

An investigation of memory rehabilitation and strategies

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Abstract

Memory is important in our everyday lives and impairment due to acquired brain injury such as stroke or decline with aging can result in difficulties completing daily activities. It is therefore important to understand how memory is assessed and treated and to explore methods to improve ability. In this thesis, I examined how subjective memory ability is evaluated, clinical practices regarding memory after stroke, current approaches to memory rehabilitation, and the efficacy of mnemonic strategies for adults across all ages. A review of subjective memory measures (**Chapter 2**) revealed a wide range of standardised metamemory questionnaires that can be used in clinical and research settings to examine self-efficacy, complaints, and multiple dimensions of metamemory. However, a survey of healthcare professionals (**Chapter 3**) demonstrated that memory after stroke is often assessed in clinical settings with non-standardised subjective measures (e.g., patient interviews) in addition to cognitive screens. Additionally, rehabilitation frequently involves the use of various external memory aids and strategies to compensate for deficits. Similarly, a review of memory rehabilitation approaches currently in use (**Chapter 4**) revealed numerous strategies across the restoration, knowledge-acquisition, compensatory, and holistic approaches that are often combined to form rehabilitation programmes in research settings. An empirical study with young adults (**Chapter 5**), demonstrated limited efficacy of a commonly used face-name mnemonic strategy to improve name recall, but better outcomes with a simplified version of the mnemonic. In contrast, a study examining the efficacy of the simplified mnemonic across middle-aged and older adults (**Chapter 6**) revealed no influence of age or mnemonic instruction on name recall. These outcomes have highlighted important considerations for evaluating memory, revealed the various methods available for researchers and clinicians to treat memory impairment, and demonstrated that mnemonic strategies might have limited efficacy for healthy adults across all age groups.

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Declaration

I, Yashoda Gopi, confirm the work presented in this thesis is my own. Where information has been derived from other sources, I confirm this has been indicated in the thesis.

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1 General introduction

1.1 Introduction

Memory is important in daily life, yet memory ability varies across individuals, and we can all experience lapses such as forgetting names at a social gathering or items on a shopping list when in a supermarket. This type of memory is termed declarative memory, which is considered to encompass information that is consciously stored and recollected (Cohen & Squire, 1980; Squire, 2004). Declarative memory includes two subtypes, memory for personal experiences, events and situations (e.g., recalling the first time you attended a friend's birthday party), which is labelled episodic memory, and memory for knowledge of facts that have been acquired over time (e.g., knowing that an apple is a fruit), which is considered semantic memory (Renoult et al., 2019; Tulving, 1972). It is well established that episodic memory ability declines with aging and can be disrupted by acquired brain injury (e.g., stroke). This can have a detrimental effect on activities of daily living and result in frustration or embarrassment. Whereas forgetting someone's name might be a minor inconvenience for some, for others such as older adults or stroke patients, this same situation may be distressing. To attenuate these effects, it is important to accurately measure memory ability, understand the impact of memory deficits, and examine how to improve memory for daily activities. In my work, I examined subjective memory assessment, memory rehabilitation after stroke, and how the use of mnemonic strategies can enhance memory performance across the adult lifespan.

Memory assessments are commonly used in clinical and research settings for examining ability, pre-post treatment assessment, and evaluating subjective complaints (Gilewski & Zelinski, 1986; Herrmann, 1982). Assessments can consist of objective memory measures that simulate memory-demanding situations where performance is tested, or subjective measures such as self-report questionnaires that are designed to examine memory functioning,

perceived ability, or complaints in daily life (Salis et al., 2019; Steinberg et al., 2013). A key distinction between these measures is that objective measures are usually targeted to assessing performance on specific tasks (e.g., recalling word lists that were learned during the task) whereas subjective measures often rely on an individual's report of their knowledge and perceptions about memory processes or their own ability (Garcia et al., 1998; Herrmann, 1982). Thus, objective measures are beneficial for examining memory ability on trained tasks, but subjective measures can reveal important aspects of memory in daily life (Miller & Radford, 2014).

Metamemory questionnaires were developed to relate knowledge and beliefs to behaviours and to examine memory ability in everyday life (Cavanaugh et al., 1998; Herrmann, 1982; Sehulster, 1981). Metamemory is defined as knowledge about general memory processes (memory knowledge), beliefs about one's own memory ability (memory self-efficacy), knowledge about one's use of memory ability in daily life (memory monitoring), and feelings about one's memory (memory-related affect) (Cavanaugh et al., 1998; Flavell & Wellman, 1975). An emphasis on having structured and ecologically valid measures of everyday memory and an interest in metacognition generated increased interest in questionnaires examining metamemory several decades ago (Herrmann, 1982). It was also expected that these measures would be helpful to reduce time- and resource-consuming observational ecological research (Clark & Maguire, 2020; Herrmann, 1982). A wide variety of metamemory questionnaires have since been developed and are currently used to examine perceived ability, knowledge/beliefs about memory, and complaints in healthy and clinical populations (Herrmann, 1982; van Rijsbergen et al., 2014). However, there is little consensus regarding the applicability, characteristics, and categorisation of memory questionnaires and the influence of individual differences on subjective reporting (Gilewski & Zelinski, 1986;

Rowell et al., 2016). Furthermore, past research has consistently demonstrated weak or no correlations between objective memory measures and memory questionnaires (Burmester et al., 2015; Crumley et al., 2014; Schmidt et al., 2001). It has been suggested that subjective and objective measures are perhaps examining different aspects of memory or that the low ecological validity of objective measures that are completed within laboratory settings may be factors that influence these limited correlations (Hall et al., 2009; Herrmann, 1982). Thus the validity of self-reports has been repeatedly questioned in past research (Crumley et al., 2014; Herrmann, 1982).

To examine metamemory questionnaires currently used in clinical and research settings, I conducted a literature review in **Chapter 2** (Gopi & Madan, 2022). The review covered memory self-efficacy, complaints, and multidimensional questionnaires. Although these questionnaires share similar underlying constructs, they also have unique characteristics that researchers and clinicians should consider for different target respondents. The review also highlighted factors that influence self-evaluation including beliefs about memory, ability to evaluate memory, recent metamemory experiences, and affect. In addition, the longstanding discrepancy between subjective and objective memory measures was explored. This review revealed that metamemory questionnaires provide essential information about everyday memory in different populations, including healthy adults and individuals with acquired brain injury, but should be approached with some caution.

1.2 Memory after Stroke

Stroke is an acquired brain injury resulting from internal cerebrovascular accidents such as blood flow disruption or blood vessel rupture (Al-Qazzaz et al., 2014; Rees et al., 2007; Turner-Stokes et al., 2003). Strokes are prevalent across the world with approximately 12

million occurring annually and an increasing incidence amongst younger adults (Feigin et al., 2022). Damage across neuronal networks due to stroke can lead to cognitive impairment and result in lifelong disability and difficulty conducting daily activities (Al-Qazzaz et al., 2014; Middleton et al., 2014). Specifically, evidence has been reported of episodic memory impairment following lesions in the medial temporal lobe due to stroke (Maeshima & Osawa, 2021). Given the global rise in stroke prevalence and consequent cognitive impairment, it is essential to consider how these deficits are addressed. Specifically, memory is frequently affected following stroke and subjective memory complaints are prevalent among stroke patients (Snaphaan & de Leeuw, 2007; van Rijsbergen et al., 2014). Memory is impacted for 11-55% of stroke patients depending on the time of assessment post-stroke and previous research has demonstrated that memory impairment can impact ability to complete activities of daily living, community participation, and can also impact the lives of people who care for stroke patients such as family members (Snaphaan & de Leeuw, 2007; Tang et al., 2020).

Evidence-based guidelines for clinicians have established a pathway for the diagnosis and treatment of physical, cognitive, and psychological sequalae of stroke (Clarke & Forster, 2015; Intercollegiate Stroke Working Party, 2016; NICE, 2013). After a stroke diagnosis, patients are admitted to a hyperacute stroke unit for specialised medical intervention, an acute unit for evaluation and treatment, an inpatient rehabilitation unit for rehabilitation, or some combination of these services (Clarke & Forster, 2015; Intercollegiate Stroke Working Party, 2016; Langhorne et al., 2002). During acute inpatient care, patients should be assessed for a variety of physical and cognitive functions by a multidisciplinary team of healthcare professionals (Clarke, 2013; Clarke & Forster, 2015; NICE, 2013).

Memory is expected to be assessed with cognitive screening alongside other cognitive domains (Intercollegiate Stroke Working Party, 2016; NICE, 2013; Turner-Stokes et al., 2003). However, cognitive screening measures are often for rapid assessment and may not allow for adequate evaluation of individual domains (Nys et al., 2005; Quinn et al., 2018). Specifically, cognitive screens are generally brief measures with several questions examining multiple domains including memory, attention, and language that are designed to be completed at the bedside within the acute stroke stage (Cullen et al., 2007; Demeyere et al., 2015). While these measures provide a broad indication of which domains may be impacted, clinical guidelines indicate that in-depth testing using standardised measures (e.g., the Rivermead Behavioural Memory Test) should be conducted to accurately provide a diagnosis relevant to the affected domain following the cognitive screen (Intercollegiate Stroke Working Party, 2016). Moreover, healthcare professionals often use a combination of standardised and unstandardised screening measures which can result in varying outcomes from further neuropsychological testing to releasing patients to their homes without sufficient support (Brainin et al., 2014; Edwards et al., 2006; Quinn et al., 2018). It is also unclear to what extent individual domains such as memory are adequately assessed after screening, which is a crucial factor in subsequent rehabilitation (Ablewhite et al., 2019; Quinn et al., 2018).

After diagnosis and creation of a treatment plan, rehabilitation can be provided in the hospital, at home, or in the community (Clarke & Forster, 2015; NICE, 2013). Clinical guidelines recommend memory rehabilitation using various strategies such as errorless learning, internal memory aids such as mnemonics, and external memory aids such as mobile phones (Intercollegiate Stroke Working Party, 2016; NICE, 2013). However, individual patient needs or abilities may require different approaches and healthcare professionals may lack adequate

training or resources to effectively implement different strategies (Harris & Sunderland, 1981). Furthermore, there remains a gap between research outcomes and clinical implementation of memory rehabilitation strategies (Langhorne et al., 2011). Therefore, memory rehabilitation has been highlighted as a top research priority and further examination of clinical practices is warranted (Pollock et al., 2014).

In **Chapter 3**, I examined the current clinical practices of assessment to treatment of memory after stroke with a survey of healthcare professionals. This survey also examined the frequency of memory impairment and the impact on activities of daily living for stroke patients from the perspective of stroke experts. The results revealed that memory is often assessed alongside other cognitive functions with various measures, yet there is little indication of detailed memory assessments being used. Memory impairment was found to be common amongst patients and has a negative impact on activities of daily living and mood. Finally, memory impairment is often treated by healthcare professionals in their daily work with patients, most often with external memory aids such as mobile phones and calendars.

1.3 Memory Rehabilitation

Given the impact of memory impairment due to stroke on functional independence and activities of daily living for patients, treatment is a priority in recovery, often conducted using various memory strategies (Jokinen et al., 2015; Schaapsmeerders et al., 2013). Memory strategies are techniques that are used to either improve memory functioning, for example using computer-based programmes that simulate memory-demanding situations, to learn specific information, for example by training patients to learn or re-learn specific words, or to compensate for memory deficits, for example, by using a mobile phone to store a shopping list (Pino, 2015; Wilson, 2002). Across research studies, various strategies have been combined to form rehabilitation programmes, which has resulted in mixed outcomes and a

lack of consensus regarding the efficacy of rehabilitation (das Nair et al., 2016; Miller & Radford, 2014; O'Neil-Pirozzi et al., 2010). It is unclear from the research methodologies how and why specific strategies are selected to be combined to form rehabilitation programmes, but it has been suggested that applying different strategies simultaneously would possibly result in general improvement of functioning (O'Neil-Pirozzi et al., 2016; Ryan & Ruff, 1988). However, this reasoning warrants some caution as it is difficult to attribute any improvement in functioning to a particular combination of strategies or to determine which strategies would provide the best outcomes when combined. It can also be difficult to determine the efficacy of individual strategies (Miller & Radford, 2014). Additionally, the dosage of rehabilitation and the transfer of benefits to untrained tasks remains unclear (López & Antolí, 2020; Martin et al., 2016; Serruya & Kahana, 2008). Thus, further research has been recommended prior to implementing memory rehabilitation programmes in clinical practice (Intercollegiate Stroke Working Party, 2016).

To examine the memory rehabilitation approaches currently in use, I conducted a literature review in **Chapter 4** (Gopi, Wilding, et al., 2022b). This review was based on the ambiguity around the purpose and strategies used in rehabilitation, where previous research has often confounded strategies within different approaches (O'Neil-Pirozzi et al., 2010; Pino, 2015). The review revealed four main approaches to memory rehabilitation: restorative, compensatory, knowledge acquisition, and holistic, each with distinct strategies. Factors that influence rehabilitation outcomes such as metacognition were evaluated, and future considerations such as training duration and assessment of rehabilitation needs were provided for the use of memory rehabilitation in research and clinical settings.

To effectively apply memory rehabilitation strategies, it is essential to further examine the efficacy and applicability of individual strategies (Miller & Radford, 2014). Across studies of strategy-based memory rehabilitation with acquired brain injury patients, internal memory aids such as mnemonics or visualisation strategies are frequently used to target improvement of face-name associations (das Nair et al., 2019; Doornhein & de Haan, 1998; Hildebrandt et al., 2006; Miller & Radford, 2014; O'Brien et al., 2013; O'Neil-Pirozzi et al., 2010, 2016; Perna & Perkey, 2016; Ryan & Ruff, 1988). Similarly, Gross et al. (2012) found that the most prevalent strategies across memory training studies for healthy older adults involved visual imagery and name learning techniques. Other common strategies include external memory aids and errorless learning, where information is taught in a structured manner to prevent participants from responding with erroneous answers or spaced retrieval, where recall of information is tested at increasing intervals (Hildebrandt et al., 2006; Miller & Radford, 2014; O'Brien et al., 2013; Ryan & Ruff, 1988). However, the use of internal memory aids is particularly interesting because they require more concentrated mental effort and deliberate memory compared to external aids or errorless learning (Clare & Jones, 2008; Thoene & Glisky, 1995). Furthermore, internal memory aids can be self-generated and applied in different situations after training, while other techniques require additional tools or can only be used to learn specific information (Creighton et al., 2013; Jamieson et al., 2017). Thus, further examination of these commonly used internal memory aids such as mnemonics is warranted.

1.4 Face-name Associations

As mentioned above, face-name associations are often a target for improvement, indicating that this is an important aspect of memory across different populations. Remembering names is a common but challenging task (Cohen & Burke, 1993; Young et al., 1985). Names are

more difficult to recall than common nouns and other biographical information such as occupations (Burton & Bruce, 1992; Cohen & Burke, 1993; Hargis et al., 2020). Furthermore, failure to recall names may have a larger negative impact on daily life compared to common nouns for which alternative words can usually be found (Cohen & Faulkner, 1986; Hanley, 2011). For example, difficulty in recalling names could result in frustration or embarrassment and can negatively impact interpersonal relations (Brédart, 2017; Brédart & Vanootighem, 2022). Several theoretical models have been proposed to account for name recall difficulty, including the sequential stage, interactive activation, node structure theory, and representational models (Brédart, 2017; Cohen & Burke, 1993; Stanhope & Cohen, 1993). These models propose that name recall difficulties stem from a lack of direct connection between a name and face, limited connections between names and semantic information, and lack of semantic meaning of names (Burke et al., 1991; Cohen, 1990; Cohen & Burke, 1993; Stanhope & Cohen, 1993). However, the representational model is particularly beneficial for understanding the steps that can be taken to improve name recall (Cohen, 1990; Cohen & Burke, 1993).

The representational model posits that names are arbitrary labels, meaningless, and difficult to image (Cohen, 1990). Names are arbitrary labels because an individual could have been named differently or different people with different characteristics can have the same name (Abrams & Davis, 2017; Schwartz, 2014). Furthermore, while object names describe their referent with semantic associations, person names have a unique referent, the individual, and have been classed as ‘pure referring expressions’ (Brédart, 2017; McWeeny et al., 1987; Semenza & Zettin, 1989). In combination, an arbitrary label that has little semantic meaning is difficult to image, similar to abstract words (Cohen, 1990; Cohen & Faulkner, 1986; McWeeny et al., 1987). Support for this model comes from studies that demonstrate the

difficulty in retrieving person names compared to words with more semantic attributes (Brédart, 2017; Cohen, 1990; Festini et al., 2013). McWeeny et al. (1987) found that it was more difficult to recall that someone's name is Mr. Baker than to recall that someone is a baker, the *Baker-baker* paradox. Thus, incidental meanings of names are ignored and names are learned as arbitrary labels (McWeeny et al., 1987). In addition, name recall remains more difficult than occupation recall whether names and occupations are presented separately or together (Cohen, 1990; Cohen & Burke, 1993; Stanhope & Cohen, 1993). Patient studies have also shown that name recall difficulties persist even when recognition and the ability to retrieve other person identifiers are retained (Miceli et al., 2000; O'Rourke & de Diego Balaguer, 2020; Semenza & Zettin, 1989).

Based on the representational model, a name is difficult to image, but would also be difficult to pair with a face. For example, participants in the study by McWeeny et al. (1987) indicated that they associated an occupation with a face through imagery, e.g., imagining a baker baking, or through occupational stereotypes, e.g., this person looks like a baker, but did not do the same with names and faces. This is presumably because semantic attributes of occupations can be used in the imagery, whereas names are more difficult to image, for example, Mr. Baker does not describe all Mr. Bakers; what does a Mr. Baker look like? (Cohen, 1990; Cohen & Faulkner, 1986). The representational model also accounts for name recall improvements when using mnemonic strategies to make names more meaningful during learning (Cohen & Burke, 1993; Cohen & Faulkner, 1986; Terry, 1994).

Strategies to improve name recall include repetition, writing names down, retrieval practice, and mnemonics (Clare & Jones, 2008; Morris et al., 2005; Neuschatz et al., 2005). Previous research has shown that repetition and verbal production of a name have limited efficacy in

improving recall (Hourihan & Smith, 2016; Wilck et al., 2022). The use of external aids such as notepads is common and can be useful for tasks such as shopping lists but perhaps less so for recalling names as it may not always be possible to retrieve the external device during a conversation (Jamieson et al., 2017). Although spaced retrieval is beneficial for name recall in experimental settings, correctly spaced retrieval opportunities may not occur naturally in social situations (Morris et al., 2005; Neuschatz et al., 2005). On the other hand, mnemonic strategies can be internally modifiable for different preferences and rely on the same cues used during encoding (Bellezza, 1981; O'Neil-Pirozzi et al., 2016).

Mnemonics include organisation, visualization, and association techniques that can be used to improve learning and recall using a cognitive cuing structure as a mediator between the cue and the learned information (Bellezza, 1981; Patten, 1972; Serruya & Kahana, 2008). Visual mnemonics such as the peg method, where information is learned in a sequence by relating the information to a rhymed list of 'pegs' (e.g., one is a bun, two is a shoe), the method of loci, which involves imaging to-be-remembered information in particular parts of a familiar location such as a room in a house, and the face-name mnemonic to connect names and faces have been successfully used to improve encoding and facilitate later recall across healthy adults and patient groups (Carney et al., 1988; Patten, 1972; Sahadevan et al., 2021). These strategies require deeper levels of processing and allow better integration between disconnected pieces of information compared to repetition, resulting in improved recall (Lockhart et al., 1976; O'Neil-Pirozzi et al., 2016).

The face-name mnemonic strategy involves linking a prominent facial feature to an imagery-based transformation of the name to improve recall (Lorayne & Lucas, 1974; Morris et al., 1978). For example, if someone is named Gordon, a prominent feature such as the ears can be

selected, the name Gordon can be transformed into the image of a garden, and a garden can be imagined growing through Gordon's ears. When recalling the name, the prominent feature is expected to invite retrieval of the interactive imagery, the name transformation, and then the name (McCarty, 1980). This builds on the use of the face as the primary cue in retrieving names in daily life and integrates deeper processing of the word and facial features to yield better retrieval (Carney & Levin, 2012; Lockhart et al., 1976; Lorayne & Lucas, 1974; Morris et al., 1978). Previous research has shown improvements in name recall when participants were instructed to use the mnemonic strategy compared to limited or no imagery instruction (Carney & Levin, 2014; McCarty, 1980; Morris et al., 1978; Pike et al., 2018; Thoene & Glisky, 1995; Yesavage & Rose, 1984). However, some studies found limited effectiveness of the strategy in naturalistic in-person settings (Lewinsohn et al., 1977; Morris et al., 2005; Patton, 1994; Pike et al., 2018). Thus, the evidence has been mixed, perhaps due to limitations of previous research, such as imposing the mnemonic components on participants and limited ecological validity of stimuli (Carney & Levin, 2012; Lewinsohn et al., 1977; Neuschatz et al., 2005).

The limitations of previous research on the face-name mnemonic strategy were addressed in an empirical study with young adults designed to evaluate the effectiveness of mnemonic strategies and an own best method approach in **Chapter 5** (Gopi, Wilding, et al., 2022a). Across two experiments, face-name pairs were presented on screen, and name recall was tested. Participants were assigned to imagery mnemonic groups or to a control group with no imagery instruction. The results demonstrated that a simplified version of the face-name mnemonic focusing on the name-transformation component was advantageous over an uninstructed approach to recall names when participants complied with instructions. However, contrary to expectations, the full face-name mnemonic technique outlined above

did not result in significantly better performance than simplified versions and showed limited efficacy compared to an own best method approach. Perhaps the full strategy is too intensive or requires additional practice across multiple sessions to be effectively learned and applied. Given the potential benefits of a simplified technique, I further examined the name-transformation mnemonic with middle-aged and older adults.

It has been suggested that name recall is disproportionately affected by aging because middle-aged and older adults have more difficulty recalling familiar names and learning new names than young adults (Almond & Morrison, 2017; Evrard, 2002; James, 2004). In contrast, some research has shown that episodic memory declines with age and recently learned name recall is worse than recall of other information for adults across all ages (Cohen & Burke, 1993; Cohen & Faulkner, 1986; Maylor, 1997; Rendell et al., 2005). In either case, name retrieval failures can negatively impact older adults who may be more aware of memory failures due to stereotypes of declining memory with increasing age (Hargis et al., 2020). Past research has shown that middle-aged adults may see forgetting names as annoying, whereas older adults find it embarrassing (Brédart & Vanootighem, 2022; Hargis et al., 2020). This can in turn impact feelings about one's general memory abilities (Cavanaugh et al., 1998).

