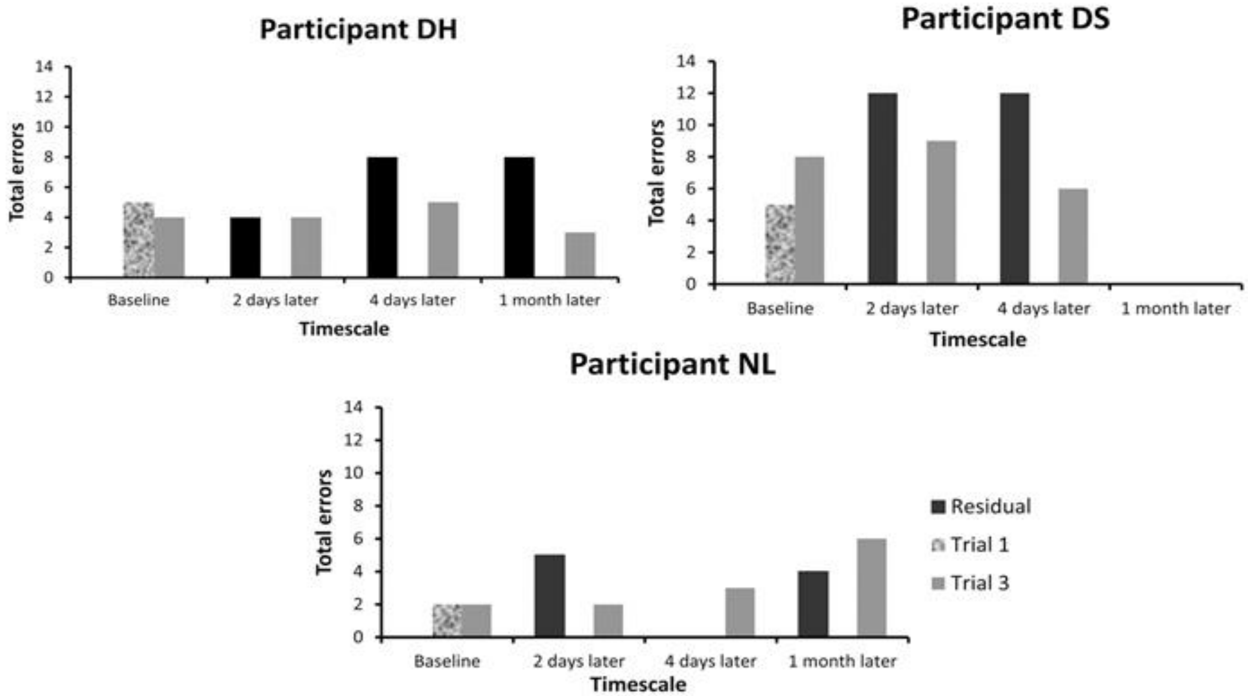


Figure 4b.2. Individual total errors across sessions. Baseline sessions on the figure depict the first (trial 1) and the last (trial 3) trial of the first acquisition session; follow-up sessions depict the residual trial (test for residual memory) and final relearning trials (trial 3).

2.5.3.4.3 Completion time

DS took substantially longer to complete the MTT than the other two participants overall. Within each session, participants completed the MMT more quickly in the third trial compared to earlier trials. More long term, again, there appeared to be no change in completion time (see Figure 4b.3).

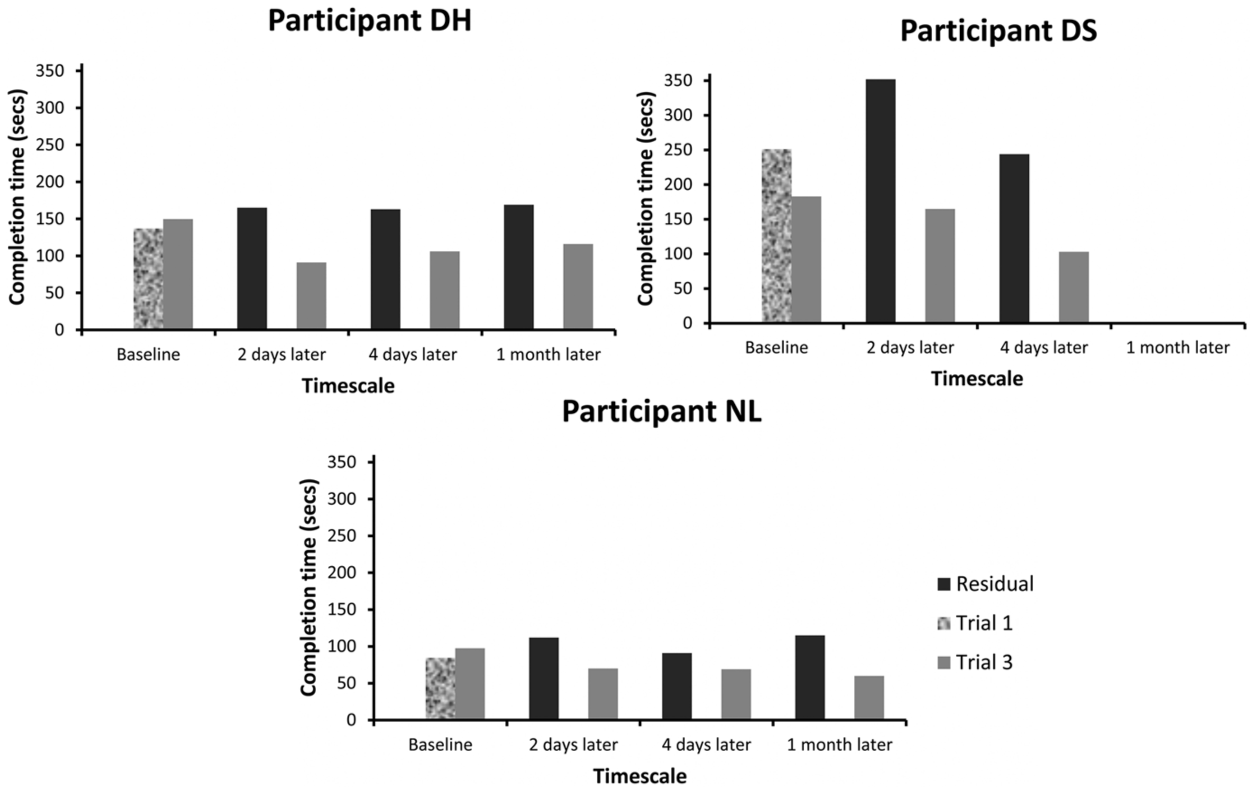


Figure 4b.3. Individual MTT completion time (seconds) across sessions. Baseline sessions on the figure depict the first (trial 1) and the last (trial 3) trial of the first acquisition session; follow-up sessions depict the residual trial (test for residual memory) and final relearning trials (trial 3).

2.5.3.5 Discussion

The results from the follow-up study indicated that, although observational learning improved task performance short term within each session with repeated trials, it did not continue to develop with repeated training sessions over a longer period of time. The routine that was learned at baseline appeared to be sustained over time. Therefore, although observational learning appears to be an improvement on verbal learning for people with dementia, acquisition of new learning is limited. This study followed only a small number of participants, however, and further investigation using large sample sizes may be useful.

2.5.4 General Discussion for *Studies 4a* and *4b*

Study 4a demonstrated that people with mild-moderate dementia were able to learn a novel everyday task better through observational learning, than through verbal instruction. The follow-up study showed that learning could be sustained, but could not be improved further, with further observational learning sessions. Previous work reported that observing a sequence of actions facilitates learning in healthy people (e.g. Cross et al., 2009). Only one study had previously tested the ability of people with dementia to learn an everyday task through observation (van Tilborg et al., 2011), and although found benefits from baseline, but no different from a verbal learning condition.

The limited amount of learning documented here is in line with previous findings showing that although performance can improve with several training sessions, it does not reach one hundred percent task accomplishment and is far below that of healthy adult learners (Dechamps et al., 2011; Lekeu et al., 2002; van Tilborg et al., 2011). Perhaps learning was impeded by the explicit nature of the observational learning session: our participants were made aware that they were required to remember the task and to reproduce the experimenter's routine. Previous research has demonstrated that people with dementia may profit more from implicit or procedural learning techniques, where skills are mastered without awareness, often through repeated exposure (Rösler et al., 2002; Zanetti et al., 2001). It is possible that more sessions and less explicit requirement may have facilitated learning in our volunteers.