Based on the results demonstrated with young adults in **Chapter 5**, it is possible that a simplified version of the face-name mnemonic technique may improve name recall for middle-aged and older adults. The face-name mnemonic strategy has shown some success with middle-aged and older adults (Troyer et al., 2006; Yesavage et al., 1983; Yesavage & Rose, 1984). However, it is also possible that the full strategy may be too complicated or require too much effort (Morris et al., 2005; Neuschatz et al., 2005). Additionally, the imposition of the mnemonic strategy components by researchers and the limited ecological

validity of the stimuli remain in the few studies conducted with middle-aged and older adults (Yesavage et al., 1983; Yesavage & Rose, 1984). Moreover, since middle-aged and older adults might already be coping with memory difficulties in everyday life, it is unclear whether they used other strategies in previous studies (Troyer et al., 2006).

In **Chapter 6**, the efficacy of the name-transformation mnemonic technique was examined across middle-aged and older adults with an online experiment in which participants were instructed to use the mnemonic strategy or to remember the face-name pairs to the best of their ability. We also collected information regarding strategy use during the task using questionnaires. Contrary to our hypotheses, there were no significant differences between the imagery and control groups, and there was no significant effect of age on name recall. Instead, we found that middle-aged and older adults are already using strategies to improve recall in daily life that they applied in the task. Thus, it is possible that the use of mnemonic strategies that involve deliberate mental effort may require training at an earlier age to be adopted into daily use.

1.5 Summary

Memory is an essential aspect of daily life, and impairments can cause difficulty in performing everyday activities. In **Chapter 2**, I reviewed the literature on subjective memory questionnaires, highlighted factors that influence subjective reporting, and examined the relationship between subjective and objective measures. **Chapter 3** addressed the limited information on the clinical practices of memory assessment and treatment with an online survey of healthcare professionals. In **Chapter 4**, I reviewed the literature to examine the approaches and strategies currently used to improve memory, as the well as factors that influence rehabilitation. I examined the efficacy of the face-name mnemonic technique for young adults in **Chapter 5** across two experiments. Based on the results, I then examined the

influence of mnemonics and age on name recall in an experiment with middle-aged and older adults in **Chapter 6**. Altogether, the chapters in this thesis addressed questions regarding subjective memory evaluation, current practices of memory rehabilitation after stroke, and memory strategies that can be used to improve ability for an important aspect of daily life – remembering names.

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2 Subjective memory measures: metamemory questionnaires currently in use

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Abstract

Subjective memory evaluation is important for assessing memory abilities and complaints, alongside objective measures. In research and clinical settings, questionnaires are used to examine perceived memory ability, memory complaints, and memory beliefs/knowledge. Although they provide a structured measure of self-reported memory, there is some debate as to whether subjective evaluation accurately reflects memory abilities. Specifically, the disconnect between subjective and objective memory measures remains a longstanding issue within the field. Thus, it is essential to evaluate the benefits and limitations of questionnaires that are currently in use. This review encompasses three categories of metamemory questionnaires: self-efficacy, complaints, and multidimensional questionnaires. Factors influencing self-evaluation of memory including knowledge and beliefs about memory, ability to evaluate memory, recent metamemory experiences, and affect are examined. The relationship between subjective and objective memory measures is explored and considerations for future development and use of metamemory questionnaires are provided.

Keywords: metamemory; memory self-efficacy; memory complaints; memory beliefs; memory evaluation

2.1 Introduction

Across research and clinical settings, there is a wide range of objective and subjective measures available to examine memory ability (Beaudoin & Desrichard, 2011; Garcia et al., 1998). Objective measures such as recall tests or neuropsychological batteries simulate memory-demanding situations and allow for performance evaluations (Garcia et al., 1998; Schmidt et al., 2001). However, individual differences can influence motivation and performance on memory tasks and objective tests might not always accurately reflect naturalistic situations (Bennett-Levy & Powell, 1980; Hultsch et al., 1985; Sander et al., 2018). On the other hand, subjective measures such as questionnaires may better highlight some individual differences specifically regarding self-perceptions about memory and reveal important information about memory in daily life (Herrmann, 1982; Hultsch et al., 1987; Troyer & Rich, 2002). Structured memory questionnaires were developed to examine the connection between beliefs and behaviour, age-related memory decline, and memory complaints in clinical settings (Cavanaugh et al., 1998; Crook et al., 1992; Herrmann, 1982). Additionally, it was expected that questionnaires would provide an efficient alternative to observational field work and a structured ecological approach to assessing everyday memory (Garcia et al., 1998; Herrmann, 1982). Given the complexity of memory, various questionnaires have been devised to examine different types of memory and for specific target groups (Gilewski & Zelinski, 1986; Herrmann, 1982). With numerous questionnaires available, determining the appropriate one to use in a research or clinical setting requires some consideration.

This review provides an overview of common *metamemory* questionnaires that are currently in use across research and clinical settings and highlights factors that should be considered when using subjective measures. The original definition of metamemory encompassed factual

knowledge about memory processes and beliefs about one's own memory ability (Cavanaugh et al., 1998; Dixon & Hultsch, 1983; Flavell & Wellman, 1975). This has been further divided into memory knowledge (factual knowledge about memory processes, tasks, and strategies), monitoring (knowledge about personal memory use), self-efficacy (beliefs about personal memory abilities), and affect (affective states linked to memory situations) (Hertzog et al., 1989; Hultsch et al., 1988). As metamemory is multidimensional, many questionnaires are encompassed under this term, yet the purpose of assessment and the items used differ and questionnaires are therefore not interchangeable (Cornish, 2000). Here, we focus on three common types of metamemory questionnaires: self-efficacy, complaints, and multidimensional. These are targeted to examining personal beliefs about ability, memory failures or complaints about memory in daily life, or multiple dimensions of metamemory (Beaudoin & Desrichard, 2011; Crumley et al., 2014; Gilewski & Zelinski, 1986). These questionnaires are generally applicable across different populations in research and clinical settings and thus their characteristics are worth exploring. However, it is important to note these broadly defined categories are not mutually exclusive and have been used interchangeably throughout the literature (Beaudoin & Desrichard, 2011; Gilewski & Zelinski, 1986).

Several characteristics were considered for including or excluding questionnaires in this review. We included structured, validated metamemory questionnaires developed for adults that are currently in use and focus on memory self-efficacy, knowledge, or complaints. Questionnaires beyond the scope of this review were those designed for a single study, targeted to one type of memory (e.g., prospective), designed and currently in use with only patient groups (e.g., stroke patients), task-specific predictions/evaluations, checklists, interviews, and open-ended questionnaires. The rationale for these inclusion and exclusion

criteria was to clearly outline a list of current, validated, structured questionnaires within each category that can be used with a wide range of adults in clinical and research settings. Self-efficacy, memory complaints, and multidimensional questionnaires were selected for examination because they have been consistently used throughout past research, yet there is little information available to distinguish the types of questionnaires and their characteristics (Gilewski & Zelinski, 1986; Herrmann, 1982). Additionally, some questionnaires were excluded as their focus was too narrow (e.g., for specific patient groups) which may be better examined in comparison to similar patient-focused questionnaires. These criteria allow for an examination of different factors such as subscales, internal consistency, and length that can aid researchers and clinicians in determining which questionnaires to use.

2.2 Self-Efficacy Questionnaires

Perceptions of one's own memory ability has been labelled memory self-efficacy (Beaudoin & Desrichard, 2011; Hultsch et al., 1988). This is distinguished from knowledge about memory processes by personal agency in different circumstances and from memory monitoring with a focus on beliefs about ability to remember rather than reporting memory successes or failures in daily life (Cavanaugh et al., 1998; Hultsch et al., 1988). Self-efficacy questionnaires often include ratings of ability to remember information in various contexts. Questionnaires currently in use are shown in Table 1.

A prominent self-efficacy questionnaire, the Squire Subjective Memory Questionnaire (SSMQ) was adapted from a memory complaints measure to a more general use questionnaire with a unidimensional structure reflecting beliefs about one's own memory (Squire et al., 1979; Van Bergen et al., 2010). On the other hand, the Subjective Memory Questionnaire (SMQ), was initially designed to target self-efficacy by assessing self-report of skills in real-life memory tasks for adults. In a different approach, the Memory Assessment Clinics Self-

Rating Scale (MAC-S) was developed to address limitations of existing memory scales for use within research and clinical settings (Bennett-Levy & Powell, 1980; Crook & Larrabee, 1990; Winterling et al., 1986). Finally, the commonly used Memory Self-Efficacy Questionnaire (MSEQ) was designed to examine individual differences in memory ability (Berry et al., 1989).

As demonstrated in Table 2, all self-efficacy questionnaires include an ability to remember subscale. These questions examine perceived memory ability for specific information (e.g., names), past actions (e.g., where an item was placed earlier), or in hypothetical scenarios (e.g., remembering a shopping list in a grocery store). Although there are differences between the items, response scales, and variations in question framing, self-efficacy questionnaires generally require respondents to evaluate their strengths and weaknesses, in line with the underlying construct of self-efficacy (Hultsch et al., 1988). There are also differences across the scales. The SSMQ includes questions about attention and perception, which can result in respondents confounding memory with other cognitive domains (Squire et al., 1979). However, it is relatively short, which can be advantageous for populations where fatigue is a concern. While the SMQ and MAC-S include frequency of forgetting subscales, only the MAC-S includes a global subscale which could be useful in understanding an individual's perception of their general memory functioning (Bennett-Levy & Powell, 1980; Crook & Larrabee, 1990). The MAC-S also has subsections of the ability subscale for different types of memory such as everyday task-oriented memory and remote memory (Winterling et al., 1986). In a different capacity, the MSEQ incorporates self-efficacy strength and level with confidence ratings and varying task difficulty levels, which is beneficial for examining nuances in self-efficacy ratings (Berry et al., 1989).

The outlined self-efficacy questionnaires have been used across different populations to examine memory distrust, help-seeking behaviours, memory training, and the link between memory self-efficacy and memory performance (Beaudoin & Desrichard, 2017; D'Angelo et al., 2021; Gigi et al., 2020; Van Bergen et al., 2010). These questionnaires can also be helpful in examining relation between perceived self-efficacy and motivation for participating in memory-demanding tasks (Ponds & Jolles, 1996). Although they share some characteristics, these scales are not interchangeable, and their differing characteristics are worth evaluating in relation to the purpose of assessment in research and clinical settings. Finally, it has been suggested that self-efficacy measures likely reflect beliefs rather than actual abilities and this should be considered when selecting a questionnaire for use (Herrmann, 1982; Ossher et al., 2013).

Table 1

Memory Self-efficacy Questionnaires

Questionnaire	Revised versions and language validations	General purpose	Subscales (no. of items)	Sample item	Response scale and indications	Internal consistency (a)
SSMQ: Squire Subjective Memory Questionnaire (Squire et al., 1979)	Dutch (Van Bergen et al., 2010); Polish (Kuczek et al., 2018); Chinese (Zhang et al., 2022)	Initially to examine memory complaints before and after electroconvulsive therapy but adapted to general subjective memory evaluation	Ability to remember (18): Perception of ability to use memory in different situations	My ability to remember things that have happened more than a year ago is	Worse than ever before - Better than ever before (9-point) (+ = better ability)	.88 - .96
SMQ: Subjective Memory Questionnaire (Bennett-Levy & Powell, 1980)	SMQ-R (Lucas et al., 1991)	Measure subjective memory abilities in adults; Developed with a clinical approach to assessing memory in everyday life	Ability to remember (36): memory ability for specific items/situations	How good is your memory for… names of streets/houses	Very bad - Very good (5-point) (+ = better ability)	N/A
			Frequency of forgetting (7): how often items/situations are forgotten	How often do you … forget a particular word in mid-sentence	Very rarely - Very often (+ = more lapses)	N/A
MAC-S: Memory Assessment Clinics, Self-Rating Scale (Winterling et al., 1986)	MAC-E (M. Miller et al., 2020)	Self-rating scale for memory based on previous measures	Global (4): general ability and distress related to memory decline	In general, as compared to the average individual, how would you describe your memory?	Very poor - Very good (5-point) (+ = better ability)	N/A
			Ability (21): ability to remember in specific situations	How would you describe your ability to remember… where you have put objects in the home or office.	Very poor - Very good (+ = better ability)	N/A

			Frequency (24): difficulty remembering in specific situations	How often would you say you do each of the following? Fail to remember a name or word but recall it later	Very often - Very rarely (+ = fewer lapses)	N/A
MSEQ: Memory Self-Efficacy Questionnaire (Berry et al., 1989)	French (Beaudoin et al., 2008)	Measure of self-efficacy for examining development and individual differences in memory evaluation	Ability to remember across 8 subscales with 5 levels per subscale: Grocery, Phone, Picture, Location, Word, Digit, Map, Errands, Photographs, Maze	If I heard it twice, I could remember 2 items from a friend's grocery list of 12 items, without taking any list with me to the store	Yes/No followed by confidence judgment (10% - 100%) (+ = higher confidence)	.83 - .90

Note. Language validations as far as known by authors. Unless otherwise specified, the scale points are consistent throughout the questionnaires and only mentioned in the first subscale. N/A = not available.

2.3 Complaints Questionnaires

Memory complaints have been broadly defined as reports of problems or failures in daily life, usually from older adults (Gilewski & Zelinski, 1986; Hertzog & Pearman, 2013). Complaints should be seriously considered by clinicians as they may be predictive of cognitive decline or dementia (Reid & MacLullich, 2006; Schmand et al., 1996). Complaints questionnaires systematically assess memory failures or problems in daily life, often focusing on frequency of forgetting. Questionnaires currently in use are shown in Table 2.

A well-established questionnaire, the Everyday Memory Questionnaire (EMQ) was initially designed to examine memory failures for head injured patients but has been widely adopted across different populations (Calabria et al., 2011; Sander et al., 2018; Sunderland et al., 1983). In a different capacity, the Memory Complaint Questionnaire (MAC-Q) and the Subjective Memory Complaints Scale (SMCS) were developed to examine memory decline and complaints, particularly for older adults (Crook et al., 1992; Schmand et al., 1996). These questionnaires have been used as brief, reliable measures to assess severity of complaints and the relationship between complaints and objective performance (Buckley et al., 2013; Mendes et al., 2008). The Frequency of Forgetting-10 (FOF-10) was derived from the Frequency of Forgetting Scale of a multidimensional questionnaire as a brief measure to be used in clinical settings (Zelinski & Gilewski, 2004). Although the authors describe this questionnaire as a self-efficacy measure, here it is considered a complaints measure as it records memory problems in everyday life rather than perceived ability (Zelinski & Gilewski, 2004). Two more recently developed questionnaires, the Subjective Memory Complaints Questionnaire (SMCQ) and the Memory Complaints Scale (MCS) were specifically targeted to assessing memory complaints (Vale et al., 2012; Youn et al., 2009). These questionnaires have been used to examine memory complaints in patient groups, the relationship between complaints

and objective measures, and for screening for mild cognitive impairment (Dalpubel et al., 2019; Huang et al., 2014; Yim et al., 2017).

As shown in Table 2, memory complaints scales focus on frequency of forgetting, memory decline, and complaints about memory functioning. The FoF-10 and SMCQ also contain global subscales to evaluate whether respondents believe that there are general memory problems (Youn et al., 2009; Zelinski & Gilewski, 2004). Memory complaints questionnaires reflect an individual's calculation of how often particular mistakes are made in daily life, which relies on memory monitoring, one of the dimensions of metamemory outlined above (Hultsch et al., 1988). However, as highlighted by Hertzog et al. (1989), it is possible that frequency of forgetting is more likely to be a combination of recent experiences and beliefs about memory than an accurate search of memory experiences.

There are several differences across complaints questionnaires worth noting. The EMQ broadly differentiates between memory and attention systems, which is beneficial to separately address domain-specific difficulties (Royle & Lincoln, 2008; Sunderland et al., 1983). In contrast to the other questionnaires, the MAC-Q examines memory change by comparing current memory ability to that of high school or college (Crook et al., 1992). However, this measure has been found to be impacted by affective status and caution has been advised when using this questionnaire with older adults (Reid et al., 2012). While the EMQ can be administered to both patients and relatives, the MCS is the only measure that contains a separate companion version (MCS-B) and also examines the impact of memory problems on daily activities (Sunderland et al., 1983; Vale et al., 2012). This can be beneficial where memory impairment impacts ability to respond and to understand the real world implications of memory problems (Garcia et al., 1998; Sugden et al., 2021; van der Werf & Vos, 2011).

Finally, there are different response scales, target items, and questionnaire lengths across these measures (Table 2). These differences highlight that complaints questionnaires are not interchangeable and considerations regarding the target group and assessment purpose are essential when selecting a questionnaire for use.

Although they are beneficial, complaints questionnaires should be interpreted cautiously as measures of noticeable memory failures rather than a veridical account of memory failures (Ossher et al., 2013). In past research, there has been some ambiguity around the term *memory complaints* and suggestion that perhaps memory complaints can be considered as an aspect of self-efficacy (Hertzog & Pearman, 2013; Jonker et al., 2000). However, as highlighted by Beaudoin and Desrichard (2011), memory self-efficacy and complaints are distinguished by forgetfulness being related to embarrassment in the context of complaints. Furthermore, as mentioned by Ossher et al. (2013), the lack of correlation they found between the EMQ and MSEQ demonstrates that complaints measures recording everyday errors and self-efficacy measures of perceived ability are distinct.

Table 2

Complaints Questionnaires

Questionnaire	Revised versions and language validations	General purpose	Subscales (no. of items)	Sample item	Response scale and indications	Internal consistency (a)
EMQ: Everyday Memory Questionnaire (Sunderland et al., 1983)	EMQ-28 (Sunderland et al., 1984); EMQ-Revised (Royle & Lincoln, 2008); EMQ-20 (Calabria et al., 2011); EMQ-R (Evans et al., 2020), Swedish (Olsson et al., 2006); Greek (Efklides et al., 2002)	Examine memory failures in everyday life	Failures (35): failures in daily life across speech, reading and writing, faces and places, actions, and learning new things	Forgetting something you were told yesterday or a few days ago.	Never - Several times in a day (5-point) (+ = more failures)	N/A
MAC-Q: Memory Complaint Questionnaire (Crook et al., 1992)	N/A	Brief, reliable measure of memory complaints in clinical or research settings	Memory decline (6): comparative ability to high school	Remembering the name of a person just introduced to you	Much better now - Much poorer now (5-point) (+ = decline)	0.57
SMCS: Subjective Memory Complaints Scale (Schmand et al., 1996)	Portuguese (Mendes et al., 2008)	Examine memory complaints	Complaints (10): memory problems in daily life	Do you have any complaints concerning your memory?	No - Yes, serious problem (4-point) (+ = more complaints)	0.72
FOF-10: Frequency of Forgetting-10 (Zelinski & Gilewski, 2004)	N/A	Short measure for clinical assessments derived from the Frequency of Forgetting MFQ scale	Global (1): general frequency of forgetting	How would you rate your memory in terms of the kinds of problems that you have?	Major problems - No problems (7-point) (+ = fewer problems)	0.80

			Frequency of forgetting (9): frequency of memory problems	How often do these present a problem for you? Where you put something	Always - Never (+ = fewer lapses)	
SMCQ: Subjective Memory Complaints Questionnaire (Youn et al., 2009)	Korean (Youn et al., 2009)	Examine subjective memory complaints in older adults in research and clinical settings.	Global memory function (4): general functioning in everyday life	Do you think that your memory is poorer than that of other people of a similar age?	Yes - No (2-point) (+ = higher severity of complaints)	0.69
			Everyday memory functioning (10): difficulty remembering/failures	Do you have difficulty in remembering an appointment made a few days ago?	Yes - No (+ = higher severity of complaints)	0.83
MCS: Memory Complaints Scale (Vale et al., 2012)	Portuguese (Vale et al., 2012)	Actively search for memory complaints	Complaints (7): general problems and frequency	How is your memory compared with when you were younger?	Same or better - Much worse (3-point) (+ = more complaints)	0.85

Note. Language validations as far as known by authors. Unless otherwise specified, the scale points are consistent throughout the questionnaires and only mentioned in the first subscale. N/A = not available.

2.4 Multidimensional Questionnaires

As mentioned above, metamemory is a multidimensional construct. The self-efficacy and monitoring constructs are examined using self-efficacy and complaints questionnaires yet there are few questionnaires that directly explore memory knowledge or affect in the same targeted approach (Cherry et al., 2000). However, these factors are sometimes included in other questionnaires as subscales. In particular, multidimensional questionnaires examine multiple aspects of metamemory in a single measure (Dixon & Hultsch, 1983). Questionnaires currently in use are shown in Table 3.

One of the early multidimensional questionnaires, the Sehulster Memory Scale (SMS), was designed to examine multiple domains of memory and experiences within a self-theory of memory framework (Sehulster, 1981). Similarly, two of the most prominent multidimensional questionnaires are the Metamemory in Adulthood Questionnaire (MIA), designed to capture aspects of memory relevant to everyday activities and the Memory Functioning Questionnaire (MFQ), developed to examine memory abilities and failures (Dixon et al., 1988; Gilewski et al., 1990). In contrast, Lineweaver and Hertzog (1998) developed two measures to separate beliefs about one's own memory, with the Personal Beliefs about Memory Inventory (PBMI), from beliefs about the memory ability of people in the general population, using the General Beliefs about Memory Inventory (GBMI). The more recently developed Multifactorial Memory Questionnaire (MMQ) was designed to tap three aspects of memory: contentment, ability, and strategy use (Troyer & Rich, 2002).

As shown in Table 3, these questionnaires generally have multiple subscales, with some that are shared across measures. For example, global ability, self-efficacy, control, and mnemonics/strategy scales are included in several questionnaires. These shared characteristics

highlight the multidimensional nature of memory and the importance of multiple scales to effectively assess knowledge and perceptions of individual ability (Dixon & Hultsch, 1983; Mogle et al., 2021). However, similar subscales are not interchangeable. For example, although the MIA and MMQ include affect-related subscales, the MIA anxiety subscale examines ability to use memory when in different emotional states whereas the MMQ contentment subscale is more targeted to satisfaction with memory ability (Hultsch et al., 1988; Troyer & Rich, 2002). The differences across questionnaires should also be noted. In contrast to the other questionnaires, the MIA examines knowledge about memory processes and the perceived importance of good memory whereas the MFQ examines perceived seriousness of forgetting (Dixon et al., 1988; Gilewski et al., 1990). On the other hand, the PBMI includes a relative standing rating where respondents are asked to compare their general memory ability to all adults of their own age and all adults of all ages (Lineweaver & Hertzog, 1998). These and other unique characteristics such as different rating scales and questionnaire lengths are important to consider when selecting a questionnaire to use. For example, if the frequency of forgetting when reading is important, the MFQ would be appropriate whereas others without this subscale may not be as valuable. These distinct subscales also support the argument that there is still work to be done in dissecting the components of the multidimensional construct of metamemory (Hultsch et al., 1987; Mogle et al., 2021).

Multidimensional questionnaires have been used to examine the interrelationships between metamemory dimensions, aging, memory strategies in daily life, and the relationship between subjective evaluations and objective memory performance (Cavallini et al., 2013; Hertzog et al., 1989; Irak & Çapan, 2018; Macan et al., 2010; Payne et al., 2017). However, they have also been criticised for their lengthy time to complete, which may deter use with certain

populations due to fatigue and consequently incomplete or inaccurate responses (Troyer & Rich, 2002; Van Bergen et al., 2010). Thus, some questionnaires have been reduced to shorter versions or specific subscales to retain essential aspects while reducing the length (Campelo et al., 2016; McDonough et al., 2019; Zelinski & Gilewski, 2004). In contrast, the MMQ was designed with considerations for patient groups and has been successfully applied with clinical populations (Illman et al., 2015; van der Werf & Vos, 2011). Another concern is that respondents may rely on generalisations or stereotypes when responding to global questions whereas they may consider distinct past experiences when responding to anchored questions (Cyr & Anderson, 2019; Mogle et al., 2020). This can potentially result in inaccurate evaluations depending on the order of questions (Cyr & Anderson, 2019). On the other hand, it has been suggested that multidimensional questionnaires might be more closely related to objective memory performance and provide much more detail about an individual's memory in daily life compared to single questions, interviews, or unidimensional questionnaires (Crumley et al., 2014). Thus consideration of the benefits and limitations of using longer questionnaires is warranted especially for older adults and patient groups (Davis et al., 1995).

Table 3

Multidimensional Questionnaires

Questionnaire	Revised versions & language validations	General purpose	Subscales (no. of items)	Sample item	Response scale and indications	Internal consistency (a)
SMS: Sehulster Memory Scale (Sehulster, 1981)	N/A	Examine perceptions of memory across 20 memory-related domains and nine memory experiences	Ability (20): perception of everyday ability	I remember conversations that I had with other people	Very poorly - Extremely well (5-point) (+ = better ability)	N/A
			Frequency of forgetting (20): frequency of items/information forgotten	I forget anniversaries, appointments, birthdays, etc.	Very often - Rarely (+ = fewer lapses)	N/A
			Social comparison (20): memory ability compared with others	I trust my memory more than I trust the memory of	Very few people - All or most people (+ = better personal ability)	N/A
MIA: Metamemory in Adulthood (Dixon et al., 1988)	MIA-Revised (McDonough et al., 2019); Arabic (Alquraan & Aljarah, 2011), Dutch (Ponds & Jolles, 1996), French (Baillargeon & Neault, 1989), Portuguese (Campelo et al., 2016), Japanese (Ide et al., 1999)	Examine metamemory in adulthood	Strategy (18): reported use of internal and external strategies	Do you write yourself reminder notes?	Never - Always (5-point) (+ = high use)	.82-.86
			Task (16): knowledge of memory processes	Familiar things are easier to remember than unfamiliar things	Agree strongly - Disagree strongly (+ = high knowledge)	.78 - .83
			Capacity (17): beliefs about own memory capacity	I am good at remembering names	Agree strongly - Disagree strongly (+ = high capacity)	.81 - .86
			Change (18): perceived change in remembering capacity	The older I get the harder it is to remember things clearly	Agree strongly - Disagree strongly (+ = stability)	.90 - .93
			Anxiety (14): perception of the relationship between anxiety and memory performance	I find it harder to remember things when I'm upset	Agree strongly - Disagree strongly (+ = high knowledge)	.83 - .87

			Achievement (16): perception of own motivation to perform well on memory tasks	It is important to me to have a good memory	Agree strongly - Disagree strongly (+ = high achievement)	.76 - .79
			Locus (9): perceived control over memory ability	I have little control over my memory ability	Agree strongly - Disagree strongly (+ = internality)	.71 - .78
MFQ: Memory Functioning Questionnaire (Gilewski et al., 1990)	FOF-10 (Zelinski & Gilewski, 2004); Italian (Pedone et al., 2005); Turkish (Şahin et al., 2013)	Developed by the same researchers of the Metamemory Questionnaire to examine subjective memory compared to objective performance	General rating (1): global memory problems	How would you rate your memory in terms of the kinds of problems that you have?	Major problems - No problems (7-point) (+ = higher perceived functioning)	General Frequency of forgetting factor: .94
			Frequency of forgetting (18): frequency of forgetting incidents	How often do these present a problem for you? personal dates (e.g., birthdays)	Always - Never (+ = fewer forgetting incidents)	
			Frequency of forgetting when reading (10): frequency of forgetting incidents while reading	As you are reading a novel, how often do you have trouble remembering what you have read . . . the chapter before the one you are currently reading	Always - Never (+ = fewer forgetting incidents)	
			Remembering past events (4): perceived functioning for past information/events	How well you remember things that occurred … last month is	Very bad - Very good (+ = higher perceived functioning)	
			Seriousness of forgetting (18): seriousness of forgetting incidents	When you actually forget in these situations, how serious of a problem do you consider the failure to be? . . . Appointments	Very serious - Not serious (+ = less serious incidents)	0.94
			Retrospective functioning (5): comparative functioning to past self	How is your memory compared to the way it was . . . when you were 18?	Much worse - Much better (+ = improvement in functioning)	0.89
			Mnemonics usage (8): use of internal and external aids	How often do you use these techniques to remind yourself about	Always - Never (+ = less use of mnemonics)	0.83

				things? . . . mental repetition		
PBMI: Personal Beliefs about Memory Instrument (Lineweaver & Hertzog, 1998)	PBMI Computerized (Hertzog et al., 2014); Japanese (Kinjo & Shimizu, 2014)	Measure beliefs about one's own memory	Global memory ability (1): global ability	My ability to remember in general is	Very poor – Very good (Continuous) (+ = better ability)	N/A
			Relative standing ratings (2): comparative scale to adults of same age	Compared to all adults my age, my memory is:	Much below average – Much above average (+ = better comparative ability)	N/A
			Retrospective change (7): comparative functioning to past self	Over the last 10 years, my memory has	Greatly declined – Greatly improved (+ = improvement)	0.96
			Prospective change (7): expected memory change in the future	When I am 75 years old, my memory will be	Much less efficient – Much more efficient (+ = predicted improvement)	0.97
			Control (4): perceived control over abilities	There are things I can do to help me remember	Strongly disagree – Strongly agree (+ = more control)	0.93
			Prospective control (9): perceived control over change	I can control the amount my memory will change in the future.	Strongly disagree – Strongly agree (+ = more control)	0.90
			Future control (5): perceived control over future abilities	In the future, the amount of control I will have over my memory will be	None - A lot (+ = more control)	0.83
			Specific memory ability (23): perceived ability in different situations	Daily Schedule: My ability to remember my daily schedule is	Very poor – Very good (+ = better ability)	0.94
GBMI: General Beliefs about	GBMI Computerized (Hertzog et al., 2014);	Measure beliefs about memory for	Global memory ability (1): global ability of healthy adults	Ability to remember in general.	Very poor – Very good (Continuous) (+ = better ability)	N/A

Memory Instrument (Lineweaver & Hertzog, 1998)	Japanese (Kinjo & Shimizu, 2014)	an average healthy adult	Control (1): amount of control adults have over their memory ability	Amount of control over present memory functioning. The extent to which the adult can do things now that will determine how his or her memory works.	No control - Complete control (+ = better control)	N/A
			Prospective Control (1): amount of control adults have over future ability	Amount of control over future memory functioning. The extent to which the adult can do things now that will determine how his or her memory will work in the future.	No control - Complete control (+ = better control)	N/A
			Specific memory ability (12): memory ability for adults in different situations	Ability to remember trivia	Very poor - Very good (+ = better ability)	N/A
MMQ: Multifactorial Memory Questionnaire (Troyer & Rich, 2002)	Languages: Dutch (van der Werf & Vos, 2011); French (Fort et al., 2004), Italian (Raimo et al., 2016)	Assess self-reported memory for use in clinical assessments	Contentment (18): satisfaction with memory ability	I am embarrassed about my memory ability.	Strongly agree - Strongly disagree (5-point) (+ = greater contentment)	0.95
			Ability (20): perception of everyday ability	How often do you leave something behind when you meant to bring it with you?	All the time - Never (+ = better subjective ability)	0.93
			Strategy (19): everyday use of strategies and memory aids	How often do you create a rhyme out of what you want to remember?	Never - All the time (+ = more frequent use of strategies)	0.83

Note. Language validations as far as known by authors. Unless otherwise specified, the scale points are consistent throughout the questionnaires and only mentioned in the first subscale. N/A = not available.

2.5 Questionnaires Beyond the Scope of This Review

Several metamemory questionnaires are not within the scope of this review. For example, the Short Inventory of Memory Experiences (SIME) has been mentioned in past reviews, but appears to be rarely used and with limited psychometric properties or scale items available (Gilewski & Zelinski, 1986; Herrmann, 1982; Herrmann & Neisser, 1978). Scales such as the Memory Controllability Inventory and the Cognitive Failures Questionnaire are commonly used but are not within the scope of the categories outlined above (Broadbent et al., 1982; Lachman et al., 1995). However, some patient groups and specific memory domain questionnaires might be of interest to researchers and clinicians examining self-reported memory, and we have provided a brief outline of some questionnaires in the Appendix.

2.6 Factors Influencing Self-Evaluation of Memory

There are individual differences in the way memory is evaluated and therefore reported on questionnaires (Cavanaugh et al., 1998; Sehulster, 1981; Van Bergen et al., 2009). Several factors may interact with memory self-evaluations including knowledge or beliefs about memory, ability to evaluate memory, recent metamemory experiences, and affect (Hertzog et al., 1989; Rowell et al., 2016; Troyer, 2001). These factors are considered below.

2.6.1 Knowledge/Beliefs About Memory

An individual's conceptualisation of memory and beliefs about stereotypes and control over memory can influence self-evaluations (Cavanaugh et al., 1998; Troyer & Rich, 2002). For example, memory self-reports have been correlated with different cognitive functions such as attention, language, and executive function (Hülür et al., 2018; Snitz et al., 2015). This is perhaps due to the inclusion of attention and executive functioning items in questionnaires

(Crook et al., 1992). To prevent respondents from considering these cognitive functions under the umbrella term of memory, a definition of memory that corresponds with the questionnaire can be included in the instructions (Mogle et al., 2020).

Although some individuals are knowledgeable about memory processes, they can still rate their own memory abilities as poor based on generalisations or stereotypes (Cavanaugh et al., 1998; Troyer, 2001). A prominent stereotype is that memory will inevitably decline with age (Cavallini et al., 2013; Kahn et al., 1975). Consequently, older adults may underestimate their memory ability whereas younger adults overestimate their memory ability (Cavanaugh et al., 1998; Fritsch et al., 2014). In addition, regular lapses in daily life might be attributed to cognitive decline for older adults whereas younger adults find them to be insignificant (Zarit et al., 1981). Furthermore, stereotypes may influence performance on objective measures whereby older adults expect to perform poorly, resulting in lack of motivation and subsequently poor performance (Bouazzaoui et al., 2020; Poon et al., 1978; Troyer & Rich, 2002). Like beliefs about aging, beliefs about the malleability of memory may influence self-evaluation and objective memory performance (Lachman et al., 1995; Thana-Udom et al., 2021). Perceptions that memory decline is unchangeable can result in negative self-evaluations and reduce motivation to participate in memory-demanding tasks (Bouazzaoui et al., 2020; Cavanaugh et al., 1998). Specifically, older adults may believe memory decline to be inevitable and irreversible, whereas young adults may view their memory to be more malleable, with more control over their abilities (Cavallini et al., 2013; Dixon & Hultsch, 1983; Lineweaver & Hertzog, 1998). On the other hand, the belief that memory is malleable may result in motivation to improve memory abilities and more positive reflections of ability (Bouazzaoui et al., 2020; Cavanaugh et al., 1998). Perhaps education about memory processes

and strategies can improve memory control beliefs and mitigate the effects of stereotypes (Lineweaver et al., 2021; Thana-Udom et al., 2021).

2.6.2 Ability to Evaluate Memory

Responding to questionnaires requires self-awareness of abilities and recent memory experiences (Davis et al., 1995; Snitz et al., 2015). Memory deficits can affect this retrieval and result in over or under-estimation of abilities (Clare et al., 2010; Helmstaedter & Elger, 2000; Hultsch et al., 1985). Young and middle-aged adults are potentially more accurate in assessing their memory abilities than older adults because they can update their self-evaluations based on regular feedback through work or education (Van Bergen et al., 2009, 2010). On the other hand, older adults or memory-impaired individuals might be more attuned to memory failures in everyday life due to general expectations of memory decline or impairment and may therefore be more realistic in estimations (Crumley et al., 2014; Van Bergen et al., 2010). Potential solutions to the difficulty of evaluating one's own memory include questionnaires for companions or checklists and diaries that capture daily remembering instances (Garcia et al., 1998; Sugden et al., 2021). However, memory may be assessed differently depending on whether it is being assessed for oneself or for another person and accurate reporting would require regular contact with the individual for behavioural observations (Helmstaedter & Elger, 2000; Sugden et al., 2021). Furthermore, discrepancies between self and other reports and objective memory measures indicate a lack of reliability in determining which approach best represents actual memory abilities (Helmstaedter & Elger, 2000; Sugden et al., 2021).

Individuals may also differentially evaluate the severity of memory failures. For example, forgetting one's keys may be considered failing memory for older adults but a rectifiable

lapse for younger adults. As highlighted by Burmester et al. (2015), open-ended questions prior to a structured questionnaire might elucidate the most distressing memory complaints. However, this might not always be feasible within clinical settings due to time limitations and having a global memory question might result in memory worries and salience of negative experiences when responding to more specific questions (Cyr & Anderson, 2019). For example, should a patient report their most distressing memory problems first, they may then exaggerate the severity of other problems on a later questionnaire.

2.6.3 Recent Metamemory Experiences

Past experiences, information provided by others, or comparisons of personal performance can influence memory evaluations (Flavell & Wellman, 1975; Hertzog et al., 1989; Sehulster, 1981). For example, if responding to a question about remembering names, an individual may recall a recent event in daily life involving recalling names (Pearman & Trujillo, 2013; Sehulster, 1981). Similarly, memory complaints may partially reflect comparison with one's own past performance or to others of a similar age (Sehulster, 1981; Zarit et al., 1981). In a different capacity, when reflecting on recent experiences some individuals may consider the use of external or internal memory aids as an extension of their own memory whereas others evaluate their memory based on performance without aids (Sander et al., 2018). In a broader scope, frequent forgetting incidents that cause embarrassment or frustration may lead to negative perceptions of general memory ability (Hertzog et al., 1989; Poon et al., 1978). Additionally, older adults who have been recently exposed to individuals with dementia could consequently consider their own normal age-related memory decline as indicators of dementia (Kinzer & Suhr, 2016; Van Bergen et al., 2009). On the other hand, this could also result in updated beliefs about what constitutes good memory and may lead to more positive self-

evaluations (Pearman et al., 2014). Similarly, older adults may consider recent memory lapses to be part of normal aging (Mogle et al., 2019; Pearman et al., 2014).

Recollection of past experiences can also be influenced by question format. Some items require consideration of recent events, others ask about prior years or decades, and some do not include an anchor (Mogle et al., 2020; Rowell et al., 2016). This can lead to different levels of specificity during retrieval and reliance on generalisations or stereotypes about more remote periods (Cyr & Anderson, 2019; Hultsch et al., 1987). However, older adults might be more accurate when recalling earlier life events whereas younger adults may be more accurate when retrieving recent events (Kahn et al., 1975; Kahn & Miller, 1978). As such, Kahn and Miller (1978) suggested that a more appropriate comparison would be to ask about a similar event recently and several years prior.

2.6.4 Affect

Temporary or chronic affective states including stress, anxiety, and depression can influence memory evaluations (Cavanaugh et al., 1998; Rowell et al., 2016; West et al., 1984). Negative feelings towards oneself before performing a memory task or responding to questionnaires may result in poorer outcomes on both (Bouazzaoui et al., 2020; Poon et al., 1978; Riege, 1983). Affect may also impact motivation to participate in memory-demanding tasks and seek help for memory problems (Gigi et al., 2020; Pires et al., 2012). On the other hand, memory problems, failures, or concerns about decline can influence anxiety and depression (Bhang et al., 2020; Mogle et al., 2019; West et al., 1984).

Past research has consistently demonstrated a link between affect and subjective memory evaluations (Buckley et al., 2013; Lineweaver & Brolsma, 2014; Rowell et al., 2016; West et

al., 1984). Scores on memory questionnaires are significantly correlated with scores on anxiety and depression measures across healthy adults and patient groups (Hall et al., 2009; Rowell et al., 2016; Yoon et al., 2019). However, evidence is equivocal regarding the link between affect and memory performance (Bouazzaoui et al., 2020; West et al., 1984). It has been suggested that memory evaluations may relate to affective states rather than actual ability and therefore screening for affective status is worthwhile when examining memory (West et al., 1984; Yoon et al., 2019). In addition, personality traits such as neuroticism and conscientiousness have been linked to memory evaluations (Pearman et al., 2014; Zelinski & Gilewski, 2004). Thus, perhaps both affect, and personality traits are worth considering alongside memory complaints.

2.7 Relationship Between Subjective and Objective Memory Measures

There is little consistency across previous research on the relationship between subjective memory evaluation and objective performance (Crumley et al., 2014; Reid & MacLullich, 2006). Some studies have found no correlation, whereas others have found only weak or moderate correlations between measures (Burmester et al., 2017; Schmidt et al., 2001). Meta-analyses have consistently revealed weak correlations between subjective and objective memory measures ($r < .20$) (Beaudoin & Desrichard, 2011; Crumley et al., 2014). There are several possible reasons for this discrepancy.

The low ecological validity of objective measures may influence the relationship between subjective and objective measures. Objective memory tests often have an element of learning information to be later tested which does not reflect learning in real life and is usually conducted in an environment with minimal to no distractions (Herrmann, 1982; Sander et al., 2018). In contrast, questionnaires prompt retrieval of past experiences and general ability (Ossher et al., 2013; Troyer & Rich, 2002). Even ‘ecologically valid’ objective tests such as

remembering a shopping list will differ in test settings compared to real life (Crumley et al., 2014). This is evidenced by nonsignificant or weak relationships between tests such as the Weschler Memory Scale and the Rivermead Behavioural Memory Test and subjective measures (Hall et al., 2009; Schmidt et al., 2001). Whereas external memory aids can be used in everyday situations, memory testing in lab situations often preclude this option (Bennett-Levy & Powell, 1980; Ossher et al., 2013; Troyer & Rich, 2002). Yet including the use of external aids in lab-based testing would introduce measurement issues regarding ceiling effects and not being able to truly measure objective memory (Crumley et al., 2014). Furthermore, when comparing subjective and objective memory, incompatible tests are often used where the objective measures have little reflection of memory tasks in everyday life (Davis et al., 1995; McMillan, 1984; Ponds & Jolles, 1996).

Another possible reason for the discrepancy is that subjective and objective measures may be examining different aspects of memory (Hall et al., 2009; Herrmann, 1982; Hultsch et al., 1985). While objective tasks require conscious recollection of information, questionnaires can invite retrieval of semantic information about memory ability and stereotypes (Schmidt et al., 2001). For example, free recall and recognition tests require concentrated learning of specific information with anticipated testing whereas questionnaire items ask about ability to remember or frequency of forgetting in various everyday situations (McMillan, 1984; Ossher et al., 2013; West et al., 1984). Thus, objective measures measure memory ability in a learning and lab-based context whereas subjective measures examine ability in everyday life (Crumley et al., 2014; Schmidt et al., 2001; West et al., 1984).

Finally, inaccurate reporting may influence the discrepancy between subjective and objective measures (Hall et al., 2009). Questionnaires generally rely on respondents' interpretation of

concept meanings and question understanding, where varying perceptions might influence outcomes (Mogle et al., 2021; Sunderland et al., 1983; Vogel et al., 2016). Additionally, individuals relying on stereotypes might negatively evaluate their memory ability even if objective performance is within a normal range (Kahn et al., 1975; Pearman et al., 2014; Troyer & Rich, 2002). Similarly, individuals with cognitive problems may underestimate or overestimate memory abilities if they are unable to accurately assess their abilities (Hall et al., 2009; Illman et al., 2015). In a different capacity, confounding memory with other cognitive domains can result in overreporting of problems as memory difficulties (Burmester et al., 2017; Hall et al., 2009).

The discrepancy between subjective and objective measures has important implications for the diagnosis and treatment of memory problems and the use of questionnaires. It has been argued that subjective reports cannot be used as a substitute for objective measures and that caution is warranted for use in clinical settings (Crumley et al., 2014; Garcia et al., 1998; Herrmann, 1982). However, it can also be argued that objective reports alone are not sufficient to examine everyday memory whereas self-report measures uncover important individual differences and information regarding an individual's concerns and feelings about their memory (Sugden et al., 2021; Troyer & Rich, 2002; van der Werf & Vos, 2011). Perhaps the best approach would then be to combine these measures in creating a memory profile (Herrmann, 1982; Poon et al., 1978).

2.8 Conclusions and Future Considerations

This review focused on three types of metamemory questionnaires. Self-efficacy questionnaires examine perceived ability in specific situations, complaints questionnaires assess memory difficulties in everyday life, and multidimensional questionnaires address multiple distinct aspects of metamemory. Individual differences such as knowledge/beliefs

about memory, ability to accurately evaluate memory, recent metamemory experiences, and affect can influence memory self-evaluations. Moreover, there are often discrepancies between reports and objective memory performance. Thus, several considerations arise for the design and use of memory questionnaires.

Many questionnaires were developed before the commonplace use of assistive technologies (e.g., mobile phones) and therefore warrant caution where questions about external memory aids exclude technology (Miller et al., 2020; Mogle et al., 2020). Additionally, some questionnaires have been criticised for limited relevance to clinical use where they include questions regarding public speaking, driving, and working that may be irrelevant to patients (Sander et al., 2018; Troyer & Rich, 2002). For example, questions derived from professional colleagues of researchers or healthcare professionals might not be applicable to patient groups who face different daily memory difficulties (Bennett-Levy & Powell, 1980; Youn et al., 2009). Perhaps ‘not applicable’ options might be helpful in determining where patient groups and healthy adults diverge in everyday memory problems (Sander et al., 2018). Thus, when developing memory questionnaires, it is essential to carefully consider the target respondents and the appropriate questions that would be relevant to their daily lives (Burmester et al., 2015; Vogel et al., 2016).