A closer look at the types of errors in the observational condition revealed a trend for reduced commissions in the observed condition. Recent imaging studies associate commissions with age-related decline in executive control and working memory, and changes in white matter (WM) integrity. Omissions, in contrast, are associated with semantic and episodic memory impairments, and are predicted by hippocampal and cortical grey matter changes (Bailey et al., 2013; Giovannetti et al., 2008, 2012; Seidel et al., 2013). Since hippocampal damage is one of the earliest markers of dementia (Storey, Kinsella, & Slavin, 2001), omission errors may be difficult to target. Here we found that better episodic memory associated with fewer omissions, supporting previous research. Our measures of executive control, however, generated varying and inconsistent results: Speed of processing was associated with fewer commissions; whilst one measure of executive functioning was associated with fewer omissions and another was not associated with either omissions or commissions, and sustained attention yielded no significant correlations. Equally, global cognitive decline was associated with higher commissions, but not omission scores. These results suggest that the omission-commission model may not be as categorical as previous studies suggest (e.g. Giovannetti et al., 2008). Additionally, the mixed pattern of results observed here, may reflect mixed pathologies amongst our participants.

We explored also whether observational learning influenced the type of distractors that were selected, but found little support, within the limited number of trials used here, for an influence of object affordances on item selection. Although there was a trend for fewer compatible substitutions in the observed condition (reflected in the increase in accomplishment), the difference was not significant for either condition or trial. We can rule out that participants were simply selecting objects based on their proximity in relation to the participant, because the objects were rearranged from trial to trial. The lack of substantial difference, between the types of distractors selected, may have been due to the fact that both the compatible and incompatible distractors were both semantically similar to the target objects. Giovannetti et al. (2010) explored the impact of target-related distractors (visually and functionally similar to the target object) versus unrelated distractors in an everyday task in people with dementia and found that only target related distractors led to substitution errors. This suggests that the semantic relevance of the distractor may be more salient (especially for someone with impaired cognitive resources), than the minute actions required to use each type of distractor.

In terms of error-monitoring, there were very few corrections and microslips, suggesting that explicit awareness of errors was not improved by observation. This lack of error awareness replicated previous findings of individuals with dementia performing everyday tasks (Bettcher et al., 2008; Giovannetti et al., 2002b). Additionally, our participants made very few non-verbal checks across either condition. Verbal checks, in contrast, were more prominent in the verbal condition, perhaps reflecting the attempts of the volunteer to maintain the instructions in the verbal medium as they worked through the sequence.

A number of limitations are outlined here. Although, statistically significant differences were found between the verbal and observed conditions, errors were still high in both conditions. Therefore, it is unclear how much clinical significance an observational learning strategy might have. Previous studies that have aimed to improve everyday task performance in people with dementia have found similar results. For example, (Brennan et al., 2009) found that an intervention that used goal cues improved everyday task performance, but the improvement was not enough to shift from an impaired range of functioning. The clinical relevance of an observational learning strategy would need to be explored in further studies. Furthermore, in the follow up study, only the observational learning sessions were implemented, further verbal instruction sessions were not. Thus, it is unclear if further learning would have occurred with further verbal instruction sessions. It is unclear whether repeated exposure to the task or the observational learning was responsible for sustaining task performance over time. Concurrent verbal instruction sessions over time would have addressed this concern and this should be explored in future research. Finally, the subset of participants that were followed up had higher baseline accomplishment scores than the baseline scores of participants in the first study and this is reflected in their higher MMSE scores too. This seemingly higher functioning of the follow up participants may have been the primary reason for why their learning was sustained over time. Future research should explore the long term effects of observational learning in people with dementia who have a lower cognitive status and baseline performance is more substantially impaired, than the participants in the follow up study.

Notwithstanding these limitations, the current studies show that for people with dementia learning a novel everyday task, observational learning improved the proportion of task steps that were accomplished, and reduced both errors and completion time. These benefits appear to be limited – volunteers never reached hundred percent task completion with no errors - but these benefits were sustained over time with further training. Future research, should aim to measure the benefits of observational learning in a larger sample, with different tasks and taking into account the limitations outlined above. The results from this study suggest that observational learning may tap residual implicit learning capabilities and may provide opportunities for intervention for people with dementia that could assist and support their day-to-day lives.

3 General Discussion

In the General Introduction of this thesis I argued that although impairments in everyday functioning are a common feature in people with dementia, little is known about the minutia of everyday task impairments and how this changes over time in a developing dementia. Furthermore, evidence for benefits from interventions or behavioural strategies that aimed to improve everyday task performance was minimal. The overarching questions asked in this thesis were:

1. What is the evidence that people with dementia can effectively monitor for errors in everyday task performance and how does this change over time as dementia develops?

2. How can everyday task performance be improved in people with dementia?

3.1 What is the evidence that people with dementia can effectively monitor for errors in everyday task performance and how does this change over time as dementia develops?

In *Study 1* a novel everyday task and a comprehensive error and error-monitoring taxonomy was developed from previous research (Bettcher et al., 2008; Giovannetti et al., 2002b; Giovannetti et al., 2007b) incorporating novel categories of error-monitoring (verbal checks and non-verbal checks). The key finding of *Study 1* was that in conditions of increasing complexity that stretched cognitive resources, older adults performed just as well as young adults in terms of both error rates and error-monitoring. The pattern of errors in both groups supported previous studies of healthy people (Giovannetti et al., 2007a), where errors of commission dominate. Contrary to prediction, older adults did not perform like people with dementia, when cognitive resources were reduced by condition manipulation, providing little support for the resource theory (e.g. Schwartz, 2006). Furthermore, the new error-monitoring categories showed that older adults made more verbal checks than young adults in the easier, standard condition, but that this appeared to have no benefits on performance. This suggests that verbal checks may not play a role in maintaining task performance, but may serve a confidence function instead, but this notion was not tested in this thesis. Additionally task complexity increased microslips for both young and older adults, suggesting that in healthy ageing efficient error-monitoring is still intact, even when faced with reduced cognitive resources.

Using the error and error-monitoring taxonomy developed in *Study 1*, *Study 2* analysed error-monitoring in four people with dementia performing their own routine everyday task, using archived video footage from a five year study. This longitudinal case-study documented the error pattern and error-monitoring changes in mild through to severe stages of dementia. The key findings of *Study 2* were that the error pattern changed in response to dementia severity and that effective error-monitoring was rare throughout all stages of dementia. Although the participants with dementia gave the impression that they were error-monitoring (they 'checked' their performance long into the severe stage), this monitoring was superficial, because error correction was rare. The error pattern changed with dementia progression (commission errors dominated in the mild stage; omissions and commissions proliferated in the moderate to severe stages; action-additions – or off task commissions – were rare throughout), but this did not fully support the omissive-commissive model of everyday action impairment (Giovannetti et al., 2008a).

Whereas previous studies showed that people with dementia are impaired in error-monitoring in novel everyday tasks (Bettcher et al., 2008; Giovannetti et al., 2002a), *Study 2* showed that error-monitoring impairments extend to routine everyday tasks too. Furthermore, these results extend previous cross-sectional results that show error-monitoring impairment in the mild-moderate stage of dementia, providing evidence for error-monitoring impairments throughout all stages of dementia.

3.2 How can everyday task performance be improved in people with dementia?

Study 3a explored whether the requirement to instruct another person on how to perform an everyday task would improve recall of a routine everyday task and error-monitoring. In four participants with dementia, the key finding was that the recall of task steps in the instructed-recall condition was comparable to the performed-recall condition, and substantially better than the verbal-recall condition. However, error-monitoring did not improve with third person instruction. The results of this study implied that the presence of visual cues from a third person perspective were a contributing factor to the good performance in the instructed-recall condition. However, the impact of overt verbalising on the recall of the everyday task steps could not be ruled out. Thus, *Study 3b* explored the impact of a verbalisation strategy on everyday task performance in four participants with mild-moderate dementia. The key finding was that the verbal strategy had no impact on recall of the everyday task, errors or error-monitoring, but it did increase task duration. The results suggested that verbalising the task steps in *Study 3a* may not have been the primary contributor to everyday task recall in the instructed-recall condition, and may actually hinder performance (by lengthening execution time). However, the results of this study must be interpreted with caution because error rates overall were low in their routine everyday task performance. Nevertheless, although minimal, errors did occur, and were not eliminated by the verbal strategy.

Study 4a tested the impact of visual cues, specifically observational learning and the priming of target object affordances, on recalling a novel tea-making routine in people with mild-moderate dementia. The key finding of this study was that when participants were taught the tea-making routine through observational learning they recalled more of the task steps, made fewer errors and were quicker at performing the task, than when they were taught through verbal instruction. This was an important finding supporting the notion of a relatively intact mirror neuron system or action observation network in people with mild-moderate dementia, and has implications for interventions to help people with dementia perform everyday tasks. Observational learning, however, did not encourage error-monitoring or influence the types of distractors that were selected. Furthermore, although observational learning improved participant recall, the benefits were limited and significant performance deficits remained. Thus, in *Study 4b* further observational learning sessions were provided to a subset of participants from *Study 4a* over a period of six weeks to determine whether or not further learning could occur. The key finding was that although further learning did not occur, the amount of learning that occurred in the first session was sustained over time.

In summary, observational learning may be a viable strategy to improve everyday task performance in people with dementia, but further work is needed to assess the extent of potential benefits.