When selecting a questionnaire, it is important to consider the target respondents memory abilities. Although there is overlap among questionnaires, they are not interchangeable and invite different considerations when responding (Vogel et al., 2016). For example, multidimensional questionnaires are lengthy and may not be beneficial where a particular domain or aspect of memory is the focus (Crook et al., 1992; Troyer & Rich, 2002). Thus, when fatigue or memory impairment may impact responding, perhaps shortened versions or

companion reports can be used (Garcia et al., 1998; Vogel et al., 2016). On the other hand, brief questionnaires might not sufficiently reveal the depth of memory deficits in the same way as multidimensional questionnaires (McDonough et al., 2019; Mogle et al., 2021; Reid & MacLullich, 2006). Thus, there is a consideration to be made regarding length, accuracy, and the target respondents' abilities. When evaluating questionnaire responses, it is worth considering how individual differences influence memory evaluations and thus rehabilitation or training. Whereas some individuals respond based on past experiences to questionnaires using implicit theories about memory, others respond based on stereotypes or generalisations (Lineweaver & Hertzog, 1998; Pearman et al., 2014). Additionally, as outlined above, various individual difference factors can influence self-evaluations and vice versa. For example, whereas self-efficacy measures might be influenced by general perceptions, schemas, and stereotypes, complaints measures might be influenced by situation-specific outcomes (Ossher et al., 2013). Therefore, it is essential to examine responses with some level of caution.

In summary, metamemory questionnaires provide a standardised approach to examine memory beliefs, ability, and complaints. At present, the consensus is that subjective and objective measures should be combined to provide the most accurate memory profile. Memory questionnaires, if selected appropriately for the target audience and assessment purpose, are essential tools in research and clinical settings.

2.9 References

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2.10 Appendix

Questionnaires Beyond the Scope of This Review

Different questionnaires from the ones outlined above have been developed to address various aspects of memory or cognition in healthy adults and clinical populations. For example, questionnaires have been designed for use in educational settings or specific studies and examining cognitive failures or the impact of memory changes on daily life (Broadbent et al., 1982; Gilewski & Zelinski, 1986; Herrmann, 1982; Kahn et al., 1975; Shaikh et al., 2019; Zarit et al., 1981). In addition, there are specific patient groups and autobiographical memory questionnaires (Davis et al., 1995; Palombo et al., 2013; Smith et al., 2000; Sutin & Robins, 2007). Although an extensive evaluation is not within the scope of this review, a brief outline of some patient group and autobiographical memory questionnaires is provided here.

Patient Groups Questionnaires

Several questionnaires have been developed to examine subjective memory for dementia and acquired brain injury patients. To screen for Alzheimer's disease, Koss et al. (1993) developed the Short-Memory Questionnaire (Short MQ), which was derived from the Memory Self-Report Questionnaire (Riege, 1983). The Short MQ has been incorporated in clinical settings to distinguish between individuals with Alzheimer's disease and healthy older adults (Garcia et al., 1998; Maki et al., 2000; Montgomery et al., 2018). To examine the frequency of retrospective and prospective memory errors of Alzheimer's patients, their carers, and healthy adults, Smith et al. (2000) developed the Prospective and Retrospective Memory Questionnaire (PRMQ). The PRMQ is used to examine relationship between subjective evaluation and objective performance and prospective and retrospective memory ability across patient populations (Hogan et al., 2021; Kliegel & Jäger, 2006; Vaskivuo et al., 2018). To examine memory problems in everyday life that may impact older stroke patients,

the Subjective Memory Assessment Questionnaire (SMAQ) was developed, but is now considered to have poor reliability (Davis et al., 1995; Salis et al., 2019).

A different questionnaire, the Brief Assessment of Prospective Memory, a shortened version of the Comprehensive Assessment of Prospective Memory, was created for use with traumatic brain injury patients but has been expanded for use with stroke patients as well (Hogan et al., 2021; Man et al., 2011, 2015). In a broader scope, the Evaluation of Everyday Memory Questionnaire was created to capture everyday memory instances of acquired brain injury patients and includes a companion version (Tropp et al., 2015). These questionnaires target specific groups, but some have been extended for use with other patient groups. In addition, these questionnaires tend to be relatively short as they target groups who may not be able to engage with longer measures (Sugden et al., 2021). Evidently, memory problems vary across populations, which should be considered when designing and selecting questionnaires for use.

Autobiographical Memory Questionnaires

Autobiographical questionnaires examine memory for past personal events (Clark & Maguire, 2020). A well-established questionnaire, the Memory Characteristics Questionnaire (MCQ), was designed to examine ratings of memory characteristics such as visual detail, spatial and temporal information, and feelings (Johnson et al., 1988). Similar to the MCQ, the Autobiographical Memory Questionnaire (AMQ) was derived from autobiographical and memory theories to examine the phenomenological characteristics of autobiographical memories including recollection, vividness, and belief in the memory's accuracy (Rubin et al., 2003; Talarico et al., 2004).

Another widely used questionnaire, the Memory Experiences Questionnaire (MEQ), was developed to examine the dimensions of autobiographical memory with a shortened version for time-limited situations (Luchetti & Sutin, 2016; Sutin & Robins, 2007). To examine individual differences in trait mnemonics, the Survey of Autobiographical Memory (SAM) was created with several subscales and a brief version developed for epidemiological research (Palombo et al., 2013). Another questionnaire, the Autobiographical Memory Characteristics Questionnaire (AMCQ) was developed to assess characteristics of autobiographical memories with 14 subscales (Boyacioglu & Akfirat, 2015). More recently, the Assessment of the Phenomenology of Autobiographical Memory (APAM) measure was created to address phenomenology of autobiographical memory with healthy adults and clinical populations with a web version for online self-administration (Vannucci et al., 2020, 2021).

These questionnaires have been used in a variety of studies examining false memories, aging, and cognitive decline (Fan et al., 2020; Mather et al., 1997; Siedlecki et al., 2015). These questionnaires share several characteristics and have generally built upon each other to fill gaps and address different aspects of autobiographical memory, which allows for targeted use depending on aims of the assessment.

3 Memory after stroke: A survey of healthcare professionals across England

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Abstract

Memory is commonly affected after a stroke and complaints of memory problems in everyday life are frequent among stroke patients. Memory impairments resulting from stroke can negatively impact ability to complete activities of daily living and should therefore be addressed along the stroke care pathway. However, it is unclear to what extent memory is currently being addressed, as it often falls under the general umbrella of cognitive functioning. Thus, it is essential to further examine the current clinical practices regarding assessment to treatment of memory across the stroke clinical care pathway. We conducted an online survey of healthcare professionals across England to obtain information of assessment methods and tests, the frequency and impact of memory impairment after stroke, and treatment methods and strategies that are currently in use. The results demonstrated a wide range of standardised and unstandardised cognitive measures in memory assessment, frequent memory problems among patients with moderate impact on activities of daily living, and a variety of treatment options being implemented.

3.1 Introduction

Cognitive domains including attention, language, and memory are often impaired following a stroke (Al-Qazzaz et al., 2014; Clarke & Forster, 2015; Hochstenbach et al., 1998; Jokinen et al., 2015; Leśniak et al., 2008; Nakling et al., 2017; Schaapsmeerders et al., 2013). While these domains interact with each other and are frequently addressed together under the umbrella of cognitive functioning, it is important to distinguish between them to appropriately assess, label, and treat impairments (Cumming et al., 2013; Jokinen et al., 2015; Nowell et al., 2020; Nys et al., 2005). Memory is impacted for at least one-third of stroke patients and memory problems are among the most common subjective cognitive complaints (das Nair et al., 2016; Hochstenbach et al., 1998; McKevitt et al., 2011; Snaphaan & de Leeuw, 2007; van Rijsbergen et al., 2014). Memory impairment can result in longer hospital stays, reduced quality of life, and can impact ability to perform activities of daily living (Al-Qazzaz et al., 2014; Fitri et al., 2020; Intercollegiate Stroke Working Party, 2016; Pilegaard et al., 2014). Clinical guidelines indicate that memory should be assessed alongside other cognitive functions using standardised measures and treated with cognitive rehabilitation strategies along the stroke care pathway (Clarke & Forster, 2015; Intercollegiate Stroke Working Party, 2016; NICE, 2013). However, the approaches used in clinical practice may vary based on availability and cost of assessments and treatments, training and experience of healthcare professionals, and patient needs (Brainin et al., 2014; Quinn et al., 2018). Furthermore, previous research has identified the need to improve understanding of and care provision relating to cognitive impairments after stroke (Pollock et al., 2014; Tang et al., 2017). Thus, further examination of the current clinical practices regarding assessment and treatment of memory after stroke and the impact of memory problems on daily life is warranted.

3.1.1 Memory Assessment

Adequate assessment of memory after stroke is necessary to provide appropriate support and rehabilitation before and after discharge from the hospital (Edwards et al., 2006; Intercollegiate Stroke Working Party, 2016; Pilegaard et al., 2014; Quinn et al., 2018; Shendyapina et al., 2020). Standardised assessments such as cognitive screens and domain-specific assessments have validated psychometric properties and well-defined administration and scoring protocols whereas non-standardised assessments include observations of patient behaviour and unstructured interviews with patients or relatives (Quinn et al., 2018; Sansonetti & Hoffmann, 2013; Stigen et al., 2017). Clinical guidelines indicate that cognitive screening using standardised measures should occur within six weeks of stroke diagnosis to rapidly assess areas of need to be targeted for further detailed assessment and intervention (Cullen et al., 2007; Gillham & Clark, 2011; Teasell et al., 2020).

A variety of screening tools are available to assess cognition such as the commonly used Montreal Cognitive Assessment (MoCA) and Mini-mental State Examination (MMSE) (Burton & Tyson, 2015; Cullen et al., 2007; Koh et al., 2009; Lees et al., 2012, 2014; Shendyapina et al., 2020; Stigen et al., 2017). Based on the results of the cognitive screening, patients may be referred to an appropriate specialist for further testing with neuropsychological batteries or domain-specific assessments (Brainin et al., 2014; Cullen et al., 2007; Edwards et al., 2006; Fitri et al., 2020; Gillham & Clark, 2011; Quinn et al., 2018). Memory assessments can include various recognition and recall tasks relevant to everyday life, e.g., for names and appointments (Al-Qazzaz et al., 2014; Cullen et al., 2007; Harris & Sunderland, 1981; Hochstenbach et al., 1998; Nakling et al., 2017).

Healthcare professionals often use a combination of standardised and non-standardised approaches to assess cognition (Cullen et al., 2007; Harris & Sunderland, 1981; Korner-

Bitensky et al., 2011; Lees et al., 2014; Pilegaard et al., 2014; Sansonetti & Hoffmann, 2013; Stigen et al., 2017; Wright & Lindesay, 1995). Lees et al. (2014) found that 85% of respondents in a survey of Scottish stroke units routinely assessed cognition in the first/acute admission stage, often with the MMSE. However, there was a wide range of cognitive screening measures and non-standardised measures such as observation and informal questioning used across the country (Lees et al., 2014). Past research has revealed that assessments are selected based on a variety of factors, including established practices within a unit, availability or cost, training, time constraints, and the effects of other physical or cognitive deficits (Brainin et al., 2014; Harris & Sunderland, 1981; Quinn et al., 2018; Sansonetti & Hoffmann, 2013; Stigen et al., 2017).

3.1.2 Impact of Memory Deficits

Memory deficits are among the most common cognitive impairments occurring after stroke (Hochstenbach et al., 1998; Jokinen et al., 2015; Leśniak et al., 2008; Pappadis et al., 2019; Park et al., 2017; Schaapsmeerders et al., 2013; Snaphaan & de Leeuw, 2007; Yang et al., 2020). Although some improvements can occur through spontaneous recovery, memory impairments can persist for years and may facilitate decline to dementia (Censori et al., 1996; Elliott & Parente, 2014; Fitri et al., 2020; Schaapsmeerders et al., 2013; Yang et al., 2020; Zucchella et al., 2014). However, physical deficits, executive function, and attention impairments may be prioritised in the initial stages of stroke care due to their visibility and impact on functioning (Al-Qazzaz et al., 2014; Brainin et al., 2014; Burton & Tyson, 2015; Fitri et al., 2020; Nys et al., 2005; Pilegaard et al., 2014; Tang et al., 2017). Thus, memory problems may become apparent at a later stage once a patient has stabilised medically or when attempting to resume daily activities such as working (Edwards et al., 2006; Quinn et al., 2018; Stroke Association, 2017).

Previous research has demonstrated that memory impairment can negatively impact performance on instrumental (e.g., washing and dressing) and extended (e.g., community and social participation) activities of daily living (Fitri et al., 2020; Middleton et al., 2014; Oros et al., 2016; Walker et al., 2003). Furthermore, memory and other cognitive impairments post-stroke are related to reduced functional independence in daily life (Fitri et al., 2020; Jokinen et al., 2015). In a study by Jokinen et al. (2015), memory impairments were present among the majority of patients three months post-stroke and were significantly related to functional dependence at a 15-month follow-up. Additionally, qualitative data have shown that memory impairments negatively impact both patients and caregivers in completing daily tasks and engaging in social situations (Tang et al., 2020). In addition to memory ability, stroke can negatively impact mood such as anxiety and depression (Evans et al., 2020; Kneebone & Lincoln, 2012; Nakling et al., 2017; Pappadis et al., 2019; Tang et al., 2020). Furthermore, anxiety or depression may influence subjective memory complaints (Evans et al., 2020; Tropp et al., 2015). On the other hand, it is possible that experiencing memory problems can affect anxiety and depression (Lo Buono et al., 2018; Tropp et al., 2015). For example, memory deficits may result in fear of developing dementia (Tang et al., 2019). Furthermore, frustration can arise for patients and carers who must adapt to new challenges in daily life (Evans et al., 2020; Tang et al., 2020). In a different capacity, it is possible that some patients may have limited awareness of memory failures and thus experience little to no mood changes in relation to their memory (Hogan et al., 2016; Wheeler et al., 2022).

3.1.3 Treatment of Memory Deficits

Memory impairment can be treated with rehabilitation to reduce the impact on daily life and improve functional outcomes (das Nair et al., 2016; Gopi, Wilding, et al., 2022b; Kneebone & Lincoln, 2012). Rehabilitation is expected to involve assessment of needs, goal setting, intervention, and reassessment to examine progress, beginning during inpatient care and

continuing in outpatient departments or in patients' homes where necessary (Gillham & Clark, 2011; Intercollegiate Stroke Working Party, 2016; Langhorne et al., 2011; NICE, 2013; Scobbie et al., 2015). Clinical guidelines recommend the use of errorless learning, mnemonics, and compensatory techniques such as electronic reminders or written checklists (Intercollegiate Stroke Working Party, 2016; NICE, 2013). In addition, addressing awareness of the memory deficit and psychoeducation are increasingly important facets of rehabilitation (das Nair et al., 2016; NICE, 2013; Wheeler et al., 2022).

Memory rehabilitation can be used to restore function to a pre-morbid level (restorative approach), learn specific information (knowledge acquisition approach), adapt to the memory deficits (compensatory approach), or to address emotional, psychological, and cognitive deficits (holistic approach) (Cumming et al., 2013; das Nair et al., 2016; Gopi, Wilding, et al., 2022b; Koh et al., 2009; Korner-Bitensky et al., 2011; van Heugten & Wilson, 2021). Computer-assisted cognitive rehabilitation in the restorative approach shows some promise but requires considerations of computer literacy and training (Cicerone et al., 2000; De Luca et al., 2018). Knowledge acquisition strategies such as errorless learning improve memory for trained tasks but have limited generalization to untrained tasks (Clare & Jones, 2008; Piras et al., 2011). Mnemonic compensatory aids are recommended for use with mild impairment whereas assistive technologies are recommended for use with moderate to severe memory impairment (das Nair et al., 2016; Pino, 2015). The holistic approach that includes compensatory strategies and a therapeutic component is becoming more widespread due to improvements in psychosocial well-being (Cicerone et al., 2019; van Heugten & Wilson, 2021).

In a survey of clinical practices across memory rehabilitation units and centres in Britain, Harris and Sunderland (1981) found that a range of rehabilitation techniques were mentioned

across restorative and compensatory approaches, with external memory aids being the most frequently used strategy. Respondents most often indicated that their goal with strategy use was to teach patients to cope with everyday memory problems (Harris & Sunderland, 1981). Rehabilitation approaches and techniques used in current clinical practice may depend on the experience or training of the healthcare professional administering the rehabilitation, the resources available, practices within a particular unit, and the needs of the stroke patient (DeJong et al., 2005; Harris & Sunderland, 1981; Shendyapina et al., 2020; Tang et al., 2017). Furthermore, the method of administration of memory rehabilitation within clinical settings remains unclear.

3.2 Present Study

It is essential to explore current clinical practices to evaluate effectiveness, examine potential avenues for research, and improve service provision within clinical settings (Shendyapina et al., 2020; Stigen et al., 2017; Stringer, 2003). Although guidelines provide recommendations, current clinical practices that fall under umbrella terms such as *cognitive assessment* and *rehabilitation* limit understanding of how specific domains are addressed. Cognitive screens contain memory components, but it is unclear the extent to which targeted memory assessments inform diagnosis and rehabilitation. Further examination of the frequency of memory deficits and their impact on activities of daily living and mood is also warranted because memory deficits may become apparent later than other deficits and affect functional dependence and different aspects of mood. Numerous treatment options exist to approach memory deficits, yet the strategies used in current clinical practice require further elaboration.

Previous research involving surveys of healthcare professionals have been conducted in a variety of countries with different regulations, have examined cognition, included mixed aetiologies, focused on assessment methods, or focused on specific healthcare professional

roles (Harris & Sunderland, 1981; Koh et al., 2009; Sansonetti & Hoffmann, 2013; Shendyapina et al., 2020; Stigen et al., 2017; Stringer, 2003; Wheatley, 1994). This study explored memory assessment, the impact of memory deficits on activities of daily living and mood, and treatment of memory problems after stroke throughout the continuum of care in England from the perspective of healthcare professionals working in stroke care. The research questions were (1) How is memory assessed after stroke? (2) What is the prevalence and impact of memory problems in stroke patients? (3) How are memory deficits treated? (4) Which healthcare professionals are involved in the assessment to treatment of memory after stroke?

3.3 Methods

3.3.1 Survey Development

The survey was developed based on previous surveys of healthcare professionals, survey development guidelines, advice from professionals in stroke care, and expected current clinical practices based on stroke care guidelines (Aday & Cornelius, 2006; Burns et al., 2008; Intercollegiate Stroke Working Party, 2016; Kelley et al., 2003; NICE, 2013). Following from the structure of previous surveys examining cognitive rehabilitation (Lees et al., 2014; Shendayapina et al., 2020), this survey was designed to include multiple choice options with distinct sections targeted to assessment, impact, and treatment of memory after stroke. These sections were selected because, as outlined in the introduction, there are gaps in the literature regarding how memory is addressed after stroke in clinical practice, and it is unclear whether clinical guidelines are being adhered to. Furthermore, past surveys of healthcare professionals have generally examined management of cognitive functions in general or targeted occupational therapists alone (Geraghty et al., 2020; Lees et al., 2014). Here, the purpose was to focus on assessment, impact, and treatment specific to memory after stroke, therefore, the questions and response options (e.g., methods of assessment and

treatments) were adapted from previous surveys but reworded to focus specifically on memory assessment (Harris & Sunderland, 1981; Lees et al., 2014). For example, Harris and Sunderland (1981) asked open-ended questions about the methods of assessment used in rehabilitation centres and hospitals for memory deficits and strategies and treatments used to help patients with memory problems. Here, we formulated a list of memory assessments and rehabilitation strategies from previous research and clinical guidelines to develop the list of response options (Harris & Sunderland, 1981; Intercollegiate Stroke Working Party, 2016). Thus, the specificity of the questions and responses across the sections were developed from previous surveys and built upon each other to address gaps in the literature. Like previous surveys, we also included a 'demographic' section to help to classify the respondents and their role along the stroke care pathway (Harris & Sunderland, 1981; Lees et al., 2014). Finally, we included wording definitions as well as "I don't know" and 'other' response options with open-ended text boxes across multiple choice questions to allow respondents to provide additional information, in line with recommendations from survey development guidelines (Burns et al., 2008).

The survey was piloted with four healthcare professionals who provided suggestions on the wording and response options. Changes to the questionnaire included clarifying the definition of memory, making the questions more direct, using familiar language from national clinical guidelines or the Stroke Association, and including examples. Following revisions, the survey was reviewed by two healthcare professionals in stroke care. The final version was expected to take a maximum of 15 minutes to complete. There was no time limit and participants could leave and return to complete the survey within a four-week period using an anonymous link. The self-administered online questionnaire consisted of 26 questions divided into four subsections: (1) respondent demographic characteristics, (2) assessment of memory problems,

(3) impact of memory problems, and (4) treatment of memory problems. There were 16 multiple choice options that allowed multiple responses. Most multiple choice questions included an ‘I don’t know’ and an ‘other (please specify)’ option with an open-ended response box. There were three open-ended responses and seven analogue slider responses. Operational definitions of keywords such as memory and relevant examples were provided to reduce potential ambiguity or misinterpretations (Burns et al., 2008). See Appendix A for survey questions and response options.

3.3.2 Procedure

The questionnaire was conducted through Qualtrics and was open to anyone with no password requirements. Respondents read an information sheet and provided informed consent and then navigated through the four sections using *next* and *back* buttons. Respondents were informed that they could withdraw from the questionnaire at any point by closing their browser. At the end of the questionnaire, the respondents had the opportunity to provide their email address or contact the researchers if they were interested in further discussing memory after stroke. All data were anonymised, and any email addresses provided at the end were separated from responses. The survey was open from June 2021 to October 2021. This study was approved by the School of Psychology Research Ethics committee.

3.3.3 Survey Distribution

The inclusion criteria were healthcare professionals who work in stroke care across England. It was expected that participants would have direct clinical experience with stroke patients and provide information based on observations and experiences in current clinical practices. The exclusion criteria were stroke patients and carers. Recruitment included a mixture of convenience and snowball approaches (Aday & Cornelius, 2006; Burns et al., 2008; Kelley et al., 2003). Professional networks/bodies of healthcare professionals were contacted by email

to distribute the survey link through their email lists or newsletters (see Appendix B). Follow-up emails were sent within one month if no response was received. The survey link was posted twice to Twitter by the researchers and emails were sent to colleagues with the link. Three survey links with different source identifiers (i.e., professional networks, social media, emails to colleagues) embedded in the link to the same landing page were distributed to examine the source of responses.

3.3.4 Data Analysis

Data were downloaded from Qualtrics and examined with JASP (Version 0.16) (JASP Team, 2021). This study was exploratory and, as such, we examined the frequency of responses for each question across respondents who completed the entire survey.

3.4 Results

The survey link was clicked 64 times with 53 (83%) of the clicks from the link sent to professional networks and 11 (17%) from the social media link. Of the total clicks on the link, 48 (75%) of the respondents provided informed consent and 46 (72%) completed the entire survey. Of those who completed the entire survey, 40 (87%) were recruited from professional networks and 6 (13%) from social media. The results were examined for participants who completed the entire survey (n = 46).

3.4.1 Demographics

Professional affiliations of the respondents who completed the survey are displayed in Table 1. Half of the respondents were occupational therapists (OT) with the other half including nurses, clinical psychologists, physiotherapists, and a stroke physician. ‘Other’ responses included a rehabilitation physician, a rehabilitation medicine physician and researcher, a lead psychological practitioner, and a stroke specialist nurse who was counted in the ‘nurse’

category. As half of the sample consisted of OTs, the frequency of responses was also examined separately for the OT-only sample (n = 23). This is in line with previous research demonstrating that OTs are at the forefront of the stroke care pathway and interact with stroke patients across all stages of care, which is a reason why they have been a target group for similar questionnaires (Korner-Bitensky et al., 2011; Lees et al., 2014; Stringer, 2003). Given that OTs are considered to have a significant role in stroke care and that this was reflected in the sample that participated in this survey, we examined the responses from the OT separately in addition to examining the entire sample.

Table 2 shows the frequency of responses for the stage of care. Across the entire sample, less than half of the respondents indicated that they work in inpatient acute care and inpatient rehabilitation, whereas more than half of the respondents selected community rehabilitation. Thirteen (28%) respondents selected more than one option for stage of care (excluding 'other' responses). There was a similar pattern for the OT sample with more respondents working in community rehabilitation than inpatient acute care or inpatient rehabilitation. Three (13%) OTs work in multiple stages of care. 'Other' responses revealed that some respondents also conduct stroke reviews at six-month follow-up (Appendix C).

Table 1

Professional affiliation of respondents.

Professional affiliation (n = 46)	Frequency n (%)
Occupational therapist	23 (50)
Nurse	9 (20)
Clinical psychologist	5 (11)
Physiotherapist	5 (11)
Stroke physician	1 (2)
Other	3 (7)

Table 2

Frequency of responses for stage of care.

Stage of care	All respondents (n = 46)	Occupational therapists (n = 23)
	n (%)	
Inpatient acute care	19 (41)	6 (26)
Inpatient rehabilitation	20 (43)	7 (30)
Community rehabilitation	26 (57)	14 (61)
Other	4 (9)	1 (4)

Respondents were asked how often they work with stroke patients. Across the entire sample, 24 (52%) respondents see stroke patients daily, 17 (37%) see patients on a weekly basis, and 5 (11%) see patients monthly. Two respondents (4%) selected more than one response. There was an average of 11.27 years (*SD* = 7.82) of experience working with stroke patients, ranging from 9.6 months to 30 years. In the OT sample, 12 (52%) respondents see stroke patients daily, 10 (43%) see patients weekly, and 1 (4%) sees patients monthly. There was an average of 10.97 years (*SD* = 6.40 years) of experience working with stroke patients, ranging from 9.6 months to 30 years. 'Other' responses revealed that patients are also seen again at the six months post-stroke follow-up (Appendix C).

3.4.2 Assessment

Respondents were asked if they follow a standardised routine or formal process to assess memory for each patient that is seen. Across the entire sample, 41 (89%) respondents indicated that there is a formal process whereas 5 (11%) indicated they do not follow a standardised process in their workplace. Across OTs, 21 (91%) indicated that they follow a standardised assessment process within their workplace for memory after stroke, while 2 (9%) indicated that they do not. The responses of the respondents who do not follow a standardised process are shown in Appendix D. Since only a few respondents do not follow a standardised process and the results were comparable to those who followed a standardised process, the responses were examined together.

The methods used in the workplace to assess memory are shown in Figure 1a for the entire sample (*n* = 46) and the OT sample (*n* = 23). Across both samples, most of the respondents indicated that cognitive screens, patient observations, and interviews with patients or relatives are used to assess memory. Two 'other' responses about the MoCA and the Oxford Cognitive

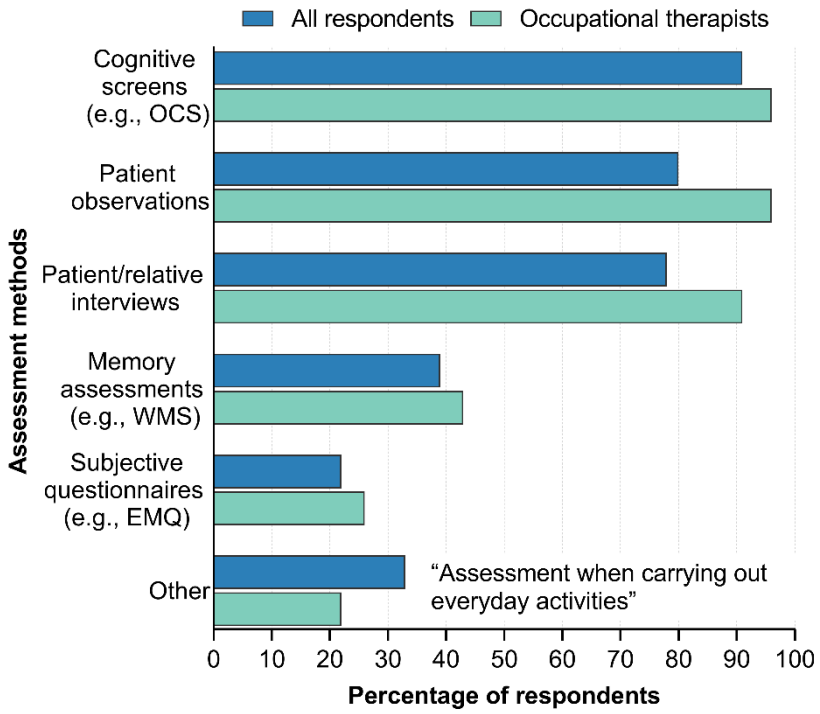
Screen (OCS) where no additional response option was selected were counted under the 'cognitive screens' category. Less than half of the respondents in both samples selected detailed memory assessments or subjective questionnaires. Across the entire sample, 35 (85%) respondents selected more than one response (excluding 'I don't know' and 'other' responses) and in the OT sample, 22 (96%) respondents indicated that more than one method is used to assess memory. 'Other' responses mentioned that functional assessments are considered as part of the memory assessment (Appendix C).

The standardised tests used in clinical practice are shown in Figure 1b. Across the entire sample, more than half of the respondents selected the OCS and MoCA, while less than half selected other cognitive screens such as Addenbrooke's Cognitive Examination-Revised (ACE-R) and detailed memory tests such as the Rivermead Behavioural Memory Test. Most respondents (70%) selected more than one standardised assessment. Across the OT sample, most of the respondents use the OCS, more than half selected the ACE-R, and less than half selected other cognitive screens such as the MoCA and detailed memory assessments such as the Weschler Memory Scale. Most OTs (76%) indicated that more than one standardised assessment is used. In addition to the seven tests that were selected in the options presented, 15 other tests including the Repeatable Battery for the Assessment of Neuropsychological Status were mentioned in the 'other' responses (Appendix C).

Figure 1

Assessment methods (1a) and tests (1b) used for all respondents (*n* = 46) and the OT sample (*n* = 23). Examples are shown for 'other' responses. EMQ = Everyday Memory Questionnaire; OCS = Oxford Cognitive Screen; MoCA = Montreal Cognitive Assessment; ACE-R = Addenbrooke's Cognitive Examination-Revised; RBMT = Rivermead Behavioural Memory Test; MMSE = Mini-mental state examination; WMS = Weschler Memory Scale; RAVLT = Rey Auditory Verbal Learning Test.

a. Assessment methods



b. Standardised tests

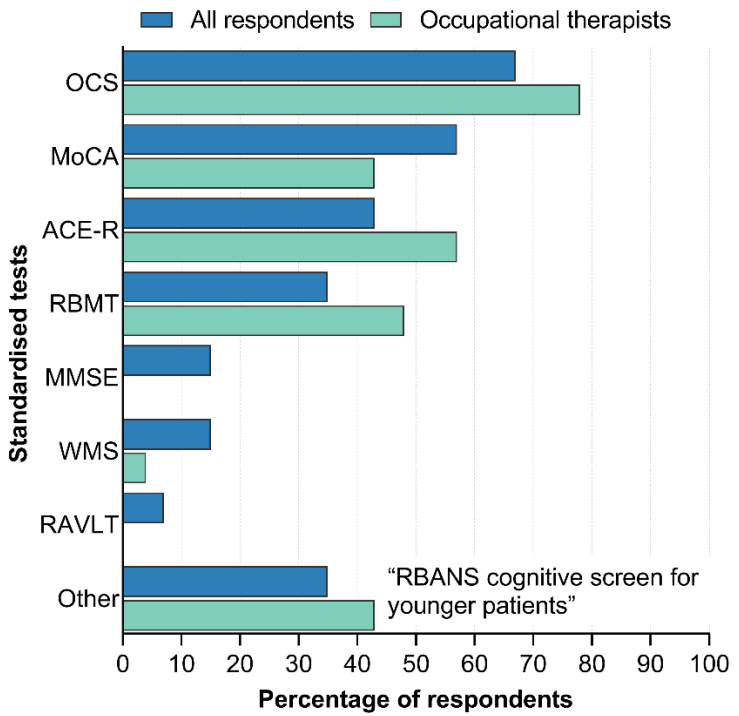


Table 3 shows the reasons for selecting assessments to examine memory. In the entire and OT samples, most respondents indicated that test selection is tailored to patient needs (e.g., to accommodate other deficits). More than half of the respondents selected time to complete (e.g., to prevent fatigue) and less than half selected availability of tests (e.g., test available in the department). Across the entire sample, more than half of the respondents (59%) selected more than one reason, and across the OT sample, most of the respondents (70%) indicated that more than one reason is considered when selecting assessments. 'Other' responses revealed that tests are selected to be part of the assessment based on evidence-based guidelines and recommendations, cost, and license to use in the UK (Appendix C).

Table 3

Reasons reported for selecting assessments.

Reason	All respondents (n = 46)	Occupational therapists (n = 23)
	n (%)	
Tailored to patient needs	37 (80)	19 (83)
Time to complete	25 (54)	15 (65)
Availability of tests	18 (39)	10 (43)
I don't know	3 (7)	0
Other	8 (17)	5 (22)

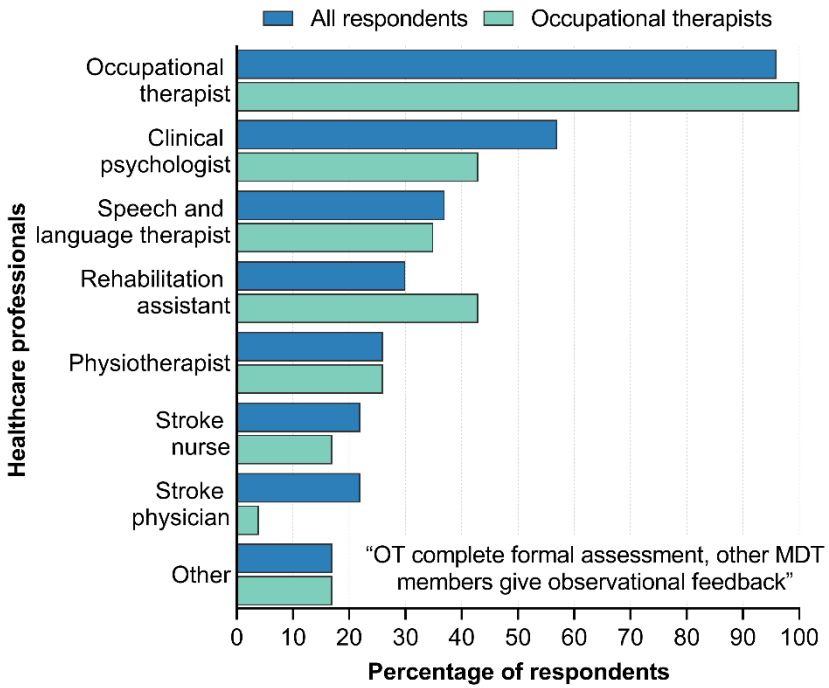
Respondents were asked which healthcare professionals are involved in assessing memory. Figure 2a shows the frequency of responses. Most of the respondents in the entire sample indicated that occupational therapists are involved in assessment. More than half of the respondents selected clinical psychologists, whereas less than half of the respondents selected other professions such as speech and languages therapists and rehabilitation assistants. Most respondents (80%) selected more than one response. All OTs indicated that OTs are involved

in assessing memory, while less than half of the respondents selected other professions, such as clinical psychologists and physiotherapists. Most of the OTs (70%) indicated that more than one healthcare professional is involved in memory assessment. ‘Other’ responses mentioned that occupational therapists often lead the assessment with other team members encouraged to provide feedback (Appendix C).

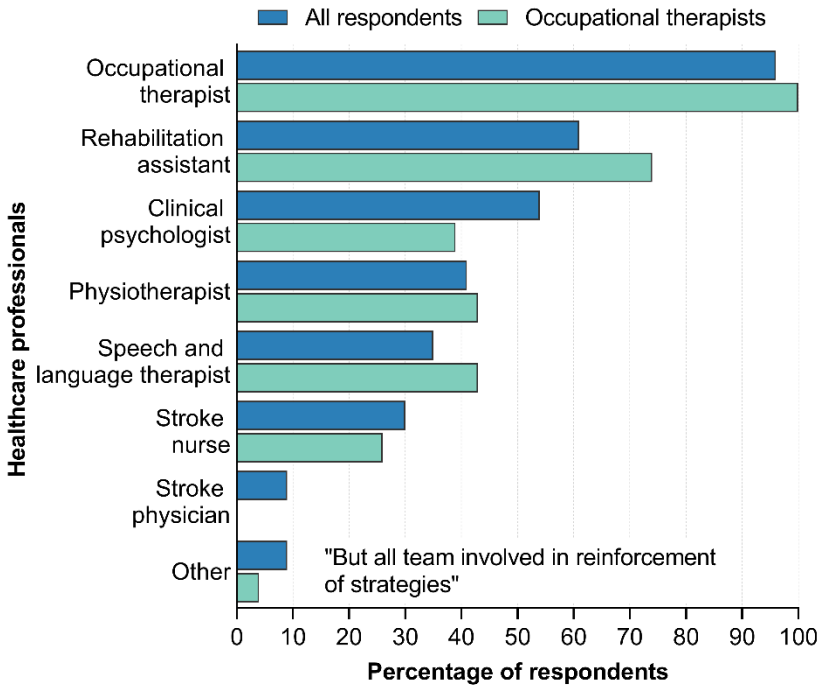
Figure 2

Multidisciplinary team members involved in memory assessment (2a) and treatment of memory deficits (2b). for the entire sample (n = 46) and the OT sample (n = 23).

2a. Assessment



2b. Treatment



3.4.2.1 Unstandardised Approach

The respondents who indicated that there is no formal or standardised approach to assessing memory for stroke patients (n = 5) were asked about the approach in their workplace in an open-ended question (see Appendix D for responses to other questions). Three respondents provided answers:

- Clinical psychologist in community rehabilitation: “It will be dependent on the aim of the interventions for the client. If memory problems, or cognitive problems more broadly, have been identified as an issue and we have agreed that assessment of these will be helpful for informing rehabilitation then some form of neuropsychometric assessment will take place. The assessments used will be dependent on how detailed/sensitive we need the information to be and so will differ from case to case.”
- Clinical psychologist in inpatient rehabilitation: “Cognitive screen. Detailed neuropsychological assessment (if able to participate). Personalised assessments when identified. Functional assessment for all patients”
- Occupational therapist in community rehabilitation: “Specific client-centred assessments as needed”

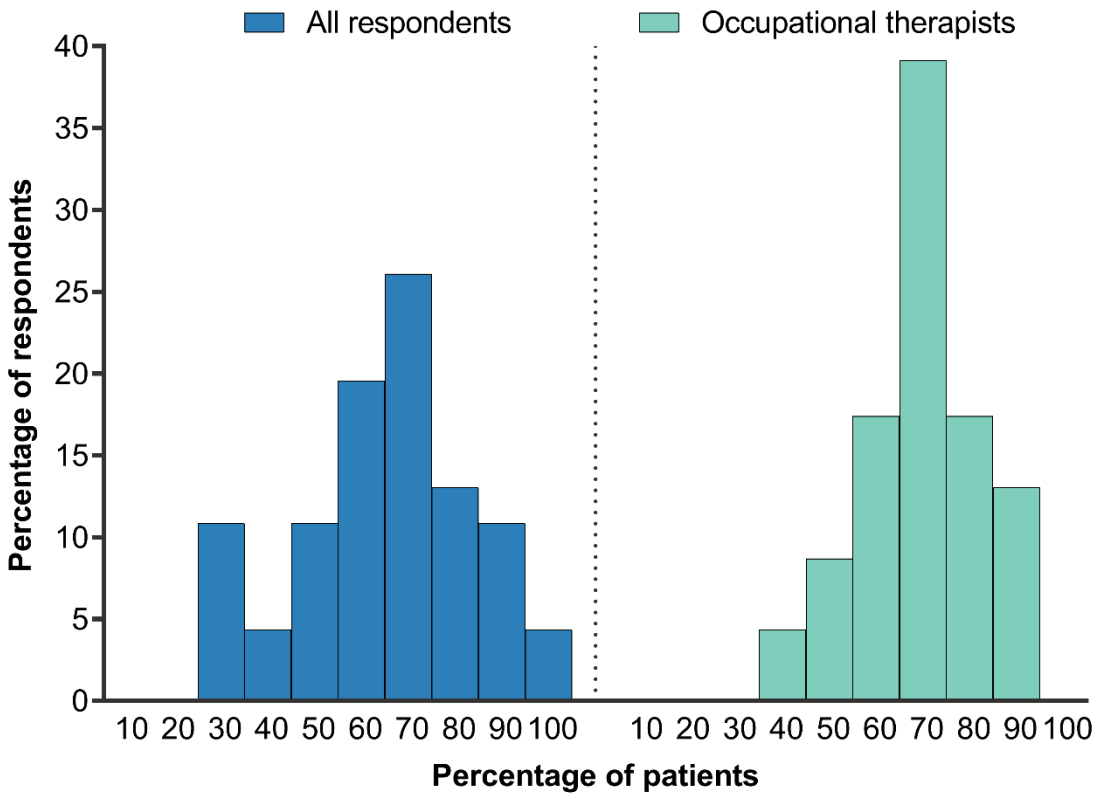
3.4.3 Impact of Memory Deficits

3.4.3.1 Prevalence

Figure 3 shows the frequency of memory problems across patients that are seen. Across all respondents, memory problems are present in 21% to 100% of the patients that are seen (*M* = 61.65, *SD* = 17.78). Across the OT sample, memory problems are present in 31% to 90% of the patients that are seen (*M* = 65.70, *SD* = 12.69).

Figure 3

Percentage of patients seen by respondents with memory problems for all participants (*n* = 46) and for OTs only (*n* = 23).



The frequency of responses for the types of memory problems experienced by patients is shown in Table 4. Across both samples, most respondents indicated that the patients they see experience short-term, prospective, and learning problems. Definitions and examples were provided to respondents in the questionnaire for short-term (the ability to hold small amounts

of information for a limited time, e.g., information in a conversation), retrospective (memory for past experiences, e.g., a childhood birthday party or general knowledge, e.g., the names of shapes), prospective (memory for planned actions in the future, e.g., to take medication), procedural (memory for how to perform actions, e.g., using a mobile phone), and learning (acquisition of new or lost knowledge, e.g., learning about stroke). The inclusion of 'learning' memory problems was based on a suggestion from a healthcare professional during survey development who indicated that learning and relearning information was an important aspect of stroke care that is differentiated from the other types of outlined memory by the necessity of acquiring new or lost information. More than half of the respondents selected procedural memory problems, whereas few respondents indicated that patients experience retrospective memory problems. All respondents (100%) in both samples indicated that more than one type of memory problem is observed in patients. 'Other' responses mentioned the impact of executive function and dementia (Appendix C).

Figure 4 shows the percentage of patients who experience short-term (4a), prospective (4b), learning (4c), and procedural (4d) memory problems according to the respondents who selected each type of memory problem. Across the entire sample, respondents who selected short-term memory problems (n = 43) indicated that between 11% and 100% of the patients that are seen have short-term memory problems (M = 54.21, SD = 19.82). Respondents who selected prospective memory problems (n = 43) indicated that problems are present in up to 100% of the patients that are seen (M = 48.42, SD = 22.12). The respondents who selected learning problems (n = 37) indicated that problems are present in up to 100% of the patients seen (M = 44.57, SD = 23.71). Respondents who selected procedural memory problems (n = 30) indicated that problems are present in up to 90% of the patients that are seen (M = 35.83, SD = 21.97).

OTs who selected short-term memory problems (*n* = 22) indicated that problems are present in 11% - 90% of the patients seen (*M* = 56.05, *SD* = 18.97). OTs who selected prospective memory problems (*n* = 22) indicated that problems are present in up to 80% of the patients that are seen (*M* = 47.41, *SD* = 18.42). OTs who selected learning problems (*n* = 21) indicated that problems are present in up to 90% of the patients that are seen (*M* = 43.81, *SD* = 23.21). Finally, OTs who selected procedural problems (*n* = 14) indicated that problems are present in up to 70% of the patients that are seen (*M* = 32.93, *SD* = 20.05).

Table 4

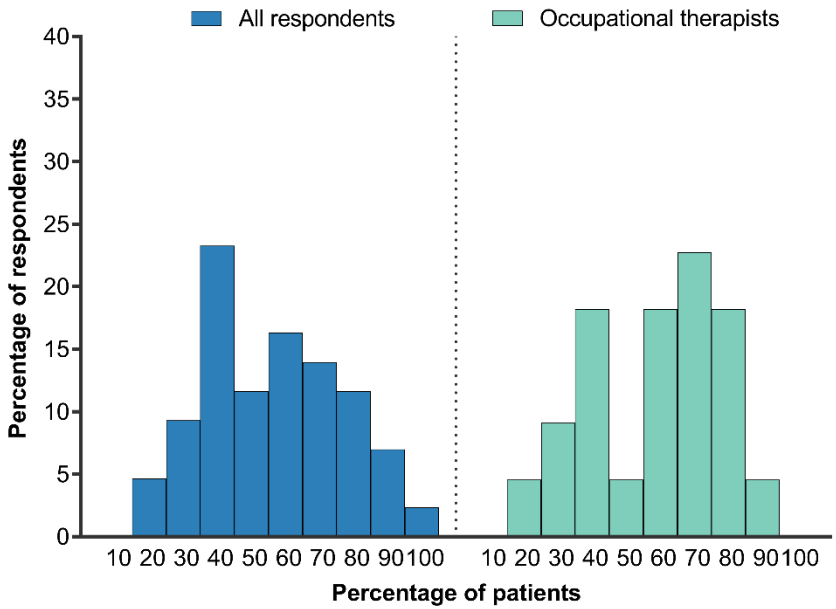
Types and percentage of patients with memory problems.