3.3 Theoretical implications

3.3.1 Theories of everyday action impairment

As reviewed in the General Introduction and in the Introduction of *Study 1*, there are two predominant theories of everyday action impairment: the resource theory and the omission-commission model. According to the resource theory (Schwartz et al., 1999; Schwartz, 2006), everyday action impairment reflects limitations in global cognitive capacity that can occur from brain damage/disease, normal ageing or distraction and conditions of high complexity in healthy adults. The resource theory makes predictions about the types of errors and error rates in relation to the severity of overall functioning: more errors occur with greater severity, particularly omissions; whereas in healthy people or in milder conditions error rates are low and these are mostly errors of commission. It also predicts that error patterns are the same across a variety of different neuropsychological profiles. In contrast, the omission-commission model predicts different error patterns for different neuropsychological profiles, specifically omissions reflect cognitive decline and episodic memory failures; commissions reflect poor executive control; and action-additions reflect the inability to inhibit actions from other tasks. This model particularly predicts a higher rate of omissions in people with dementia, due to episodic memory failures (Bailey et al., 2013; Giovannetti et al., 2008, 2012; Seidel et al., 2013).

Study 2 of this thesis builds on these two theories by providing evidence of everyday action impairment across all stages of dementia. The pattern of errors documented was that commissions were common in the mild stage and omissions rare, whilst in the moderate and severe stages of dementia omission and commission errors occurred in equivalent proportions. Action-additions were rare throughout all stages of dementia. The pattern of commissions dominating in the mild stage is consistent with the resource theory, however the resource theory would predict a greater dominance of omissions with greater dementia severity, and this was not observed. The results in this thesis also provide a challenge for the omission-commission model that also predicts more omissions in people with dementia. The participants in *Study 2* may have been atypical, with error patterns suggesting equivalent executive functioning and episodic memory decline throughout all stages of dementia. Unfortunately, one drawback of the archive data was that, a comprehensive neuropsychological evaluation was absent from the original data collection (Rusted & Sheppard, 2002); thus, associations between types of errors and different cognitive processes was not possible. Interestingly, action-additions were rare throughout all stages of dementia. If action-additions indicate an inability to inhibit other tasks (Giovannetti et al., 2012), then *Study 2* suggests that people with dementia do not have this problem and can be contrasted with action disorganisation syndrome, which produces many action-additions (e.g. Forde, Rusted, Mennie, Land, & Humphreys, 2010). In *Study 4a*, where neuropsychological evaluation was available for participants performing a novel everyday task, the error pattern observed was mostly errors of commission. Furthermore, better episodic memory associated with fewer omissions, supporting both the resource theory and omissive-commissive account.

Measures of executive control, however, generated varying and inconsistent results: Speed of processing was associated with fewer commissions; whilst one measure of executive functioning was associated with fewer omissions and another was not associated with either omissions or commissions, and sustained attention yielded no significant correlations. Global cognitive decline was associated with higher commissions, but not omission scores. These results provide little evidence for the omission-commission model, which may not be as categorical as previous studies suggest (Giovannetti et al., 2008). *Study 1* also tested the resource theory in healthy older adults, hypothesising that if errors increase with reduced cognitive capacity then this could be achieved in healthy older adults by manipulating task complexity. However, errors did not increase with task complexity and errors were mostly errors of commission – providing little support for the resource theory.

In summary, the resource theory and omission-commission model were not fully supported in this thesis and these may need to be adapted to better explain everyday action impairment in the severe stage of dementia. Regression analyses with larger numbers of participants could provide a clearer picture of the associations between different cognitive processes and everyday action impairment in a larger sample size (the power was too low for regression in this thesis).

3.3.2 Observational learning

In *Studies 4a* and *4b* the capacity to learn a novel everyday task through observation alone was tested in people with mild-moderate dementia. This is the first study to directly test this in people with dementia, and it demonstrated that people in mild-moderate dementia can recall a task better after observation, than after verbal instruction. This supports the literature that suggest observation facilitates learning of a motor skill by allowing the observer to determine the key spatial and/or temporal features of the task, and avoiding the need for creating a cognitive representation of the task through trial and error (Wulf, Shea, & Lewthwaite, 2010). Although, this thesis did not include neuroimaging methods, previous work has suggested the possibility that the action observation network is somewhat intact, when other more explicit memory systems are impaired, in mild to moderate dementia (Storey et al., 2001). However, *Study 4b* showed little evidence of further learning with repeated trials of observational learning, which suggests that observational learning, may have limited benefits in people with dementia.

3.4 Clinical implications

The research presented in this thesis has several clinical implications. The result that observing actions (*Studies 4a* and *4b)* was better for recalling a task in people with dementia than listening to step-by-step instructions has practical and real world implications. This knowledge could inform carers and health care professionals, such as occupational therapists, on an effective method for teaching everyday motor skills to people with dementia, through showing the individual step-by-step how to perform tasks, rather than telling him/her how to perform the task. Although, observation was more beneficial to memory than verbal instruction, it was not hundred percent effective in learning a novel task. Research has shown that handedness influences the learning of motor skills. Michel and Harkins (1985) tested the observational learning of a knot-tying task in both right- and left-handed participants observing either left or right-handed models. Participants who observed a same-handed model learned significantly faster than participants who observed an opposite-handed model. In another study, the observation of same-handed models performing a complex spatiotemporal task led to improved learning compared to the observation of opposite handed models (Rohbanfard & Proteau, 2011). It is possible that this may have influenced performance in our participants also, and this should be controlled for in a larger-scale replication.

The benefits of observational learning could be applied in cognitive prosthetic technology for everyday functioning in people with dementia. Intelligent assistive technology to compensate for memory impairments has been gaining rapid attention in recent years (see Jamieson, Cullen, McGee-Lennon, Brewster, & Evans, 2013, for a review). The performance of everyday tasks could be supported through technology that incorporates videos of task steps, for example. An assistive technology system, called COACH (a combination of audio and video cues that prompt people with dementia to assist them on hand washing) was piloted in smart homes of people with dementia (Mihailidis, Boger, Craig, & Hoey, 2008) and is continuingly being improved (Czarnuch & Mihailidis, 2012). Although, observational learning could be beneficial for clinical rehabilitative strategies, the individual's personality and desire to respond to intervention may play a more important role in the effectiveness of any intervention. Similarly, the results from *Study 3a* showed that overall the four participants with dementia responded differently to the verbal instruction condition. This further emphasises the individual differences of people with dementia, which would have an impact on the effectiveness of an everyday task intervention. Therefore, interventions designed to help people with dementia should be tailored to suit the needs, abilities and personality of each person with dementia.

3.5 Limitations

There were a number of limitations in the present PhD research, which have been addressed in the discussions of each study, and will be discussed here under four general themes: archive data, case-study design, novel versus routine everyday tasks and dementia diagnosis.

3.5.1 Archive data

The present thesis includes two studies based on archive data (*Studies 2* and *3a*). The key issue surrounding research that uses retrospective archive data is that it was collected to answer different research questions and test different hypotheses than the current research. While the studies reported here exploited unanalysed aspects of the archive data, the compromise was that the conditions were predetermined and additional conditions that may have more cleanly manipulated the elements under investigation were not an option.

Another limitation to the archive studies (*Studies 2* and *3a*) was that at the time of the original data collection (data were collected from 1990s) the diagnostic procedures for dementia were not as rigorous, and the study did not capture a full neuropsychological profile for its participants. The lack of detailed neuropsychological measures in these studies limited the extent to which inferences about the participants' change in cognitive status could be made and also limited the interpretation of their data in the context of theories of everyday action (e.g. resource theory and omission-commission model).

These limitations, however, are counterpoised by the rich, unique everyday task performance data that was acquired from four people with dementia over five years. There is no other study to date that has looked at everyday task performance in such detail over such a long period of time in people with dementia. Thus, this research provides a noteworthy contribution to the literature of everyday action in dementia, uniquely charting the longitudinal trajectory of the everyday tea-making routines in this group of people with dementia, which would not otherwise have been possible within the time-frame of a doctoral thesis.

3.5.2 Case-study design

The present thesis included four case-study papers (Studies, *2*, *3a*, *3b*, and *4b*). Case-study designs have a number of limitations: they are not necessarily generalizable to the wider population; the context specific knowledge they provide may not always be as valuable as general knowledge derived from large scale studies; and they are mostly useful for preliminary or pilot research in order to generate hypotheses (see Flyvbjerg, 2006, for a review of the criticisms). However, there appears to be a resurgence of case-studies in psychology (see Radley & Chamberlain, 2012; Shadish & Sullivan, 2011, for reviews), due to the recognition of the value of this particular methodology (Flyvbjerg, 2006; Hammond & Gast, 2010; Radley & Chamberlain, 2012; Shadish & Sullivan, 2011). The case-studies in this thesis provide rich, detailed data of a single everyday task. A single case-study is sufficient to falsify a hypothesis (Flyvbjerg, 2006; Popper, 2002), and *Study 3a* indeed contributed to model falsification. More importantly, the case-studies in this thesis illustrate clearly the individual differences in responding to cognitive strategies, which is crucial for cognitive intervention development. Large scale studies would wash out these individual differences, thus case-studies of this kind provide a significant adjunct to large scale studies. Finally, the case-study research in this thesis provided an important learning process for the author – an important objective for doctoral investigative research.