Memory type	All respondents (*n* = 46)	Occupational therapists (*n* = 23)
	n (%)	
Short term	43 (93)	22 (96)
Prospective	43 (93)	22 (96)
Learning	37 (80)	21 (91)
Procedural	30 (65)	14 (61)
Retrospective	7 (15)	3 (13)
Other	4 (9)	2 (9)

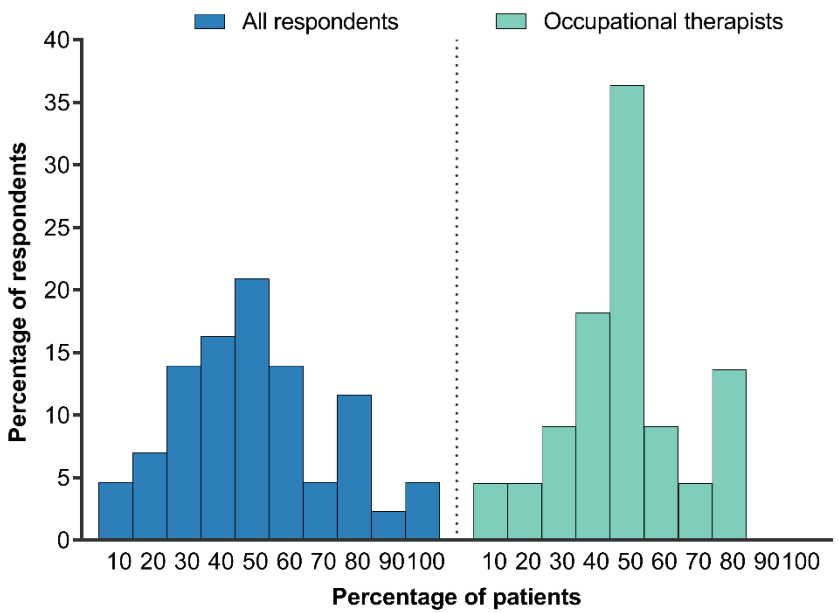
Figure 4

Prevalence of short-term (4a), prospective (4b), learning (4c), and procedural (4d) memory problems.

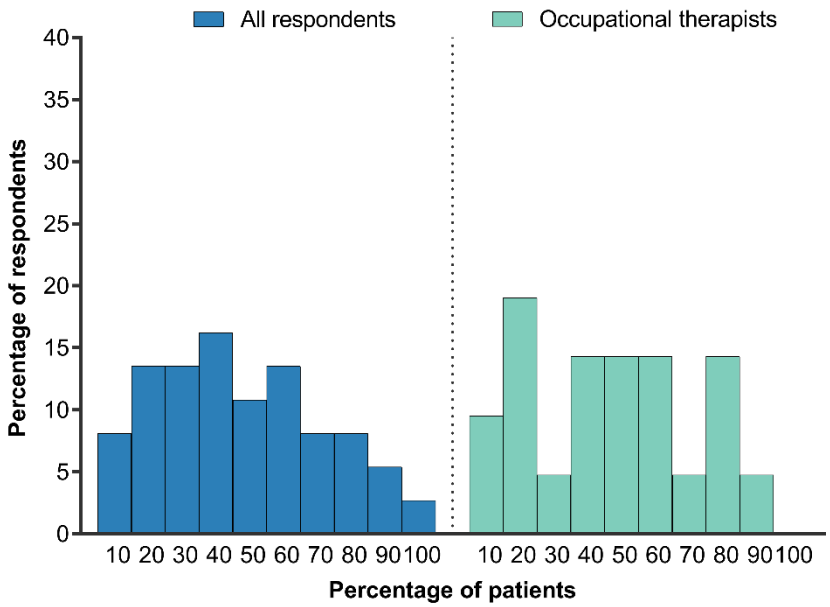
4a. Short-term memory problems



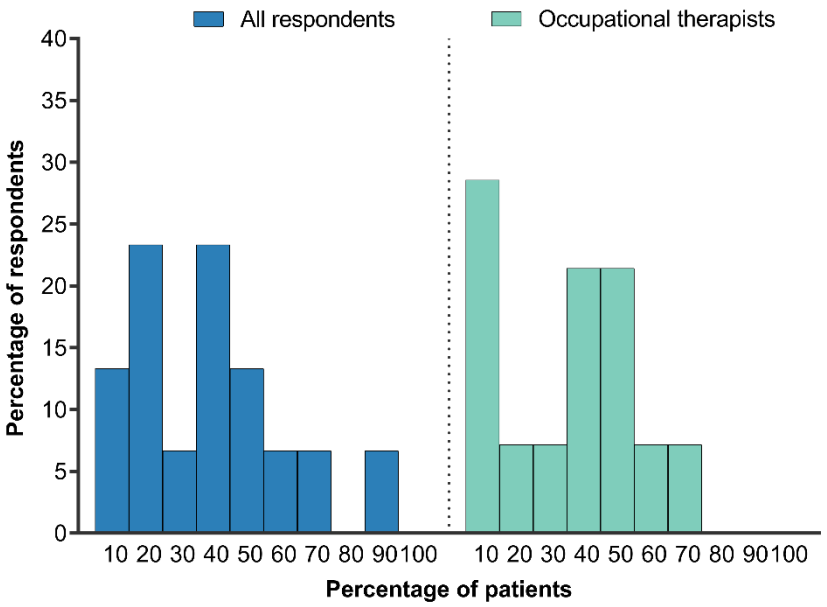
4b. Prospective memory problems



4c. Learning problems



4d. Procedural memory problems



3.4.3.2 Activities of daily living and mood

Respondents were asked about the impact of memory problems on activities of daily living. Across the entire sample (n = 46), five (11%) respondents indicated that there is very little impact, 33 (72%) indicated that there is moderate impact, and 14 (30%) indicated that there is severe impact of memory deficits on activities of daily living such as dressing, bathing, eating, and social participation. Four respondents (9%) selected more than one response. In the OT sample (n = 23), 19 (83%) respondents selected moderate impact and 5 (22%) selected severe impact. One respondent (4%) selected more than one response.

Respondents were asked about the impact of memory problems on mood of stroke patients. Table 5 shows the frequency of responses. Most respondents in the entire sample selected frustration (e.g., getting upset when not being able to remember) and negative self-evaluation (e.g., saying they can't do anything right). More than half of the respondents indicated that patients experience motivation to improve memory (e.g., with memory games) whereas less than half of the respondents selected no impact on mood (e.g., if unaware of deficits). Most respondents (91%) selected more than one response. All OTs selected frustration and most selected negative self-evaluation. More than half of the OTs indicated that there is motivation to improve, whereas less than half selected no impact. Most OTs (96%) indicated that memory problems impact more than one aspect of mood in stroke patients. The 'other' responses mentioned anxiety and identity issues (Appendix C).

Table 5

Impact of memory deficits on mood.

Mood	All respondents (*n* = 46)	Occupational therapists (*n* = 23)
	n (%)	
Frustration	43 (93)	23 (100)
Negative self-evaluation	36 (78)	19 (83)
Motivation to improve	30 (65)	14 (61)
No impact	15 (33)	8 (35)
Other	4 (9)	1 (4)

3.4.4 Treatment of Memory Deficits

Respondents were asked which healthcare professionals are involved in treating memory deficits. The frequency of responses for the entire sample and the OT sample is shown in Figure 2b. Most of the respondents in the entire sample indicated that occupational therapists are involved in the treatment of memory problems. More than half selected clinical psychologists and rehabilitation assistants, whereas less than half selected other members of the multidisciplinary team such as physiotherapists and speech and language therapists. Most of the respondents (85%) selected more than one response. In the OT sample, all respondents indicated that OTs are involved in treatment. Most of the respondents selected rehabilitation assistants, whereas less than half of the OTs selected other team members such as clinical psychologists and physiotherapists. Most OTs (83%) indicated that more than one team member is involved in treating memory deficits. ‘Other’ responses (Appendix C) mentioned that all team members are involved in reinforcement of the strategy.

Treatment methods used in the workplace are shown in Table 6. In the entire sample, most respondents indicated that memory strategies are incorporated into daily work with patients or patients are involved in targeted memory rehabilitation. A few respondents indicated that

medication is used, or no treatment is provided. Most respondents (70%) selected more than one response. Across the OT sample, most of the respondents selected memory strategies incorporated into daily work and targeted memory rehabilitation. Most of the OTs (78%) indicated that more than one treatment method is used. 'Other' responses (Appendix C) revealed that self-awareness and education to patients and carers are included as part of rehabilitation.

Table 6

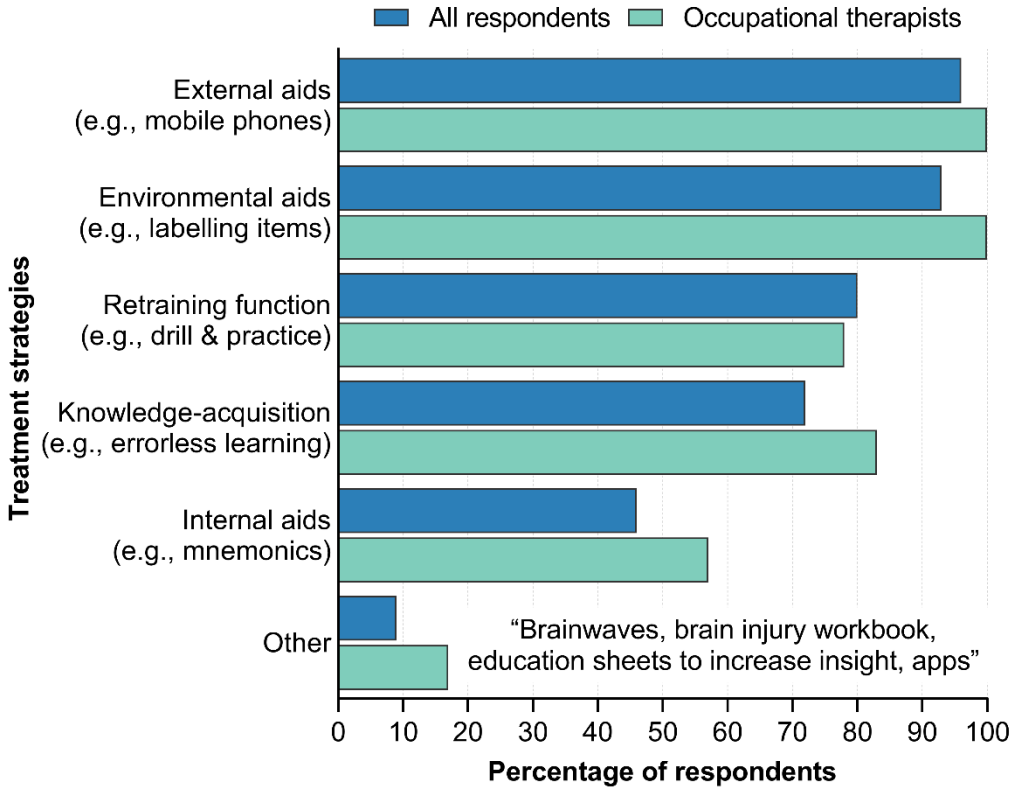
Methods of treatment for memory impairment.

Method	All respondents (n = 46)	Occupational therapists (n = 23)
	n (%)	
Memory strategies in daily work	41 (89%)	22 (96%)
Targeted memory rehabilitation	35 (76%)	19 (83%)
Medication	3 (7%)	0
No treatment	3 (7%)	0
I don't know	1 (2%)	0
Other	6 (13%)	4 (17%)

The strategies used to treat memory deficits are shown in Figure 5. Most respondents in the entire sample indicated that external memory aids (e.g., calendars), environmental aids (e.g., labelling items in the house), retraining function (e.g., repetition), and knowledge acquisition techniques (e.g., errorless learning) are used to treat memory problems. Less than half of the respondents selected internal memory aids (e.g., mnemonics). Most respondents (96%) selected more than one strategy. Across the OT sample, all OTs indicated that external and environmental aids are used. Most OTs selected retraining function and knowledge acquisition strategies, and more than half of the OTs selected internal memory aids. All OTs (100%) indicated that more than one strategy is used in memory rehabilitation. The 'other' responses included the use of mobile phone applications and worksheets (Appendix C).

Figure 5

Treatment strategies used by all respondents (*n* = 46) and OTs (*n* = 23) in memory rehabilitation after stroke.



Respondents who indicated that targeted memory rehabilitation is used were asked how progress is measured. As shown in Table 7, most respondents in the entire sample (*n* = 35) and the OT sample (*n* = 19) who selected targeted memory rehabilitation indicated that goal achievement, observations of patient behaviour, and subjective evaluation from patients and carers are used for progress measurement. Less than half of the respondents selected neuropsychological testing. Most respondents (97%) in the entire sample selected more than one response and all OTs (100%) indicated that more than one method is used to measure progress. 'Other' responses (Appendix C) mentioned that re-screening of patients is used in community rehabilitation.

Respondents who selected targeted rehabilitation were also asked to determine the degree to which memory rehabilitation is effective. Across the entire sample (*n* = 35), two respondents (6%) indicated that memory rehabilitation is not effective at all, 28 (80%) indicated that it is moderately effective, and one (3%) respondent considered it to be extremely effective. Four (11%) respondents indicated that they did not know. Across the OTs (*n* = 19), one respondent (5%) indicated that memory rehabilitation is not effective at all, 17 (89%) indicated that it is moderately effective, and one (5%) respondent indicated that they did not know.

Table 7

Measurement of progress in memory rehabilitation.

Measurement	All respondents (*n* = 35)	Occupational therapists (*n* = 19)
	n (%)	
Goal achievement	32 (91)	18 (95)
Observations of patient	31 (89)	18 (95)
Subjective evaluation	27 (77)	16 (84)
Neuropsychological testing	14 (40)	8 (42)
Other	2 (6)	0
I don't know	1 (3)	0

Note. Only respondents who selected ‘Targeted memory or cognitive rehabilitation’ in question 14.

3.5 Discussion

This exploratory study examined current clinical practices of assessment to treatment of memory after stroke and the impact of memory problems on activities of daily living and mood. A total of 46 healthcare professionals working in stroke care across England completed an online questionnaire, reflecting input from key roles in the multidisciplinary stroke team. Respondents included occupational therapists, nurses, and clinical psychologists who work in inpatient acute care, inpatient rehabilitation, and community rehabilitation settings. As half of the sample consisted of OTs, the results for this group were examined separately.

Demographic data showed that most of the healthcare professionals who completed the study worked in community rehabilitation. This perhaps reflects the stage of care where memory is likely addressed. As previously mentioned, physical deficits and other cognitive deficits such as executive function and attention are likely to be prioritised in the earlier stages of care. Therefore, the advertisement and information sheet may have attracted healthcare professionals who work in community rehabilitation and are involved in memory care. Several respondents also indicated that they work across multiple stages of care along the stroke care pathway. Most healthcare professionals in both the entire sample and the OT-only sample are in frequent contact with patients either on a daily or weekly basis and across all respondents there was an average of 11 years of experience working with stroke patients. Thus, the respondents in this study can be considered stroke experts who are in regular contact with patients.

The results revealed that memory assessment after stroke often follows a standardised process that is completed for every patient involving cognitive screens such as the OCS, MoCA, and ACE-R (Fig. 1). This is in line with evidence-based guidelines that recommend the use of standardised measures to assess different cognitive domains after stroke (Intercollegiate Stroke Working Party, 2016; NICE, 2013). Apart from cognitive screens, we also found that healthcare professionals frequently include patient observations and interviews with patients and relatives as part of memory assessment (Fig. 1a). Open-ended responses also revealed that functional assessments, where patients are observed completing daily life tasks, are also considered (Appendix C). In addition, most respondents indicated that multiple assessment methods and tests are used. This is consistent with the findings of previous surveys with healthcare professionals, highlighting that standardised and non-standardised measures are often combined to create a profile of cognitive deficits (Ablewhite et al., 2019; Geraghty et al., 2020; Lees et al., 2014; Pilegaard et al., 2014; Sansonetti & Hoffmann, 2013;

Shendyapina et al., 2020; Stigen et al., 2017). However, the use of non-standardised methods such as interviews and observations has been criticised for lack of reliability and validity, yet they continue to be used within clinical settings, perhaps due to the familiarity of use, access, and lack of training with standardised measures (Lees et al., 2014; Pilegaard et al., 2014; Sansonetti & Hoffmann, 2013; Stigen et al., 2017).

The use of detailed memory assessments and standardised subjective memory measures appears to be infrequent (Fig 1). This perhaps reflects the structure of the stroke care pathway where initial cognitive screens are used to detect impairments which are then followed up using targeted assessments, as highlighted in comments (Appendix C). The respondents indicated that assessments are often selected based on the patient's needs and the time required to complete the assessment (Table 3). Consistent with findings from previous research, additional factors in test selection included availability of test materials and cost, as highlighted in open-ended responses (Appendix C; Ablewhite et al., 2019; Geraghty et al., 2020; Sansonetti & Hoffmann, 2013). Based on these outcomes, it is not surprising that the relatively short and freely available OCS is frequently used by the respondents in this study, as it was designed for stroke patients with consideration for other deficits such as hemiplegia and aphasia (Burton & Tyson, 2015; Demeyere et al., 2015).

In contrast to previous studies where the MMSE was a dominant measure, here only 17% of the respondents in the entire sample and none of the OTs indicated that the MMSE is used to assess memory, with one comment suggesting cost and access as a reason (Korner-Bitensky et al., 2011; Lees et al., 2014; Stigen et al., 2017; Stringer, 2003; Wright & Lindesay, 1995). However, an additional 15 assessments were mentioned in the comments, highlighting that the heterogeneity of the assessments mentioned by Lees et al. (2014) remains in clinical settings, which may result in ambiguity regarding the accuracy of diagnoses and comparisons

between patients. Finally, respondents indicated that memory assessments are mostly administered by occupational therapists and clinical psychologists. Moreover, multiple team members are involved with comments revealing that occupational therapists generally lead the assessments, but the entire stroke team is encouraged to provide feedback (Appendix C). This is in line with recommendations of collaborative working across team members in the stroke team, even when one healthcare professional leads a particular task (Clarke, 2013; Clarke & Forster, 2015; Gillham & Clark, 2011).

Respondents who do not follow a standardised procedure to assess memory mentioned that the assessments may vary based on client-specific needs and results of initial cognitive assessment. Apart from this, the methods and tests used, and professionals involved in assessing memory are comparable to those of the respondents who follow a standard procedure (Appendix D). Additionally, only 11% of the respondents in the entire sample indicated that they do not follow a standard procedure, highlighting that current clinical practice regarding assessment of memory is generally standardised, following recommendations in clinical guidelines (Intercollegiate Stroke Working Party, 2016; NICE, 2013).

Across the entire sample of healthcare professionals, respondents indicated that memory problems are present in 21% - 100% of the patients that are seen (Fig. 3). Across the OTs, respondents indicated that memory problems are present in 40% to 90% of the patients that are seen. In comparison, past research has shown that memory deficits after stroke are present in 13% - 50% of patients after stroke, which is reduced to 11% - 51% after one year (Snaphaan & de Leeuw, 2007). However, it is important to note that this study examined the prevalence of memory problems among patients they see from the perspective of healthcare professionals who are in frequent contact with stroke patients. This may have resulted in

higher reported prevalence compared to studies examining memory deficits in stroke patient samples. Short-term, prospective, learning, and procedural memory deficits are commonly observed by healthcare professionals (Fig. 4). In contrast, retrospective memory deficits are infrequently observed (Table 4). However, all respondents indicated that multiple types of memory deficits are present in the stroke patients they see, suggesting that patients are often experiencing complex memory problems. This is consistent with previous research demonstrating that general world knowledge and memory for past events are retained after stroke whereas prospective and working memory impairments are common (Evans et al., 2020; Fitri et al., 2020; Hogan et al., 2016; Lugtmeijer et al., 2021; Maeshima & Osawa, 2021). It is important to note the type of memory deficit may vary by stroke location and severity, which was not examined here (Al-Qazzaz et al., 2014; Schaapsmeerders et al., 2013). Open-ended responses also mentioned the influence of executive function and attention in addition to memory, demonstrating that memory deficits are often considered alongside other cognitive deficits (Appendix C).

Respondents in both samples indicated that memory deficits after stroke moderately impact activities of daily living of the patients they see. This is consistent with previous research that shows a negative impact of memory on activities of daily living and functional outcomes (Fitri et al., 2020; Middleton et al., 2014; Tang et al., 2020). The results also demonstrated that mood is affected by memory deficits (Table 5). Specifically, frustration and negative self-evaluation are commonly observed. These negative effects on mood may be the result of forgetting instances, for example, ‘tip of the tongue’ experiences that impact communication and make stroke patients frustrated with their abilities (Evans et al., 2020). Additionally, the impact of anxiety and fear relating to dementia were highlighted in the comments, suggesting that patients may worry about further cognitive decline due to memory lapses in daily life (Appendix C). This is consistent with previous research suggesting that stroke patients

experience fear of dementia related to memory difficulties (Tang et al., 2019). In contrast, some stroke patients are motivated to improve their memory, perhaps resulting from difficulty completing activities of daily living (Table 5). Several respondents also indicated that there was no impact of memory problems on mood, which is possibly due to lack of awareness of deficits.

The results regarding treatment of memory deficits provided some new insights into current clinical practices of memory rehabilitation after stroke. We found that occupational therapists are most often involved in rehabilitation (Fig. 2b). Rehabilitation assistants and clinical psychologists are also involved, and open-ended responses revealed that other team members reinforce strategies in the treatment plan (Appendix C). These data highlight that the healthcare professionals who form the multidisciplinary team are integral in both assessment and treatment of cognition after stroke, with the occupational therapists generally being at the forefront across the continuum of care (Clarke, 2013; Koh et al., 2009; Korner-Bitensky et al., 2011; Stringer, 2003; Wheatley, 1994). Healthcare professionals approach memory rehabilitation by incorporating memory strategies into daily work with patients or by providing targeted memory rehabilitation and open-ended responses revealed that targeted rehabilitation mainly occurs in community rehabilitation (Table 6; Appendix C).

The strategies used in memory rehabilitation by respondents most often include external memory aids and environmental aids (Fig. 5). This is comparable to past research indicating that external memory aids are preferred by healthcare professionals and stroke patients, perhaps due to their ease of use and accessibility (Harris & Sunderland, 1981; Koh et al., 2009; Nowell et al., 2020; Stringer, 2003; Tang et al., 2020). We also found that retraining function through repetitive exercises is often used in clinical settings (Fig. 5). This is consistent with research indicating that healthcare professionals use computer-based cognitive

retraining programmes (Nowell et al., 2020). However, past research is equivocal regarding the transfer to activities of daily living for these programmes (Cicerone et al., 2000; Wilson, 2013). The results also revealed that knowledge acquisition techniques such as errorless learning are often incorporated into memory rehabilitation in clinical settings (Fig. 5; Appendix C). This is in line with guideline recommendations and past research that supports the use of these techniques that can capitalise on preserved abilities (Cicerone et al., 2019; Intercollegiate Stroke Working Party, 2016; NICE, 2013; Shigaki et al., 2014; Wilson, 2013).

In contrast to external aids and knowledge acquisition techniques, respondents indicated that internal memory strategies, such as mnemonics, are less frequently used in clinical practice. This is perhaps because these strategies require mental manipulation of information and self-awareness, which may be particularly difficult for individuals with memory impairment to learn and adopt into daily use (Haskins et al., 2012; Pino, 2015). Moreover, these strategies require a certain level of self-awareness that may be disrupted due to stroke (Shigaki et al., 2014). As such, recommendations have generally indicated that they should be used with individuals who have mild memory impairments (Cicerone et al., 2019; Shigaki et al., 2014).

According to the respondents, the progress of targeted memory rehabilitation is often measured through goal achievement, patient observations, and subjective evaluations from patients and relatives (Table 8). This is consistent with progress measurements in cognitive rehabilitation, where goal setting is considered best practice (Nowell et al., 2020; Scobbie et al., 2015; Stringer, 2003). However, it has been suggested that these methods are not standardised and can vary widely (Scobbie et al., 2015; Stringer, 2003). Furthermore, less than half of the respondents indicated that neuropsychological tests are used to measure progress in targeted rehabilitation, although the use of standardised measures is recommended (Intercollegiate Stroke Working Party, 2016). Various factors such as training, access to

testing materials, and time and space available for testing may influence the decision to use certain progress measures (Quinn et al., 2018). Most of the respondents in this study considered targeted memory rehabilitation to be moderately effective. In contrast, respondents in Harris and Sunderland's (1981) study reported memory rehabilitation as marginally to moderately effective. Thus, the results in the present study can be considered an improvement from the perspective of healthcare professionals regarding the provision and efficacy of memory rehabilitation for stroke patients.

3.5.1 Limitations and Future Considerations

Several limitations of this study should be addressed. The small sample size is worth noting in comparison to similar surveys (Koh et al., 2009; Lees et al., 2014; Sansonetti & Hoffmann, 2013; Shendyapina et al., 2020; Webb et al., 2021). However, the inclusion criteria were more limited here and, since there is no database of healthcare professionals in England, it is not possible to know how many people in the country meet the criteria. Moreover, the information sheet refers to memory after stroke. Therefore, healthcare professionals who work with stroke patients that do not have memory problems may have opted not to participate. Thus, there may have been a sampling bias may for individuals who are interested in memory. Future research can address this by collecting reasons for not completing the questionnaire from those who read the information sheet but did not complete the survey.

We initially aimed to conduct the survey during a period with reduced pressures on the healthcare professionals. However, due to time limitations, the questionnaire was conducted from June to September 2021 during the Covid-19 pandemic and possibly changing guidelines and circumstances for treating stroke patients. Moreover, we did not specify whether the questions referred to prior to the pandemic or changes made during the pandemic. We therefore urge some caution with the interpretation of the results. However, a recent

survey has demonstrated that the frequency of formal cognitive assessment in the UK has not been severely disrupted by the pandemic and as such, similar circumstances may be expected for stroke assessment (Webb et al., 2021).

To maintain a short length questionnaire, the scope of our questions may have been limited and should be addressed in future research. It is essential to examine the extent to which non-standardised measures are integrated into memory assessment after stroke. Furthermore, it is important to clarify when and how detailed memory assessments are performed, as current data show that memory is often considered alongside other cognitive functions. Further examination of mood and cognition after stroke is also warranted, with regards to the connection between memory deficits and depression and anxiety. Finally, the treatment of memory deficits should be further explored. For example, the extent to which memory strategies are incorporated into daily work with patients should be investigated to obtain a clearer understanding of the method and dosage of rehabilitation. These factors may indicate why respondents considered targeted memory rehabilitation to be moderately effective and may highlight opportunities for improvement in the recommendations for implementing memory strategies.

3.6 Conclusion

The results of this study have shown that memory after stroke is addressed alongside other cognitive functions along the stroke care pathway. Memory assessment usually follows a formal procedure for each patient using a combination of standardised and non-standardised assessments. There is a relatively high prevalence of memory problems amongst the patients that are seen, with short-term, prospective, learning, and procedural memory frequently affected. Healthcare professionals reported moderate impact of memory problems on activities of daily living for stroke patients. Memory problems also impact frustration,

negative self-evaluation, and motivation to improve memory. In current clinical practice, treatment for memory typically involves memory strategies incorporated into daily work or targeted memory rehabilitation using external and environmental memory aids. Targeted memory rehabilitation is measured through goal setting, patient observations, and subjective evaluations from patients. Finally, healthcare professionals reported that targeted memory rehabilitation is moderately effective in improving memory deficits after stroke.

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3.8 Appendices

Appendix A

Questionnaire Items

Question	Response options			
Demographics				
1. What is your professional affiliation in relation to stroke care?	▪ Clinical psychologist ▪ Occupational therapist	▪ Physiotherapist ▪ Rehabilitation assistant	▪ Stroke nurse ▪ Speech and Language therapist	▪ Stroke physician ▪ Other (please specify)
2. At what stage along the patient journey do you work with stroke patients? Please select all that apply.	▪ Inpatient acute care	▪ Inpatient rehabilitation	▪ Community rehabilitation	▪ Other (please specify)
3. How often do you see stroke patients? Please select all that apply	▪ Daily	▪ Weekly (several times per week)	▪ Monthly (several times per month)	▪ Other (please specify)
4. How long have you worked with stroke patients?	▪ Years _____			
4a. How long have you worked with stroke patients? *Question displayed if Q4 = 0*	▪ Months _____			
Memory assessment				
5. In your workplace, is there a formal/standardised process to assess memory problems in stroke patients? (e.g., a routine that is followed for assessing all patients)	▪ I don't know	▪ Yes	▪ No	
6. Please select the method(s) used in your workplace to assess memory problems in stroke patients.	▪ I don't know ▪ Cognitive screen (e.g., Mini-Mental State Examination) ▪	▪ Detailed memory assessments (e.g., Weschler Memory Scale) ▪ Interviews with patient or relatives	▪ Observations of patient ▪ Subjective memory questionnaires	▪ Other (please specify)

			(e.g., Everyday Memory Questionnaire)	
6a. In your workplace, what is the process for assessing memory problems in stroke patients? (e.g., targeted assessment for patients as is necessary) *Question displayed if Q6 = No*	▪ Open response			
7. Please select the standardised test(s) used in your workplace to assess memory in stroke patients.	▪ I don't know ▪ Addenbrookes Cognitive Examination Revised (ACE-R)	▪ Mini-Mental State Examination (MMSE ▪ Montreal Cognitive Assessment (MoCA)	▪ Oxford Cognitive Screen (OCS) ▪ Rey Auditory Verbal Learning Test (RAVLT) ▪ Rivermead Behavioural Memory Test (RBMT)	▪ Weschler Memory Scale (WMS) ▪ Other (please specify)
8. How are memory tests selected to be part of the assessment? Please select all that apply.	▪ I don't know ▪ Time to complete (e.g., shorter tests to prevent fatigue)	▪ Availability of tests (e.g., which test materials are available in the department)	▪ Tailored to patient needs (e.g., to accommodate other deficits)	▪ Other (please specify)
9. Please select the members of the stroke team who are involved in assessing memory problems of stroke patients.	▪ Clinical psychologist ▪ Occupational therapist	▪ Physiotherapist Rehabilitation assistant	▪ Stroke nurse Speech and Language therapist	▪ Stroke physician ▪ Other (please specify)
Impact of memory problems				
10. Approximately what percentage of the patients with whom you work experience stroke-related memory problems?	▪ Slider from 0 – 100%			
11. In general, which types of memory are affected in stroke patients with whom you work? Please select all the apply.	▪ Short-term: the ability to hold small amounts of information for a limited time (e.g., information in a conversation)	▪ Retrospective: memory for past experiences (e.g., a childhood birthday party) or general knowledge/facts learned throughout life (e.g., the names of shapes)	▪ Procedural: memory for how to perform actions (e.g., using a mobile phone)	▪ Learning: acquisition of new or lost knowledge or skill (e.g., learning about stroke)

	▪ Prospective: memory for planned actions in the future (e.g., to take medication)	▪ Other (please specify)
11a. Approximately what percentage of stroke patients with whom you work experience **short-term** memory problems? This can include repeatedly asking the same question, difficulty recalling recent information such what they had for breakfast or forgetting items on a shopping list when in a store. *Question displayed if Q11 = Short-term*	▪ Slider from 0 – 100%	
11b. Approximately what percentage of stroke patients with whom you work experience **retrospective** memory problems? This can include difficulty remembering familiar names, events before their stroke, or the meaning of common words. *Question displayed if Q11 = Retrospective*	▪ Slider from 0 – 100%	
11c. Approximately what percentage of stroke patients with whom you work experience **prospective memory** problems? This can include forgetting to attend appointments, take medication, or bring necessary items when leaving the house. *Question displayed if Q11 = Prospective*	▪ Slider from 0 – 100%	
11d. Approximately what percentage of stroke patients with whom you work experience **procedural memory** problems?	▪ Slider from 0 – 100%	

This can include difficulty remembering how to write, use cutlery, or drive a car. *Question displayed if Q11 = Procedural*				
11e. Approximately what percentage of stroke patients with whom you work experience learning memory difficulties? This can include learning or re-learning names, faces, or motor skills. *Question displayed if Q11 = Learning*	▪ Slider from 0 – 100%			
11f. Approximately what percentage of stroke patients with whom you work experience **other** memory difficulties? This includes the other memory difficulties previously specified. *Question displayed if Q11 = Other (please specify)*	▪ Slider from 0 – 100%			
12. In your experience, how do stroke-related memory problems impact activities of daily living (e.g., washing, dressing, toileting, bathing, eating, drinking, shopping, cooking, housework, and community and social participation)?	▪ I don't know	▪ Very little impact (patient can perform most/all ADLs)	▪ Moderate impact (patient can perform few ADLs)	▪ Severe impact (patient cannot perform ADLs)
13. In general, how do stroke-related memory problems impact the mood/attitude of the stroke patients with whom you work? Please select all that apply.	▪ I don't know ▪ Frustration (e.g., getting upset when not being able to remember information)	▪ Motivation to improve memory (e.g., searching for ways to improve such as with memory games)	▪ Negative self-evaluation (e.g., saying they can't do anything right) ▪	▪ No impact on mood (e.g., if unaware of memory deficits) ▪ Other (please specify)
Treatment of memory problems				
14. In your experience, how are memory problems treated in your workplace? Please select all that apply.	▪ I don't know ▪ Medication ▪	▪ No treatment ▪ Memory strategies incorporated into daily work with patients	▪ Targeted memory or cognitive rehabilitation ▪	▪ Other (please specify)

15. In your experience, which memory rehabilitation techniques are used for stroke patients? Please select all that apply.	▪ I don't know ▪ Environmental aids (e.g., asking others to help remember, labelling items in the house)	▪ External aids (e.g., pill boxes, calendars, mobile phones) ▪ Internal memory aids (e.g., mnemonics, rhyming)	▪ Retraining function (e.g., drill and practice exercises, repetition of information)	▪ Specific knowledge-acquisition techniques (e.g., spaced retrieval, vanishing cues, errorless learning) ▪ Other (please specify)
15a. How is the progress of memory rehabilitation measured? Please select all that apply. *Question displayed if Q15 = Targeted memory or cognitive rehabilitation*	▪ I don't know ▪ Goal achievement (e.g., reaching a specified outcome goal)	▪ Neuropsychological testing ▪ Observations of patient performance on everyday activities	▪ Progress isn't routinely measured	▪ Subjective evaluation (e.g., by patients or relatives) ▪ Other (please specify)
15b. In your experience, is memory rehabilitation effective? *Question displayed if Q15 = Targeted memory or cognitive rehabilitation*	▪ I don't know	▪ Extremely effective	▪ Moderately effective	▪ Not effective at all
16. Please select which members of the team are involved in treating memory problems of stroke patients.	▪ Clinical psychologist ▪ Occupational therapist	▪ Physiotherapist ▪ Rehabilitation assistant	▪ Stroke nurse ▪ Speech and Language therapist	▪ Stroke physician ▪ Other (please specify)
17. Thank you for completing this survey. If there is anything you would like to add or clarify please add it here (optional).	▪ Open response			

Note. Survey version set from URL. If 'no' was selected for any consent question, a message was displayed to close browser to withdraw.

Appendix B

Professional Networks

Professional network	Target profession	Distribution method
Association of British Neurologists	Neurologists	Newsletter
British Association of Stroke Physicians	Stroke Physicians	Newsletter
British Society of Rehabilitation Medicine	Consultants, Senior Allied Health Professionals, Rehabilitation Nurses	Email
National Stroke Nursing Forum	Stroke Nurses	Email
Royal College of Occupational Therapists Specialist Section - Neurological Practice	Occupational Therapists	Email
Royal College of Speech and Language Therapists	Speech and Language therapists	Facebook research page
The British Psychological Society Division of Neuropsychology	Neuropsychologists	Newsletter
The Society for Research in Rehabilitation	Stroke professionals	Twitter

Note. List only contains networks that agreed to distribute the survey.

Appendix C

Open-ended Responses

Questions	Responses
At what stage along the patient journey do you work with stroke patients?	• "six month stroke reviews for all local patients completed by me." • "Outpatient reviews and TIA" • "Stroke review follow up clinic at 6 months" • "ESD"
How often do you see stroke patients?	• "Occasionally, few per year" • "Routinely: initially post discharge, then at 6/52, then at 6/12. (however stroke pt can contact us at any time outside of those times for a review)" • "and at six months post stroke"
Please select the method(s) used in your workplace to assess memory problems in stroke patients.	• "Assessment when carrying out everyday activities" • "Functional assessment" • "functional tasks" • "Narrative analysis (Charlie Chung)" • "Functional assessments (making drink/snack/ washing/dressing) which incorporate memory but also many other aspects of cognition" • "Functional memory assessment such as the Rivermead" • "6-CIT as initial screen. if deficit found then we refer on to stroke specialist OT for further assessment" • "Oxford Cognitive Screen" • "MOCA" • "Functional assessments eg washing and dressing/ kitchen" • "Mainly led by OT and neuropsychology"
Please select the standardised test(s) used in your workplace to assess memory in stroke patients.	• "RBANS CAM BUTT non verbal" • "RBANS" • "RBANS" • "I have used the RBMT in the past but not routinely"

	• "We also use Rookwood, BADS, RBANS, BIT test and CAM for more detailed assessment." • “BMPIB-ii” • “further assessments completed by neuropsychologist” • “RBANS cognitive screen for younger patients” • “O-log” • "Addenbrooke's Cognitive Examination III and Mini Version" • “UMACE: Universal Memory and cognitive examination” • "Perceive Recall Plan Perform System of Assessment CAMPROMPT SOTOF METS (has some prospective memory aspects)" • “RBANS”
How are memory tests selected to be part of the assessment?	• “To explore particular aspects further” • “Guidelines and recommendations” • “Evidence-based.” • “cost for licence e.g MOCA / MMSE no longer used in the trust for this reason.” • “Which test materials are available for Free, licensed to use in UK without formal training and recommended in guidelines” • "The main criteria would be: 1. The approrpiate assessment to the predicted impairment, or what has been picked up on in screens or in observation 2. Tests that assess memory as part of overall profile. For example, the PRPP assesses a range of cognitive domains, including some memory, bus mostly procedural memory. " • “OT lead”
Please select the members of the stroke team who are involved in assessing memory problems of stroke patients.	• “OT and Clinical Psychologists complete standardised assessments. All members of the MDT are encouraged to feedback observational/functional assessments.” • “Psychological Practitioner, assistant psychologist” • “We don't have a clinical psychologist in our team” • “Assistant Psychologist” • “stroke nurse” • “OT complete formal assessment, other MDT members give observational feedback” • “RM physicians” • “These are the leads but the whole team feedback and provide continuous assessment”

In general, which types of memory are affected in stroke patients with whom you work?	• "Exec function also impacts this" • "You will sometimes see episodic or semantic memory affected in severe stroke, however much more common is difficulty with working memory (which is really an attention function) or prospective memory" • "Autobiographical - names of familiar people" • "Often mixed with other conditions such as dementia"
In general, how do stroke-related memory problems impact the mood/attitude of the stroke patients with whom you work?	• "anxiety relating to possible dementia" • "Fear that they may be developing a dementia or are "going mad"." • "Anxiety about what is happening day-to-day, due to difficulty remembering" • "identity issues"
Please select which members of the team are involved in treating memory problems of stroke patients.	• "Note there is no clinical psychologist in our area" • "But only acute, in hosp" • "Rehabilitation Physician" • "But all team involved in reinforcement of strategies"
In your experience, how are memory problems treated in your workplace?	• "Increasing self-awareness as a first step to strategy use. Procedural learning techniques such as errorless learning and chaining if severe memory impairment" • "Education patient and carers to improve insight and application of strategies Graded functional task practice using errorless learning" • "Lots of psychoeducation to the client and those around them, family/carers/work colleagues." • "Brian education" • "Referred on to community therapy services or inpatient rehab mainly due to the short length of stay in acute and lack of staffing." • "Very little targeted cognitive rehab takes lace in ,in patient rehab units mainly occurs once atient is in community rehab team."
In your experience, which memory rehabilitation techniques are used for stroke patients?	• "depends on patient need" • "Brainwaves, brain injury workbook, education sheets to increase insight, apps" • "Brain tree training Charlie Chung cognitive rehabilitation concepts Use of My therappy cognitive rehabilitation applications such as PEAK." • "If there is a primary memory deficit, which is rare, then restorative rehab works poorly and strategy use is more effective. However when the recall deficit has an attentional basis, then attention training can be effective."

How is the progress of memory rehabilitation measured?	• "Re screening" • "In inpatient stroke care there is less opportunity due to admission duration for repeat neuropsychology measurement but this is often handed over to the community neuropsychology team"

Appendix D

Results for Unstandardised Approach to Assessment

Across the respondents who indicated that there is no formal or standardised approach to assessing memory for stroke patients (*n* = 5), 4 (80%) indicated that cognitive screens, patient observations, and interviews with patients and relatives are the methods of memory assessment whereas 3 (60%) selected detailed memory assessments and subjective memory questionnaires. 'Other' responses (40%) were "Discussion with carers and colleagues" and "Are you experiencing memory problems- plus ask carer or formal carer". Most participants (80%) selected more than one method of assessment. For the standardised assessments used, the ACE-R and OCS were selected by 3 (60%) respondents, 2 (40%) selected the RBMT and the WMS, and 1 (20%) selected the MoCA and RAVLT. 'Other' responses (60%) included: "BMIPB Doors & People", "Cognitive Assessment of Minnesota (CAM)", and "None". Most respondents (80%) selected more than one assessment. Respondents were asked how tests are selected to be part of the assessments. Four (80%) respondents indicated that tests are tailored to patient needs with time to complete selected by 3 (60%) respondents. One (20%) 'other' response stated "None". More than half of the respondents (60%) selected more than one reason.

Respondents were asked which healthcare professionals are involved in assessing memory. Most participants (80%) indicated that occupational therapists and clinical psychologists are involved in assessing memory, 2 (40%) respondents selected speech and language therapists and 1 (20%) selected stroke physician, stroke nurse, and rehabilitation assistant. Most respondents (80%) indicated that more than one healthcare professional is involved in the assessment of memory after stroke.

4 Memory rehabilitation: Restorative, specific knowledge acquisition, compensatory, and holistic approaches

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REVIEW

Memory rehabilitation: restorative, specific knowledge acquisition, compensatory, and holistic approaches

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Abstract

Memory impairment following an acquired brain injury can negatively impact daily living and quality of life—but can be reduced by memory rehabilitation. Here, we review the literature on four approaches for memory rehabilitation and their associated strategies: (1) the restorative approach, aimed at a return to pre-morbid functioning, (2) the knowledge acquisition approach, involving training on specific information relevant to daily life, (3) the compensatory approach, targeted at improving daily functioning, and (4) the holistic approach, in which social, emotional, and behavioral deficits are addressed alongside cognitive consequences of acquired brain injury. Each memory rehabilitation approach includes specific strategies such as drill and practice (restorative), spaced retrieval (knowledge acquisition), memory aids (compensatory), or a combination of psychotherapy and cognitive strategies (holistic). Past research has demonstrated mixed support for the use of restorative strategies to improve memory function, whereas knowledge acquisition strategies show promising results on trained tasks but little generalization to untrained tasks and activities of daily living. Compensatory strategies remain widely used but require intensive training to be effectively employed. Finally, the holistic approach is becoming more widespread due to improvements in psychosocial wellbeing, yet there are considerable resource and cost requirements. Several factors can influence rehabilitation outcomes including metacognition and emotional disturbances. Considerations for future research to improve the applicability of strategies for memory rehabilitation include assessing memory impairment severity, examining memory needs in daily life, and exploring the long-term effects of memory rehabilitation.

Keywords Memory impairment · Memory rehabilitation · Acquired brain injury · Memory strategies · Memory aids

Introduction

An acquired brain injury (ABI) involves an insult to the brain resulting in neuronal activity changes and can be derived from traumatic brain injuries (TBI) such as accidents or falls, or from non-traumatic internal events such as stroke (De Luca, et al. 2018a, b; Fernandez et al. 2017; Rees et al. 2007; Turner-Stokes et al. 2003). Memory impairment following an ABI can negatively impact daily living and quality of life (Claesson et al. 2005; Pohjasvaara et al. 1997; Slenders et al. 2020; Tang et al. 2020; Wood 2017). Moreover, previous research has indicated that there is potentially a link between ABI and progression to dementia; however, the methodologies of previous studies have been mixed or of poor quality and findings should be considered with caution (das Nair et al. 2016; Hicks et al. 2019; Kuźma et al. 2018). Memory deficits are among the most common cognitive deficits and subjective complaints for stroke and TBI survivors in hospitals, rehabilitation centers, and community settings (Barman et al. 2016; Censori et al. 1996; Cumming et al. 2013; das Nair et al. 2016; Hochstenbach et al. 1998; Shigaki et al. 2014; Wade et al. 1986). Although some improvements in memory abilities can occur through spontaneous recovery, memory impairments can persist for years after the injury (Censori et al. 1996; Elliott and Parente 2014; Galetto and Sacco 2017; McInnes et al. 2017; Rasquin et al. 2002; Schaapsmeerders

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et al. 2013; Zucchella et al. 2014). Cognitive rehabilitation is one option to reduce the impact of memory impairment.