3.5.3 Novel versus routine tea-making tasks

In the thesis, both novel and routine tea-making tasks were used. In *Study 1* healthy older and young adults were tested on a novel tea-making task, otherwise the participants would have performed at ceiling in a routine everyday task (Giovannetti et al., 2007b). In the longitudinal case-studies of people with dementia (*Studies 2*, *3a* and *3b*), the participants' own tea-making routine performance was assessed, because the interest was in how performance changed with dementia progression and how potential behavioural strategies could halt deterioration in routine tasks. In *Studies 4a* and *4b*, a novel tea-making task was implemented for participants with mild-moderate dementia, to properly test capacity for acquisition of material under observational learning. However, it is important to acknowledge that different memory systems are responsible for recalling novel tasks and retrieving routine tasks, and future studies should consider whether data from novel learning can be properly applied to (re)learning of previously acquired routines.

3.5.4 Dementia diagnosis

Although every effort was made to recruit a homogenous dementia sample, this was very difficult due to the complexities with diagnosing the different sub-types of dementia and a high rate of comorbidity of DAT and VaD (Langa et al., 2004). As a result, *Studies 3b, 4a* and *4b* included participants with DAT, VaD and mixed dementia. This may have caused a problem due to differences in impairment between the different sub-types. For example, people with mixed dementia are reported to have significantly lower global cognitive functioning, attention and visuo-constructural ability than people with DAT (Dong et al., 2013). Similarly, people with VaD score differently on a number of executive functioning measures and better in episodic memory measures than people with DAT (Yuspeh, Vanderploeg, Crowell, & Mullan, 2002). This may have influenced the results in the studies that included heterogeneous samples, however, the sample size was too low to analyse group differences by dementia sub-type and most were participants with DAT. Future research should explore the differences in everyday task performance amongst different dementia sub-types. This may determine whether or not different dementia sub-types require different methods to help them with everyday tasks.

3.6 Future directions

In this thesis, small-scale pilot studies suggested potential strategies to help everyday task performance in people with dementia. Future work must test the impact of such strategies in longitudinal, large-scale, randomised control studies. A study to test the effects of an observational learning behavioural strategy could include teaching people with dementia an everyday task or motor skill that they have chosen to (re)learn. The personal significance of the task to be learned to the individual may promote learning further (Lam et al., 2010). Additionally, the priming of the actions required for target task objects could be further explored. In *Study 4a* the actions required to use the target objects were not primed sufficiently, hence substitution errors involving compatible distractors were rare. As discussed in *Study 4a*, this may have been due to the semantic similarities of the distractors to the target objects, making that more salient than the motor actions required to use each object. It would be interesting to explore whether observational learning could prime people with semantic dementia to select distractors (or indeed the target object) based on the actions required to use the objects, rather than their semantic relevance. This would have implications for everyday task (re)learning in people with semantic dementia.

Assistive technology that presents videos of task steps for participants is an area for development. Such technology could be tailored to each individual and could use actual footage of the individual with dementia performing the correct actions him/herself. This may encourage the individual to pay greater attention to the videos, may promote greater immersion into the task and the individual's own handedness, position and speed at which he/she performs the actions could be mapped for optimal efficacy. Audio cues may produce further benefit (Mihailidis et al., 2008) and could be used in conjunction.

3.7 Final conclusions

In conclusion, this thesis presented work exploring performance of an everyday task in people with dementia and documenting changes longitudinally. The research developed an error and error-monitoring taxonomy that incorporated error-monitoring categories that were not previously explored. The key findings were that people with dementia are surprisingly competent in their own routine tasks even in severe dementia; however, error-monitoring is rare even in the mild stage of dementia. Two strategies aimed at enhancing everyday task performance in people with dementia were explored. One of those strategies, observational learning, had promising results and the clinical implications of this has been discussed. The thesis makes an important contribution to research on everyday action impairment and cognitive-focused interventions in people with dementia.

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5 Appendices

5.1 Appendix A1: Table of objects used in TT

Table A1. Objects used in TT.

Object Type	Token 1 ('Jack')	Token 2 ('Jill')	Distractor objects
Water boiler	Silver kettle	White kettle	N/A
Water	Water from tap	Spring water from bottle	Apple juice
Cup	Travel mug	White mug	Glass
Tea	Earl Grey teabag	Tetley teabag	Coffee
Teapot	No teapot	With teapot	N/A
Tea-cosy	No Tea-cosy	With tea-cosy	Tea towel
Milk	With milk	No milk	Powder creamer
Sweetener	Sugar from a bowl (1 teaspoon)	Artificial sweetener (2 sweeteners)	Sugar lumps
Stirrer	Teaspoon	Wooden stirrer	Tablespoon
Biscuit	Chocolate chip cookie	Custard cream	Cake
Tray	Tray marked 'Jack'	Tray marked 'Jill'	N/A

5.2 Appendix A2: Table of error taxonomy

Table A2. Tea-making task error taxonomy.

Error category	Error type	Definition	Example
Commission	Perseveration	An action is performed a second time (or more) after it had already been performed.	Sugar added to the travel mug on two separate occasions
	Anticipation	Object is used before completing the necessary preceding steps.	Milk is put in travel mug before pouring the water.
	Quantity	Too much or too little of an object is used.	An excessive amount of sugar is put in cup, when only needed one teaspoon full.
	Substitution	Alternate object selected in place of target object.	Puts artificial sweetener into travel mug, instead of sugar; Puts sugar into white mug instead of artificial sweetener.
	Action addition	Additional step is performed	Artificial sweetener is put into travel mug as well as sugar.
Omission	Omission	A task step is never performed.	Does not add any sugar to travel mug.

5.3 Appendix A3: Table of error-monitoring taxonomy

Table A3. Error-monitoring taxonomy.

Error-monitoring variable	**Monitoring process**	**Description**	**Example**
Error correction			
	Correction	Individual rectifies an overt error immediately after the action or after a delay.	Adds water from tap to the kettle, instead of from the bottle, for Jill's cup of tea and then immediately empties the tap water to replace it with bottled spring water.
Microslips			
	Microslips	Initiation and termination of an incorrect action before the error is completed.	Picking up, but not using, the tablespoon, instead of the teaspoon.
Checking			
	Verbal	Verbalization indicating that the participant is checking or monitoring their progress.	"I'm just going to check I put the teabag in the cup."
	Non-verbal	A non-verbal gesture, which indicates that the participant is checking or monitoring their progress.	Physically checks the cup to see if he/she has put the teabag in the cup.

5.4 Appendix A4: Table of verbal monitoring coding guide

Table A4. Verbal monitoring coding guide.

Function	Description	Examples
Schema check	Any verbalization that indicates recalling or attempting to recall the task steps and/or task goal.	"I can't remember what Jack has in his tea..." "Did you say Jill has milk?"
Reflective implementations	Any verbalization that indicates reflecting, evaluating and planning the task at hand, but <u>doesn't include active attempt to retrieve task schema.</u>	"I've put sweeteners in Jill's cup." "I need to brew the teapot".
Practical checks	Any verbalization that indicates a need for a practical or technical clarification or a matter of fact statement.	"How do you switch this kettle on?" "Does the kettle switch off by itself?" "We've run out of teabags."

5.5 *Appendix A5: Study 1 correlation table*

Table A. Correlation table of neuropsychological measures and error/error monitoring variables.

Measures/variables	TMT ratio	DSST	Map-TEA
TMT ratio	1	-.11	-.03
DSST	-.11	1	.34**
Map TEA	-.03	.34**	1
Omissions in standard	.21	-.05	-.03
Commissions in standard	.17	-.30*	-.16
Omissions in dual	.07	-.25	-.16
Commissions in dual	.39**	-.16	.13
SC in standard	.05	-.08	-.07
RI in standard	.05	-.09	-.32*
PC in standard	.08	.09	.13
SC in dual	-.07	-.22	-.11
RI in dual	.05	-.11	-.29*
PC in dual	-.10	.27*	.19
Microslips in standard	.09	-.25	-.25
Microslips in dual	-.02	.10	-.08

* $p < .05$; ** $p < .01$; *** $p < .001$; all 2-tailed.
TMT ratio = Trails-B/Trails-A; DSST = Digit Symbol Substitution Test; Map-TEA = Map Test of Everyday Attention; SC = Schema check; RI = Reflective implementation; and PC = Practical check.

5.6 Appendix B1: Table of updated error taxonomy

Table B1. Error taxonomy

Error category	Error type	Definition	Example
Commission	Perseveration	An action is performed a second time (or more) after it had already been performed.	Sugar added to the cup on two separate occasions.
	Anticipation	Object is used before completing the necessary preceding steps.	Water is poured from kettle before switching on kettle to boil.
	Quantity	Too much or too little of an object is used.	An excessive amount of sugar is put in cup, when only needed one teaspoon full.
	Substitution	Alternate object selected in place of target object.	Coffee put into teapot instead of tea.
	Action-addition	Additional off task step is performed.	Gets cereal from cupboard and places in bowl.
	Location	Searches in incorrect/inappropriate place for a well-known item that is always kept in same location.	Searches for sugar in fridge.
	Replacement	Replaces an item that was just used in an inappropriate place.	Puts sugar into fridge after using it.
	Tool	Using a well-known tool/item incorrectly.	Unable to switch on kettle. Or uses knife to stir tea.
Omission	Omission	A task step is never performed.	Does not add any tea to cup.

5.7 Appendix B2: Table of updated error-monitoring taxonomy

Table B2. Error-monitoring taxonomy.

Error monitoring variable	**Monitoring process**	**Description**	**Example**
Error correction			
	Correction	Individual rectifies an overt error immediately after the action or after a delay.	Pours water into cup from kettle, before boiling water; then immediately pours the contents of cup out and boils the kettle before pouring boiled water into cup.
Microslips			
	Microslips	Initiation and termination of an incorrect action before the error is completed.	Picking up, but not using, the knife, instead of the teaspoon.
Checking			
	Verbal	Verbalization indicating that the participant is checking or monitoring their progress.	*See examples below*
	Verbal check categories		
	Schema check (SC)	Any verbalization that indicates recalling or attempting to recall the task steps and/or task goal.	"I can't remember what goes next..." "Did you want tea?"
	Reflective implementations (RI)	Any verbalization that indicates reflecting, evaluating and planning	"I've put sugar in the cup."

		the task at hand, but does not include active attempt to retrieve task schema.	"I need to brew the teapot".
	Practical checks (PC)	Any verbalization that indicates a need for a practical or technical clarification or a matter of fact statement.	"How do you switch this kettle on?" "Does the kettle switch off by itself?" "We've run out of teabags."
	Non-verbal	A non-verbal gesture, which indicates that the participant is checking or monitoring their progress.	Physically moves towards and looks in the cup to see if he/she has put the teabag in the cup.

5.8 Appendix B3: Accomplishment score guide for Study 2

Accomplishment score guide

Each participant's accomplishment score comprises the proportion of their personalized tea-making protocol that they are able to recall and perform correctly. Thus, for each correct action of the tea-making protocol that is carried out, the participant is rewarded with one credit. If participants make a commission error and never correct it then they do not get credited for the associated action. The following rules apply when calculating the accomplishment score:

Rules:

- Actions conducted in the wrong order do not affect the accomplishment score, but the anticipation remains.
- Perseverations that involve the correct action should be credited for that action, but the error is given.
- Uncorrected substitutions are not credited for the associated action.
- The participant is credited for any 'locate' action as long as they find what they are looking for, regardless of whether or not they made any location errors
- Replacement actions are not part of the protocol; thus, if an item is put in the wrong place this would not affect the accomplishment score, but the error still stands.
- If an action is completely omitted then the participant is not credited for that action.
- If an action involves an incorrect tool, then the participant is only credited if s/he later carries out the action with the correct tool.
- Action-additions are not counted in the accomplishment score.
- Actions that involve the wrong quantity of the item should be credited, but the error remains.

5.9 Appendix C1: Table of demographics and sessions in Study 3a

Table C1. Demographic data and the number of sessions per case-study.

Participant	Sex	Age at outset	Dates in study	MMSE at outset
AH	Male	71	Apr 1992-Sep 1994	17
TL	Male	67	Oct 1991-Apr 1994	19
DB	Female	81	April 1993-Nov 1994	15
FM	Male	83	Oct 1992-Sep 1997	18
		Number of sessions by DAT-stage		
Participant	**Mild**	**Mild-Moderate**	**Moderate**	**Severe**
AH	0	6	9	6
TL	0	3	4	0
DB	0	4	3	0

Number of sessions by year (FM was a control for time)

	Year 1	Year 2	Year 3	Year 4	Year 5
FM	4	3	4	4	5

5.10 Appendix C2. Table of error-monitoring taxonomy in Study 3a

Table C2. Error-monitoring taxonomy.*

Error monitoring process	**Description**	**Example**
Verbal checks	Verbalization indicating that the participant is checking or monitoring their progress.	**In performed-recall condition:** "I'm just going to check I put the teabag in the cup." **In instructed-recall condition:** *To the experimenter* "Did you put the teabag in the cup?"
Non-verbal checks	A non-verbal gesture, which indicates that the participant is checking or monitoring their progress. In the instructed-recall condition this physical gesture should NOT include the participant moving/touching the task objects.	**In performed-recall condition:** Physically checks the cup to see if he/she has put the teabag in the cup. **In instructed-recall condition:** Moves toward and looks at task progress, but does not touch/move objects.
Intervention *(in instructed-recall condition only*)	Participant gets up from seat and physically intervenes with the task, by carrying out task actions him/herself, rather than instructing.	Instead of telling experimenter to locate cup, he gets up from seat and opens the cupboard and retrieves the cup him/herself.

Rules for coding interventions:

1. Only code as an intervention if the action is related to the protocol.
2. Do not include repetitions of actions already performed by experimenter.
3. Do not include actions that the participant later instructs the experimenter to carry out.
4. Several interventions involving the same action are only coded once.
5. Interventions do not include verbal/non-verbal checks.
6. Interventions can include corrections, but not microslips.

7. Interventions cannot be substitutions or action-additions, but the errors still remain.

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*The full error-monitoring taxonomy is reported elsewhere (Balouch & Rusted, 2013, 2014); only additional categories related to the instructed-recall condition are described here.

5.11 Appendix C3: Table of error and error-monitoring descriptive data in Study 3a

Table C3. Means (and standard deviations) of error and error-monitoring categories of substantial data in each case-study.

	Errors			Error-monitoring	
	Omissions	**Commissions**	**Anticipations**	**Non-verbal checks**	**Verbal checks**
AH					
Mild-moderate (n = 6)					
Performed-recall	0.33 (0.82)	1.50 (1.23)	0.67 (0.82)	1.67 (2.25)	6.50 (2.35)
Instructed-recall	1.50 (1.23)	2.00 (1.90)	1.50 (1.52)	0.67 (.82)	2.83 (2.86)
Moderate (n = 9)					
Performed-recall	2.44 (2.13)	2.22 (2.78)	0.33 (.50)	2.67 (2.00)	3.33 (2.06)
Instructed-recall	0.56 (1.33)	2.67 (1.94)	1.78 (1.48)	0.67 (0.87)	3.67 (2.06)
Severe (n = 6)					
Performed-recall	3.50 (3.21)	1.67 (1.21)	0.33 (.21)	1.50 (1.05)	5.67 (3.78)
Instructed-recall	2.50 (.55)	4.00 (1.79)	0.83 (.98)	0.33 (.52)	2.83 (1.73)
TL					
Mild-moderate (n = 3)					
Performed-recall	0.00 (0.00)	0.33 (0.58)	0.33 (0.58)	2.67 (3.79)	6.33 (1.16)
Instructed-recall	2.67 (1.53)	1.00 (0.00)	0.67 (0.58)	0.67 (0.58)	4.67 (3.79)
Moderate (n = 4)					
Performed-recall	1.75 (1.26)	0.75 (0.96)	0.00 (0.00)	4.50 (2.08)	4.50 (3.70)
Instructed-recall	6.00 (1.83)	3.25 (0.96)	1.25 (0.96)	1.00 (2.00)	1.00 (0.82)
DB					

Mild-moderate (n = 4)					
Performed-recall	1.00 (1.16)	2.50 (3.32)	0.00 (0.00)	0.25 (0.50)	7.25 (4.27)
Instructed-recall	0.50 (0.58)	1.00 (1.16)	0.50 (1.00)	0.50 (.58)	8.00 (2.59)
Moderate (n = 3)					
Performed-recall	0.00 (0.00)	0.67 (1.16)	0.00 (0.00)	1.67 (1.16)	7.67 (3.22)
Instructed-recall	2.33 (2.08)	3.33 (3.51)	0.67 (0.58)	1.00 (1.00)	9.67 (6.43)
FM					
Year 1 (n = 4)					
Performed-recall	0.00 (0.00)	1.50 (1.73)	0.00 (0.00)	2.75 (2.75)	6.00 (4.08)
Instructed-recall	1.00 (0.82)	2.75 (2.22)	0.75 (0.96)	0.75 (0.96)	4.25 (2.63)
Year 2 (n = 3)					
Performed-recall	0.00 (0.00)	4.33 (2.08)	0.67 (0.58)	3.67 (1.16)	10.00 (3.46)
Instructed-recall	1.00 (1.73)	1.33 (0.58)	0.33 (0.58)	0.33 (0.58)	3.33 (1.53)
Year 3 (n = 4)					
Performed-recall	0.00 (0.00)	4.75 (2.22)	0.75 (0.96)	4.50 (1.73)	11.25 (6.08)
Instructed-recall	0.75 (0.96)	3.00 (1.83)	0.25 (0.50)	1.25 (1.26)	4.50 (1.00)
Year 4 (n = 4)					
Performed-recall	0.00 (0.00)	5.75 (2.63)	1.00 (0.82)	5.50 (1.29)	12.00 (2.94)
Instructed-recall	0.50 (1.00)	5.25 (1.26)	0.75 (0.50)	4.50 (2.65)	8.00 (3.37)
Year 5 (n = 5)					
Performed-recall	0.20 (0.45)	4.20 (4.92)	2.00 (0.45)	2.20 (1.64)	13.20 (2.95)
Instructed-recall	0.40 (0.89)	6.40 (0.89)	0.80 (0.84)	1.80 (1.31)	5.80 (1.64)

5.12 Appendix D: Table of measures used in Study 3b

Table D. Measures used in *Study 3b*.

Measure	Reference	Construct measured	Scoring	Time administered
National Adult Reading Test (NART).	(Nelson, 1982)	Estimate of pre-morbid full-scale IQ.	Number of errors inserted into equation. Score range: 50 (low intelligence) – 131 (high intelligence)	Outset of study.
Mini Mental State Examination (MMSE).	(M F Folstein et al., 1975)	Global cognitive functioning.	Mild 20-26 Moderate 10-20 Severe <10	Every session.
FAS test.	(Spreen & Strauss, 1998)	Executive functioning.	Sum of correct words for each letter.	Six monthly sessions.
Digit Symbol Substitution Test (DSST).	(Wechsler, 1987)	Speed of processing.	Number of correct substitutions in 90 seconds. Score range: 0-100.	Six monthly sessions.
Word recall.	(J. M. Rusted & Warburton, 1992)	Episodic memory.	Number of correct words immediately recalled. Score range: 0-10.	Six monthly sessions.
Map Test of Everyday Attention (Map-TEA).	(Robertson et al., 1996)	Sustained attention.	Number of correct targets identified. Raw score range: 0-80.	Six monthly sessions.
The Cognitive Failures	(Broadbent et al.,	Self-reported failures	Score range: 0	Six monthly

Questionnaire (CFQ).	1982)	in perception, memory and motor function.	(no cognitive failures) -100 (high cognitive failures).	sessions.
Lawton Instrumental Activities of Daily Living (IADL) scale.	(Lawton & Brody, 1969)	Ability to carry out IADLs.	Score range: 0 (low functioning, dependent) - 7 (high functioning, independent).	Six monthly sessions.
Quality of Life in Alzheimer's Disease (QOL-AD)	(Logsdon et al., 1999)	Quality of life (patient report used only, not caregiver report)	Score range: 13 (low QOL) -52 (high QOL).	Six monthly sessions.

5.13 Appendix E1: Modified Tea-making Task guide used in Studies 4a and 4b

Modified Tea-making Task (MTT) guide

Outline

The MTT requires the participant to learn two novel tea-making routines - see Table E1.1: one under a verbal condition (instructions are verbalized) and the other under an observed condition (instructions are performed). In both conditions, the participant is presented with an array of objects for making tea on a worktop or table in a kitchen setting and knowledge of the objects is checked prior to the task commencing. The participant must remember these instructions and make the tea according to those instructions immediately following the instructions.

Each participant performs three trials in each condition to assess learning over time. Once the instructions are given, the experimenter does not remind participants of the instructions during the task. If participants ask the experimenter for reminders of the tea-making routine, the experimenter uses prompts such as: "Just do what you can remember from my instructions".

The layout of the task objects is randomised for each trial (see Tables E1.2 and E1.3) to ensure that learning derives from mode of instructions (verbal or observed) and not recall or proximity of object location. There are two parallel tea-making routines, one for each condition to avoid practice effects from condition to condition. For each tea-making routine there are 9 target objects, 5 of these match distractor objects (one compatible distractor and one incompatible distractor) making a total 10 distractor objects in each routine (see Tables E1.4 and E1.5). The compatible distractor shares the same action or hand gesture to use/lift/grip as the target item (e.g. the same action is required to lift two different colour cups of equal proportion and shape). In contrast, an incompatible distractor requires a different action or hand gesture to use than the target object (e.g. a different hand gesture would be required for two cups of varying size).

The following depicts how the objects should be arranged in each trial of each routine, this is followed by the instructions that the experimenter gives to the participant for each condition and a finally list of prompts that the experimenter must use as stated.

Table E1.1. MTT routines.

Routine 1	Routine 2
Kettle is pre-filled and pre-boiled by the experimenter to avoid waiting time.	
1. Switch on the kettle	1. Switch on the kettle
2. Open the Assam tea box by lifting the flap	2. Open the Darjeeling tea box by lifting the flap
3. Put one Assam teabag in the small bluebell cup	3. Put one Darjeeling teabag in the big red poppy cup
4. When the water has boiled, pour the boiled water onto the teabag	4. When the water has boiled, pour the boiled water onto the teabag
5. With the teaspoon remove the teabag and place it in the teabag dish	5. With the teaspoon remove the teabag and place it in teabag dish
6. Add some whole milk from the carton	6. Add some semi-skimmed milk from the jug
7. Add one teaspoon full of white sugar	7. Add one brown sugar lump
8. Stir the tea	8. Stir the tea
9. Put the cup of tea on the serving tray	9. Put the cup of tea on the serving tray
10. Take one chocolate chip cookie out of the bag	10. Take one custard cream biscuit from the jar by twisting the lid
11. Place the chocolate chip cookie on the serving tray.	11. Place the custard cream on the serving tray.

Table E1.2. Arrangement of MMT objects in Routine 1 for each trial

Trial 1:						
Kettle	Custard creams in bag	Assam teabag in box	Whole milk in jug	Small bluebell cup	White sugar lumps in bowl	Serving tray
Whole milk in carton	Lady Grey teabag in caddy	Small red poppy cup	White sugar in bowl	Semi-skimmed milk in carton	Teabag dish	
Ginger nut biscuits in jar	Brown sugar in bowl	Chocolate chip cookies in bag	Big bluebell cup	Teaspoon	Darjeeling teabag in box	
Trial 2:						
Kettle	Ginger nut biscuits in jar	Assam teabag in box	Whole milk in carton	Small red poppy cup	White sugar in bowl	Serving tray
Semi-skimmed milk in carton	Darjeeling teabag in box	Big bluebell cup	Brown sugar in bowl	Whole milk in jug	Teabag dish	
Chocolate chip cookies in bag	White sugar lumps in bowl	Custard creams in bag	Small bluebell cup	Teaspoon	Lady Grey teabag in caddy	
Trial 3:						
Kettle	Darjeeling teabag in box	Chocolate chip cookies in bag	Semi-skimmed milk in carton	Big bluebell cup	Brown sugar in bowl	Serving tray
Whole milk in jug	Assam teabag in box	Small bluebell cup	White sugar lumps in bowl	Whole milk in carton	Teabag dish	
Custard creams in bag	White sugar in bowl	Ginger nut biscuits in jar	Small red poppy cup	Teaspoon	Lady Grey teabag in caddy	

Table E1.3. Arrangement of MTT objects in Routine 2 for each trial

Trial 1:						
Kettle	Ginger nut biscuits in jar	Darjeeling teabag in box	Semi-skimmed milk in carton	Big red poppy cup	Brown sugar in bowl	Serving tray
Semi-skimmed milk in jug	Assam teabag in caddy	Big bluebell cup	Brown sugar lumps in bowl	Whole milk in jug	Teabag dish	
Chocolate chip cookies in bag	White sugar lumps	Custard creams in jar	Small red poppy cup	Teaspoon	Lady Grey teabag in box	
Trial 2:						
Kettle	Chocolate chip cookies in bag	Darjeeling teabag in box	Semi-skimmed milk in jug	Big bluebell cup	Brown sugar lumps in bowl	Serving tray
Whole milk in jug	Lady Grey teabag in box	Small red poppy cup	White sugar lumps	Semi-skimmed milk in carton	Teabag dish	
Custard creams in jar	Brown sugar in bowl	Ginger nut biscuits in jar	Big red poppy cup	Teaspoon	Assam teabag in caddy	
Trial 3:						
Kettle	Lady Grey teabag in box	Custard creams in jar	Whole milk in jug	Small red poppy cup	White sugar lumps	Serving tray
Semi-skimmed milk in carton	Darjeeling teabag in box	Big red poppy cup	Brown sugar in bowl	Semi-skimmed milk in jug	Teabag dish	
Ginger nut biscuits in jar	Brown sugar lumps in bowl	Chocolate chip cookies in bag	Big bluebell cup	Teaspoon	Assam teabag in caddy	

Table E1.4. Objects in Routine 1.

Object type	Target objects	Compatible distractors (same action)	Incompatible distractors (different action)
Kettle	Prefilled & pre-boiled kettle	None	None
Cup	Small bluebell cup	Small red poppy cup	Big bluebell cup
Tea	Assam teabag in box	Darjeeling teabag in box	Lady Grey teabag in caddy
Milk	Whole milk in carton	Semi-skimmed milk in carton	Whole milk in jug
Sweetener	White sugar in bowl (one teaspoon full)	Brown sugar in bowl	White sugar lumps in bowl
Stirrer	Teaspoon	None	None
Teabag dish	Teabag dish	None	None
Biscuit	Choc-chip cookies in bag (one)	Custard creams in bag	Ginger nut biscuits in jar
Serving tray	Serving tray	None	None

Table E1.5. Objects in Routine 2.

Object type	Target objects	Compatible distractors (same action)	Incompatible distractors (different action)
Kettle	Prefilled & pre-boiled kettle	None	None
Cup	Big red poppy cup	Big bluebell cup	Small red poppy cup
Tea	Darjeeling teabag in box	Lady Grey teabag in box	Assam teabag in caddy
Milk	Semi-skimmed milk in jug	Whole milk in jug	Semi-skimmed milk in carton
Sweetener	Brown sugar lumps in bowl (one lump)	White sugar lumps in bowl	Brown sugar in bowl
Stirrer	Teaspoon	None	None
Teabag dish	Teabag dish	None	None
Biscuit	Custard creams in jar (one)	Ginger nut biscuits in jar	Chocolate chip cookies in bag
Serving tray	Serving tray	None	None

Instructions to participants (verbal condition)

“First of all can you name all the objects on the worktop for me please?

The aim of this task is for you to make me a cup of tea exactly as I like it.

I’m going to tell you how I like my tea and I want you to make the cup exactly according to my step by step instructions. Once you start making the tea, I won’t be able to remind you of the instructions.

You may need to have more than one go at it, to get it exactly right, so we will go over the routine three times in total.

Please remember that you are not allowed to touch anything until you actually need to use it.

Please can you repeat what I just said, so that I know you’ve understood the instructions?
Do you have any questions so far?

Now I’m going to tell you the step-by-step instructions on how to make the tea. Listen to me carefully.”

(*Now the experimenter reads the instructions of one of the routines exactly as it is worded in Table A1. The experimenter must point and touch target objects with a pen as the instructions for those items are spoken. The experimenter must allow a two second gap between verbalizing each step.*)

Instructions to participants (observed condition)

“First of all can you name all the objects on the worktop for me please?

The aim of this task is for you to make me a cup of tea exactly as I like it.

I’m going to show you how I like my tea and then you will need to make the cup in exactly the same way as I made it. Once you start making the tea, I won’t be able to remind you of how I made the tea.

You may need to have more than one go at it, to get it exactly right, so we will go over the routine three times in total.

Please remember that you are not allowed to touch anything until you actually need to use it.

Please can you repeat what I just said, so that I know you've understood the instructions?
Do you have any questions so far?

Now I'm going to show you step-by-step how to make my tea. Watch me carefully."

(*Now the experimenter fully performs each action of one of the routines without verbalizing the actions.)*

Prompts

For the verbal condition:

- If participant is not listening to instructions, then say: "You need to listen carefully."
- Whilst instructions are being read, if participant asks "which one did you say?" Then point to the item again and reiterate the name of the item.

In observed condition:

- If participant looks like they are not watching the task whilst showing them the actions, then say: "You need to watch me carefully".
- In observed condition when experimenter is performing, if participant asks: "Which one did you use?" Then you can point to the target item and say "this one", but do not say "I used the Assam teabag" (for instance).

When participant is performing:

- If they ask for reminders or they say they cannot remember, then simply say: "Just do what you can remember from my instructions" (for verbal condition) or "Just do what you can remember from when I made it" (for observed condition).
- If participant moves items around to help them remember before the task has begun, then say: "Remember, you must not touch items until you need to use them".

5.14 Appendix E2: Table of error-monitoring taxonomy used in Studies 4a and 4b

Table E2. Error taxonomy

Error category	Error type	Definition	Example
Commission	Perseveration	An action is performed a second time (or more) after it had already been performed.	Sugar added to the cup on two separate occasions.
	Anticipation	Object is used before completing the necessary preceding steps.	Water is poured from kettle before switching on kettle to boil.
	Quantity	Too much or too little of an object is used.	An excessive amount of sugar is put in cup, when only needed one teaspoon full.
	Action addition	Additional off task step is performed.	Chocolate chip cookies are placed on tray in addition to a custard cream biscuit.
	Compatible substitution	A compatible distractor is selected, instead of its related target object.	Lady Grey teabag in box is selected instead of Darjeeling teabag in box.
	Incompatible substitution	An incompatible distractor is selected, instead of its related target object.	Assam teabag in caddy is selected instead of Darjeeling teabag in box.
	Substitution other	Alternate object selected in place of target object, which does not include the compatible and incompatible distractors.	Teabag is placed on tray instead of teabag dish.
Omission	Omission	A task step is never performed.	Does not add any tea to cup.

5.15 Appendix E3. Table of descriptive data from Study 4a.

Table E3. Means and standard deviations of MTT variables across conditions and trials.

MTT variables		Verbal	Observed
Completion time (secs)			
	Trial 1	217.64 (95.21)	150.86 (55.46)
	Trial 2	158.72 (56.94)	144.49 (76.24)
	Trial 3	153.13 (51.63)	141.98 (37.67)
Accomplishment %			
	Trial 1	51.68 (22.28)	47.85 (22.24)
	Trial 2	50.24 (23.15)	44.02 (21.49)
	Trial 3	46.89 (14.93)	55.50 (19.85)
Total errors			
	Trial 1	9.05 (4.13)	7.37 (3.06)
	Trial 2	7.79 (2.64)	8.74 (3.31)
	Trial 3	8.11 (2.08)	7.16 (2.73)
Omissions			
	Trial 1	2.58 (1.98)	2.84 (1.61)
	Trial 2	2.53 (2.07)	3.37 (1.54)
	Trial 3	2.68 (1.86)	2.16 (1.54)
Commissions			
	Trial 1	6.47 (3.94)	4.53 (2.25)
	Trial 2	5.26 (2.38)	5.37 (3.02)
	Trial 3	5.42 (2.22)	5.00 (2.11)
Compatible substitutions			
	Trial 1	1.32 (1.20)	1.58 (1.07)
	Trial 2	1.37 (.90)	1.21 (.92)
	Trial 3	1.32 (1.00)	1.05 (.78)
Incompatible substitutions			
	Trial 1	1.32 (1.11)	1.00 (1.11)
	Trial 2	1.47 (1.12)	1.22 (1.36)
	Trial 3	1.58 (.84)	1.32 (1.06)
Other substitutions			
	Trial 1	.16 (.38)	.32 (.58)
	Trial 2	.11 (.32)	.37 (.60)
	Trial 3	.26 (.45)	.37 (.83)
Perseverations			
	Trial 1	1.11 (2.03)	.32 (.58)
	Trial 2	.47 (.84)	.58 (.69)

	Trial 3	.47 (.84)	.26 (.45)
Anticipations			
	Trial 1	1.42 (.84)	1.05 (.78)
	Trial 2	1.11 (.81)	1.63 (.90)
	Trial 3	1.16 (.83)	1.53 (1.02)
Action-additions			
	Trial 1	.53 (1.07)	.11 (.32)
	Trial 2	.37 (.83)	.21 (.42)
	Trial 3	.21 (.54)	.26 (.56)
Quantity			
	Trial 1	.63 (.96)	.16 (.38)
	Trial 2	.37 (.60)	.16 (.38)
	Trial 3	.42 (.77)	.21 (.42)

5.16 Appendix E4: Table of error-monitoring data in Study 4a

Table E4. Means and standard deviations of error-monitoring variables across conditions and trials.

Error-monitoring variables		Verbal	Observed
Proportion of errors-corrected			
	Trial 1	.01 (.03)	.01 (.03)
	Trial 2	.00 (.00)	.02 (.06)
	Trial 3	.01 (.03)	.02 (.05)
Microslips compatible			
	Trial 1	.58 (1.26)	.47 (.70)
	Trial 2	.53 (.77)	.58 (1.02)
	Trial 3	.37 (.76)	.39 (.50)
Microslips incompatible			
	Trial 1	.21 (.54)	.26 (.56)
	Trial 2	.58 (1.17)	.58 (1.61)
	Trial 3	.37 (.68)	.37 (.76)
Microslips other			
	Trial 1	.31 (.58)	.21 (.42)
	Trial 2	.16 (.38)	.47 (.70)
	Trial 3	.32 (.67)	.26 (.56)
Non-verbal checks			
	Trial 1	1.11 (2.21)	1.05 (2.78)
	Trial 2	.74 (1.05)	1.32 (2.21)
	Trial 3	.58 (1.02)	.42 (.84)
Schema checks			
	Trial 1	4.63 (4.78)	3.00 (3.93)
	Trial 2	1.84 (2.19)	2.68 (2.75)
	Trial 3	2.00 (2.69)	2.16 (2.41)
Reflective implementations			
	Trial 1	6.05 (7.66)	4.37 (5.74)
	Trial 2	3.26 (3.75)	3.68 (5.91)
	Trial 3	3.84 (4.87)	2.68 (4.20)
Practical checks			
	Trial 1	2.00 (2.05)	.84 (.96)
	Trial 2	.53 (.70)	.84 (1.07)
	Trial 3	.84 (1.17)	.53 (.77)

5.17 Appendix F: Table of raw data in Study 4b

Table F. Raw error and error-monitoring data on each case across trials and sessions

	Participants		
	NL	**DS**	**DH**
Session 1 – trial 1			
Completion time (secs)	107.84	252.68	384.08
Accomplishment	72.73%	72.73%	81.82%
Total errors	4	6	4
Omissions	2	3	0
Commissions	2	3	4
Substitution compatible	1	0	1
Substitution incompatible	0	0	1
Proportion of errors corrected	0%	0%	0%
Microslip	0	0	1
Non-verbal check	0	0	5
SC	0	6	4
RI	1	3	5
PC	1	2	3
Session 1 – trial 2			
Completion time (secs)	71.84	136.96	147.04
Accomplishment	63.64%	45.45%	72.73%
Total errors	4	6	4
Omissions	2	5	2
Commissions	2	1	2
Substitution compatible	2	0	1
Substitution incompatible	0	0	0
Proportion of errors corrected	0%	0%	0%
Microslip	0	0	0
Non-verbal check	0	0	0
SC	0	0	1
RI	1	2	5
PC	0	1	0
Session 1 – trial 3			
Completion time (secs)	86.88	130.56	189.76
Accomplishment	81.82%	36.36%	63.64%
Total errors	3	9	6
Omissions	0	6	1
Commissions	3	3	5
Substitution compatible	2	0	0
Substitution incompatible	0	1	3
Proportion of corrections	33%	0%	0%

Microslip	0	0	2
Non-verbal check	0	0	0
SC	0	1	3
RI	1	0	3
PC	0	0	0
Session 2 – trial 1			
Completion time (secs)	84.48	251.04	137.16
Accomplishment	81.82%	54.55%	72.73%
Total errors	2	5	3
Omissions	0	5	2
Commissions	2	0	1
Substitution compatible	0	0	0
Substitution incompatible	2	0	1
Proportion of errors corrected	0%	0%	0%
Microslip	2	2	0
Non-verbal check	0	12	0
SC	1	0	1
RI	2	4	1
PC	1	0	1
Session 2 – trial 2			
Completion time (secs)	90.20	192.48	123.40
Accomplishment	81.82%	36.36%	63.64%
Total errors	2	10	4
Omissions	1	4	1
Commissions	1	6	3
Substitution compatible	0	2	0
Substitution incompatible	0	0	1
Proportion of errors corrected	0%	0%	0%
Microslip	2	1	0
Non-verbal check	0	7	1
SC	2	3	1
RI	1	6	3
PC	0	0	2
Session 2 – trial 3			
Completion time (secs)	97.60	192.48	149.68
Accomplishment	90.91%	36.36%	81.82%
Total errors	2	10	8
Omissions	0	4	2
Commissions	2	6	6
Substitution compatible	0	2	2
Substitution incompatible	0	0	1
Proportion of errors corrected	50%	0%	0%
Microslip	2	1	0

Non-verbal check	0	7	0
SC	2	3	0
RI	2	6	0
PC	1	0	0
Session 3 – residual			
Completion time (secs)	112	352	165
Accomplishment	100%	36.36%	72.73%
Total errors	5	12	4
Omissions	0	2	0
Commissions	5	10	4
Substitution compatible	1	4	2
Substitution incompatible	1	1	0
Proportion of errors corrected	0%	8%	0%
Microslip	0	6	1
Non-verbal check	0	5	0
SC	1	1	8
RI	1	3	1
PC	0	2	0
Session 3 – trial 1			
Completion time (secs)	74	138	151
Accomplishment	63.64%	45.46%	63.64
Total errors	2	9	6
Omissions	2	4	0
Commissions	0	5	6
Substitution compatible	0	1	1
Substitution incompatible	0	1	3
Proportion of errors corrected	0%	0%	0%
Microslip	1	3	2
Non-verbal check	0	4	0
SC	0	0	5
RI	0	2	0
PC	0	0	0
Session 3 – trial 2			
Completion time (secs)	99	205	86
Accomplishment	90.91%	63.64%	72.73%
Total errors	5	9	5
Omissions	0	2	1
Commissions	5	7	4
Substitution compatible	1	1	2
Substitution incompatible	0	1	1
Proportion of errors corrected	20%	0%	0%
Microslip	0	2	0
Non-verbal check	0	4	0

SC	0	0	0
RI	0	2	0
PC	0	2	0
Session 3 – trial 3			
Completion time (secs)	70	165	91
Accomplishment	100%	54.55%	81.82%
Total errors	2	9	4
Omissions	0	2	1
Commissions	2	7	3
Substitution compatible	1	2	0
Substitution incompatible	1	1	1
Proportion of errors corrected	0%	0%	0
Microslip	2	1	0
Non-verbal check	0	5	0
SC	0	0	0
RI	0	1	0
PC	0	0	0
Session 4 - residual			
Completion time (secs)	91	244	163
Accomplishment	100%	45.45%	45.46%
Total errors	0	12	9
Omissions	0	2	3
Commissions	0	10	6
Substitution compatible	0	4	2
Substitution incompatible	0	0	1
Proportion of errors corrected	0%	0%	0%
Microslip	1	2	0
Non-verbal check	1	6	1
SC	1	0	2
RI	1	0	2
PC	0	0	1
Session 4 – trial 1			
Completion time (secs)	85	109	121
Accomplishment	100%	64.55%	81.82%
Total errors	4	10	4
Omissions	0	3	0
Commissions	4	7	4
Substitution compatible	0	2	2
Substitution incompatible	1	0	0
Proportion of errors corrected	25%	0%	0%
Microslip	1	0	0
Non-verbal check	0	2	0
SC	1	0	0

RI	1	0	0
PC	0	0	0
Session 4 – trial 2			
Completion time (secs)	67	92	124
Accomplishment	90.91%	63.64%	63.64%
Total errors	1	4	6
Omissions	0	3	0
Commissions	1	1	6
Substitution compatible	0	1	1
Substitution incompatible	1	0	3
Proportion of errors corrected	0%	0%	0%
Microslip	1	0	1
Non-verbal check	0	0	0
SC	0	0	1
RI	0	0	1
PC	0	0	0
Session 4 – trial 3			
Completion time (secs)	69	103	106
Accomplishment	81.82%	54.55	63.64%
Total errors	3	6	5
Omissions	0	2	1
Commissions	3	4	4
Substitution compatible	1	2	2
Substitution incompatible	1	1	1
Proportion of errors corrected	0%	0	0%
Microslip	0	0	0
Non-verbal check	0	1	0
SC	0	0	0
RI	0	0	0
PC	0	0	0
Session 5 - residual			
Completion time (secs)	115	N/A	169
Accomplishment	81.82%	N/A	36.36%
Total errors	4	N/A	8
Omissions	0	N/A	3
Commissions	4	N/A	5
Substitution compatible	0	N/A	1
Substitution incompatible	2	N/A	2
Proportion of errors corrected	0%	N/A	0%
Microslip	1	N/A	1
Non-verbal check	0	N/A	1
SC	1	N/A	3
RI	3	N/A	2

PC	0	N/A	0
Session 5 – trial 1			
Completion time (secs)	66	N/A	120
Accomplishment	72.73%	N/A	36.36%
Total errors	3	N/A	8
Omissions	2	N/A	3
Commissions	1	N/A	5
Substitution compatible	0	N/A	2
Substitution incompatible	0	N/A	2
Proportion of errors corrected	0%	N/A	0%
Microslip	0	N/A	1
Non-verbal check	0	N/A	0
SC	0	N/A	1
RI	1	N/A	0
PC	0	N/A	0
Session 5 – trial 2			
Completion time (secs)	73	N/A	128
Accomplishment	63.64%	N/A	63.64%
Total errors	4	N/A	7
Omissions	2	N/A	0
Commissions	2	N/A	7
Substitution compatible	0	N/A	2
Substitution incompatible	1	N/A	1
Proportion of errors corrected	0%	N/A	0%
Microslip	2	N/A	0
Non-verbal check	0	N/A	0
SC	1	N/A	0
RI	0	N/A	1
PC	0	N/A	0
Session 5 – trial 3			
Completion time (secs)	60	N/A	116
Accomplishment	72.73%	N/A	72.73%
Total errors	6	N/A	3
Omissions	1	N/A	0
Commissions	5	N/A	3
Substitution compatible	0	N/A	1
Substitution incompatible	1	N/A	2
Proportion of errors corrected	0%	N/A	0%
Microslip	0	N/A	1
Non-verbal check	0	N/A	0
SC	0	N/A	1
RI	0	N/A	0
PC	0	N/A	0