Cognitive rehabilitation involves the use of various techniques expected to improve functioning in one or more cognitive domains (De Luca, et al. 2018a, b; Galetto and Sacco 2017; Lincoln et al. 2002; Rees et al. 2007; Wilson 2013). The techniques are used to restore function, to provide specific information relevant to everyday life, and as supportive tools to improve daily functioning (Cumming et al. 2013; das Nair et al. 2016; das Nair and Lincoln 2012; Rees et al. 2007; Schacter and Glisky 1986; Shigaki et al. 2014). Cognitive rehabilitation that is intended to improve memory is commonly thought to involve four approaches (das Nair et al. 2016; das Nair and Lincoln 2012; Prigatano 2013; Rees et al. 2007; Tate 1997; Wilson 2009). The *restorative approach* involves a re-training of memory abilities, the *specific knowledge acquisition approach* involves learning information relevant to a particular need in everyday life, and the *compensatory approach* involves the use of internal and external memory aids for various situations (Cicerone et al. 2000; Pertíñez and Linares 2015; Pino 2015; Schacter and Glisky 1986; Tsaousides and Gordon 2009). More recently, a *holistic approach* has emerged whereby emotional and social factors are addressed alongside cognitive consequences of ABI using a combination of compensatory aids and a therapeutic component (Ben-Yishay 2000; Cicerone et al. 2019; Prigatano 2013).

Practice guidelines and recommendations for implementation of evidence-based cognitive rehabilitation within clinical settings can be found in dedicated manuals (Haskins et al. 2012; Intercollegiate Stroke Working Party 2016; van Heugten and Wilson 2021; Velikonja et al. 2014). In this review, we consider each of the outlined memory rehabilitation approaches, focusing on their implementation with stroke and TBI survivors. Although similar reviews have been conducted in the literature, they have included a variety of patient groups, examined general cognitive rehabilitation inclusive of other cognitive domains, or have focused on specific strategies within an approach (Barman et al. 2016; Clare and Jones 2008; Pino 2015; Shigaki et al. 2014; Tate 1997; Tsaousides and Gordon 2009). While these subjects are worth examining, it would be beneficial to have an overview of the rehabilitation approaches available to target memory deficits and the strategies that are currently in use for stroke and TBI patients. Here, we specifically outline the major approaches to memory rehabilitation, explore the strengths and limitations of strategies within each approach, highlight factors that may influence the outcome of rehabilitation, examine limitations of current approaches, and provide considerations for researchers and clinicians regarding memory rehabilitation after ABI.

Restorative approach

The goal of the restorative approach (also referred to as *retraining* or *restitution)* is to improve memory to a level similar to that of pre-morbid functioning (De Luca, et al. 2018a, b; Pino 2015; Prigatano 1987; Rothi and Horner 1983; Schacter and Glisky 1986; Velikonja et al. 2014). It is widely held that brain plasticity underlies the restorative approach and that activation of the residual neural network surrounding the damaged brain tissue may at least partially improve functional outcomes and prevent further loss (Berlucchi 2011; Cumming et al. 2013; Kleim and Jones 2008; Rothi and Horner 1983; Zencius et al. 1990). Although it is impossible for damaged neurons to be replaced or regenerated, it is considered possible that surviving neurons can establish new connections through axonal and dendritic sprouting and synaptogenesis (Berlucchi 2011; Kane and Ward 2021; Murphy and Corbett 2009). This should in turn result in plasticity-dependent remodeling of the neural networks where connectivity patterns may be altered following the presentation of new stimuli (Berlucchi 2011; Caeyenberghs et al. 2018; Gabrieli et al. 2021; Galetto and Sacco 2017). Strategies falling within the restorative approach have traditionally centered around repetitive drill and practice exercises, stemming from the idea that the brain is a "mental muscle" that can be strengthened through exercise when damaged (das Nair et al. 2016; das Nair and Lincoln 2012; Harris and Sunderland 1981; Schacter and Glisky 1986; Tate 1997). More recently, there has been a shift to computer-assisted cognitive rehabilitation (CACR) based on limited efficacy of drill and practice (De Luca, et al. 2018a, b; Fetta et al. 2017; Pertíñez and Linares 2015; Velikonja et al. 2014).

Drill and practice exercises have been commonly conducted with word or list learning or paragraph recall tasks (Hart and Hayden 1986; Sohlberg and Mateer 1989; Tate 1997; Tsaousides and Gordon 2009). Gasparrini and Satz (1979) suggested that rote repetition with encouragement may be an effective treatment for memory problems. Although this condition was implemented as a control, participants showed significant improvement on a paired-associate memory task. However, it was noted that encouragement alone may result in improvements in performance, and this may have factored into the results. Moreover, a visual imagery mnemonic was still superior to the rote repetition with encouragement condition (Gasparrini and Satz 1979). In a study by Berg et al. (1991), memory-impaired patients completed either strategy training with multiple cognitive strategies, pseudo-rehabilitation (drill and practice of memory tasks and games), or received no training. On subjective measures, participants in both the strategy training and pseudo-rehabilitation groups reported

significant improvements in memory capacity, insight into memory problems, coping with daily memory problems, and decreased anxiety about memory functioning. However, while the strategy training group showed significant improvements on objective memory performance measures after the training and at a later follow-up, the drill and practice group showed no significant changes, with similar scores to those of the control group throughout (Berg et al. 1991). Similar outcomes with drill and practice from various studies have resulted in these exercises being used as a control to account for general training effects (Doornhein and de Haan 1998; Glasgow et al. 1977; Kaschel et al. 2002; Schacter and Glisky 1986; Wilson 1982).

Based on the limited efficacy and transfer of drill and practice exercises, the strategies of the restorative approach have shifted toward CACR, which includes software designed to improve cognitive functioning, brain training programs, and virtual reality programs (De Luca, et al. 2018a, b; Gamito et al. 2015; Kim et al. 2011; Wentink et al. 2016; Yip and Man 2013). These strategies differ from traditional drill and practice exercises because they can be programmed to match the needs of the individual, include adaptive intensity of training, provide instant feedback, and can incorporate stimuli that simulate real-world situations and interactions to better facilitate generalization (Fernandez et al. 2017; Lebowitz et al. 2012; Maggio et al. 2019). It is expected that due to the adaptive intensity of the training and feedback, neural plasticity processes below the neuronal level (synapses are changed or created based on experiences) and at the neuronal network level (networks are altered due to changes in synapses and new synaptic connections) will be altered in such a way that can be sustained over time to maintain improvements seen during the CACR (Berlucchi 2011; Caeyenberghs et al. 2018; De Luca, et al. 2018a, b; Fernandez et al. 2017; Kane and Ward 2021). This targeted rehabilitation would then presumably translate to neuroplastic adaptations that are sufficient to result in functional level changes in daily life (Fernandez et al. 2017).

In a study by Fernandez et al. (2017), ABI patients were either allocated to an experimental group where they received CACR with RehaCom software or a control group who received standard rehabilitation over an eight-week period. The experimental group engaged with the software that provided compensatory strategies and training procedures to improve cognitive functions including memory and attention. In addition, there were individualized subprograms and levels of difficulty and participants received immediate feedback. The control group received similar training with activities targeted to improve cognitive functions including memory and attention using paper-and-pencil tasks. Both the experimental and control groups showed significant improvements across a variety of neuropsychological tests including memory tests. However, the experimental group showed significantly higher improvements in attention and memory following treatment compared to the control group. Thus, the authors suggest the superiority of CACR compared to a non-computerized approach, perhaps due to the incorporation of immediate feedback to improve self-awareness, higher levels of stimulation through improved stimuli quality and presentation to improve attention and focus, and dynamic adaptations to individual needs that increase motivation (Fernandez et al. 2017). Similar studies have highlighted improvements on cognitive tests when using CACR dedicated software such as RehaCom and CogMed in comparison with non-computerized approaches for individuals with ABI (De Luca, et al. 2018a, b; Lebowitz et al. 2012; Ressner et al. 2018; Yoo et al. 2015). However, limited effect on activities of daily living, small sample sizes, limited or no follow-up, and outcome measures that may not reflect ecologically relevant tasks demonstrate that there should be some caution when considering the effect of this type of CACR on functional outcomes and transfer of gains to real-world settings (De Luca, et al. 2018a, b; Fernandez et al. 2017; Ressner et al. 2018; Yoo et al. 2015).

The results with brain training programs such as Lumosity have been less promising, especially regarding generalization effects (Connor and Standen 2012; Simons et al. 2016; Wentink et al. 2016; Withiel et al. 2019). Wentink et al. (2016) compared a CACR intervention using Lumosity to a control condition involving education about the brain and stroke with stroke survivors across and eight-week period. They found limited effects of training for the intervention group compared to the control group and only for cognitive tests that were like the games in the training. In addition, no significant differences were found on subjective measures of cognition, self-efficacy, or quality of life. Thus, the authors suggest that targeting one cognitive domain may be more effective compared to targeting multiple domains and emphasize the need to tailor CACR training to individual needs of the participants (Wentink et al. 2016). Similar results with brain training programs have resulted in the suggestion that the effectiveness of these programs for use with individuals with ABI warrants further examination (Connor and Standen 2012; Wentink et al. 2016; Withiel et al. 2019). The contrast in support for memory rehabilitation programs such as RehaCom to the mixed outcomes with brain training programs such as Lumosity is worth noting. Although these approaches share similarities, it is possible that the divergence in evidence supporting the rehabilitation programs over the brain training programs relates to the target groups in development of the programs. For example, rehabilitation-specific programs may include aspects that are tailored to individuals suffering deficits in cognition, whereas brain training programs designed for improving cognition across a wide audience may not have the necessary adaptations required for individuals with cognitive deficits (Connor

and Standen 2012; Simons et al. 2016; Withiel et al. 2019). Thus, it is perhaps essential to consider the target group for memory rehabilitation in relation to the features available within CACR programs.

Another strategy of CACR is virtual reality programs with both immersive and non-immersive options where virtual environments are created that allow users to engage with stimuli within that environment (Faria et al. 2020; Gamito et al. 2015; Kim et al. 2011; Maggio et al. 2019). Recent studies have demonstrated efficacy on improving task-related outcomes for individuals with ABI, posing virtual reality as a promising avenue in cognitive rehabilitation (Faria et al. 2020; Gamito et al. 2015; Kim et al. 2011; Maggio et al. 2019; Wilson 2013; Yip and Man 2013). However, current consensus indicates that further research is needed regarding the generalization to tasks in real life, training duration, and underlying mechanisms of virtual reality (Faria et al. 2020; Maggio et al. 2019; Velikonja et al. 2014; Yip and Man 2013).

There are several benefits to CACR, including immediate and dynamic feedback to participants, progressive learning, and customization to individual needs (Faria et al. 2020; Fernandez et al. 2017; Gamito et al. 2015; Wentink et al. 2016; Yoo et al. 2015). Immediate and dynamic feedback allows for improved self-awareness of current functioning level and motivation to continue with treatment, and progressive learning and adaptation to individual needs will prevent frustration or boredom, potentially improving adherence to the program (Faria et al. 2020; Fernandez et al. 2017; Lebowitz et al. 2012; Pertíñez and Linares 2015; Withiel et al. 2020). Moreover, some CACR programs can be administered at home and are relatively low-cost options, which may improve accessibility, particularly for individuals who have limited mobility options (Withiel et al. 2019; Yip and Man 2013). Another benefit of CACR, especially with virtual reality, is improved ecological validity of tasks that can be programmed to simulate real-life situations, which is difficult to attain using traditional paper-and-pencil methods (Faria et al. 2020; Gamito et al. 2015; Kim et al. 2011; Maggio et al. 2019; Wilson 2013; Yip and Man 2013). While these benefits of CACR are promising, barriers to compliance include the risk of fatigue impeding continuation of use, hemiparesis making using the technology difficult, negative feedback resulting in frustration and negative self-evaluations, lack of awareness of deficits, and computer literacy level (Connor and Standen 2012; Lebowitz et al. 2012; Pertíñez and Linares 2015; Wentink et al. 2016; Withiel et al. 2020; Yip and Man 2013). Moreover, there is limited evidence of transfer to activities of daily living or similar tasks (van Heugten and Wilson 2021; Wentink et al. 2016; Yoo et al. 2015). Recent reviews of CACR emphasized the wide variation of participant etiologies, small sample sizes, duration of time since injury and age span across research studies, making it difficult to draw conclusions regarding the effectiveness of improvements in cognitive functioning, although there appears to be some benefits for working memory (Fetta et al. 2017; López and Antolí 2020). CACR is a promising avenue for memory rehabilitation after ABI, yet further examination is warranted to determine the patients who would be able to access such a treatment approach and the training duration required to produce lasting effects.

Summary

Although it was expected that drill and practice would be efficacious, especially if used with computer training, because computers could serve as a useful tool for repeated presentation and testing of stimuli, this was not the case (Kapur et al. 2002, 2004; Sohlberg and Mateer 1989). Additionally, improvements for memory of learned information through repetition does not indicate improvement in general memory functioning (Hart and Hayden 1986; Schacter and Glisky 1986). Overall, there appears to be little evidence supporting the use of repetitive drill and practice exercises in restoring function (Cicerone et al. 2000; Kapur et al. 2002; Prigatano 1987; Schacter and Glisky 1986; Tate 1997; Wilson 2009). However, CACR shows more promise in improving outcomes with the ability for dynamic adaptation to suit individual needs, a variety of tasks available, feedback to improve self-awareness, and the potential to include ecologically valid stimuli to promote generalization (Faria et al. 2020; Wilson 2013). Some barriers to CACR may include fatigue, hemiparesis, computer literacy, awareness of deficits, and negative self-evaluations resulting from negative feedback (Pertíñez and Linares 2015; Withiel et al. 2020). Moreover, further research is needed to demonstrate transfer effects to tasks in everyday life and to examine the required training duration and potential long-term effects of CACR (Withiel et al. 2019, 2020). Although CACR provides some promise for the restoration approach with regards to improvements on objective memory measures, further examination of the effects on functional outcomes and underlying mechanisms is warranted.

Specific knowledge acquisition approach

Based on the limited evidence of success with drill and practice, an alternative approach was proposed: the *acquisition of domain-specific knowledge*. This entails teaching knowledge that is relevant to the individual's everyday life in specific domains (e.g., names of hospital staff or remembering when and how to complete household duties) without the expected improvement in general memory functioning (Glisky and Schacter 1988; Kapur et al. 2004; Pino 2015; Schacter and Glisky 1986). Strategies within this approach

include the vanishing cues method, errorless learning, and spaced retrieval (Censori et al. 1996; Clare and Jones 2008; Evans et al. 2000; Haslam 2017; Schacter and Glisky 1986). These strategies are thought to draw on preserved implicit memory abilities (that do not require conscious processing) to acquire specific knowledge or skills with appropriate training, instead of explicit memory abilities (that require conscious processing) which have been shown convincingly to be disrupted for memory-impaired patients (Baddeley and Wilson 1994; Clare and Jones 2008; Glisky and Schacter 1988; Haslam et al. 2011; Hunkin and Parkin 1995; Kessels and de Haan 2003; Wilson et al. 1994; Wilson and Fish 2017).

Method of vanishing cues

This is a technique whereby as much cue information as is needed to produce the correct response is provided and then gradually withdrawn over several learning trials (Cheyne 1966; Haslam 2017; Kapur et al. 2004; Kessels and de Haan 2003; Moffat 1992). For example, in verbal memory tasks, a complete word is presented on the first trial and letters of the word are gradually removed from right to left as participants provide the correct response on each subsequent trial (Clare and Jones 2008; Glisky et al. 1986; Riley and Venn 2015). Incorrect responses are corrected by adding a letter until the participant can produce the word or by presenting the complete word (Evans et al. 2000; Glisky et al. 1986; Hunkin and Parkin 1995; Riley and Venn 2015). It has been proposed that the vanishing cues method would result in better recall than the standard anticipation method, where the complete word is shown after each guess regardless of response (Cheyne 1966; Hunkin and Parkin 1995). This proposal is based on the assumption that the vanishing cues method has similar characteristics as priming and would more efficiently tap implicit memory processes that remain intact for memory-impaired patients (Cheyne 1966; Glisky et al. 1986).

Glisky et al. (1986) assessed the vanishing cues method compared to a standard anticipation method. In the vanishing cues condition, memory-impaired patients were presented with definitions of computer-related words along with a fragment of the word, which contained one letter fewer than the participant required to correctly produce the word in the previous trial. In the standard anticipation condition, participants were shown the definition and guessed the word, followed by the presentation of the correct answer regardless of correct/incorrect guess. Across an eight-week period, the proportions of words correctly recalled across both conditions increased but with better performance in the vanishing cues condition (Glisky et al. 1986). Hunkin and Parkin (1995) were unable to replicate these findings and instead found a general improvement with both the vanishing cues and standard anticipation methods. The authors noted that a possible reason for the discrepancy is that their memory task required explicit memory and was therefore incompatible with the vanishing cues method (Hunkin and Parkin 1995). Recent evidence suggests that the type of instructions provided at the encoding stage during a vanishing cues tasks may influence outcomes (Riley and Venn 2015). Intentional instructions (i.e., those that encourage the use of explicit memory) can allow for more elaborate encoding during the task and can be used with individuals who have less severe memory deficits and are still able to capitalize on explicit memory abilities. In contrast, those who have more severe deficits may have more success with recall when provided with automatic instructions (i.e., those that encourage the use of implicit memory) during a vanishing cues task (Riley and Venn 2015). Thus, it is perhaps essential that the memory task and type of instructions provided align with the targeted memory ability.

The initial motivation for using the method of vanishing cues in rehabilitation was to provide information about computer terms required to use computers as external aids, but the technique has also been used with some success in learning face-name associations and list learning (Glisky et al. 1986; Glisky and Schacter 1988; Riley et al. 2004; Riley and Venn 2015; Thoene and Glisky 1995). However, it has been observed that the method of vanishing cues can be time-consuming because it may require many learning trials (Hunkin and Parkin 1995; Kessels and de Haan 2003; Riley et al. 2004). In particular, Glisky and Schacter (1988) noted that memory-impaired patients require many more learning trials than do controls. Moreover, on a transfer task where the wording of the vocabulary definition was altered (e.g., *loop* is changed from "a repeated portion of a program" to "if you want a program to perform the same operations repeatedly, you must put it in a ____"), control participants produced significantly more words without requiring letter cues than did the memory-impaired patients (Glisky et al. 1986). Based on these results and the difficulty for memory-impaired patients to respond to open-ended questions regarding the learned information, Glisky and Schacter (1988) noted that there are likely to be difficulties in transferring learned material between the laboratory and the real world when using the vanishing cues method with memory-impaired patients. Similarly, Riley and Venn (2015) suggest that the arbitrary list of words with limited practical relevance used in their study may have contributed to the attrition rate and suggest the use of more engaging and ecologically relevant stimuli in future research with the vanishing cues method.

Errorless learning

This strategy involves preventing errors as much as possible during learning. Errorless learning is based on the assumption that memory for learned information will improve by reducing guessing and thus incorrect responses (Baddeley and Wilson 1994; Clare and Jones 2008; Shigaki et al. 2014; Wilson 2002, 2013). Errorless learning paradigms often include an errorful condition, where participants are provided with word stems (e.g., "BR") and guess the word, and an errorless condition, where participants are provided with the correct word (e.g., "BREAD") immediately after the stem (Baddeley and Wilson 1994; Evans et al. 2000; Fish et al. 2015; Wilson et al. 1994). It has been proposed that the errorful condition will introduce incorrect responses to the question through guessing, whereas the errorless condition eliminates that possibility, reinforcing only the memory trace for the correct information (Baddeley and Wilson 1994; Fish et al. 2015; Haslam et al. 2011; Wilson et al. 1994; Wilson and Fish 2017). Thus, this method may benefit memory-impaired patients who have difficulty correcting errors, which relies on explicit memory processes (Baddeley and Wilson 1994; Evans et al. 2000; Haslam et al. 2011; Kessels and de Haan 2003; Wilson and Fish 2017).

Baddeley and Wilson (1994) compared errorless and errorful learning across people with severe memory impairments, healthy older adults, and healthy young adults. Participants completed multiple learning and test trials in both errorless and errorful conditions. All three participant groups showed marked improvements when using the errorless learning method compared to the errorful method, but memory-impaired patients were significantly more affected by the advantage of the errorless learning compared to healthy young and older adults. This outcome is consistent with the view that memory-impaired patients have difficulty eliminating errors on their own, which can be resolved by training them with only correct information and reducing the possibility of encoding incorrect information through guessing (Baddeley and Wilson 1994). Comparable improvements using the errorless learning strategy with memory-impaired patients have been reported for learning person and object names, word lists, and face-name associations (Evans et al. 2000; Haslam et al. 2011; Wilson et al. 1994). In addition, it has been shown that errorless learning is superior to errorful learning for event-based prospective memory tasks for memory-impaired individuals, indicating a potential avenue for future research to explore the possibility of integrating errorless learning into activities of daily living (Fish et al. 2015; Wilson and Fish 2017). Similar to the method of vanishing cues, learning one item at a time over multiple trials may result in lengthy sessions for errorless learning (Evans et al. 2000; Wilson et al. 1994). Finally, the difficulty associated with achieving a truly errorless learning procedure has been noted as there are likely fewer rather than no errors compared to the errorful learning conditions (Clare and Jones 2008; Fish et al. 2015; Wilson and Fish 2017). As such, it has been suggested that errorless learning might be more aptly described as "error-reducing."

Spaced retrieval

Here, to-be-remembered information is presented and tested at increasing intervals, based on evidence that distributed practice results in better memory for information compared to massed practice (Censori et al. 1996; Creighton et al. 2013; Harris 1992; Haslam 2017; Wilson 2002). Mistakes are corrected immediately and if the information cannot be recalled, it is provided, reducing errors during learning (Clare and Jones 2008; Creighton et al. 2013). Additionally, when errors occur, the retrieval interval is reduced to the previous one before being progressively increased again (Haslam et al. 2011).

In a study by Schacter et al. (1985), memory-impaired patients completed spaced retrieval training over eight weeks using faces and experimenter-provided characteristics of the faces (names, occupations, hobbies). Participants showed improved recall of characteristic information from baseline to post-training assessment, which extended to those with severe memory deficits (Schacter et al. 1985). In addition, retrieval practice has been shown to have greater benefits for ABI patients in word and name recall in comparison with spaced restudy and massed practice (Evans et al. 2020; Sumowski et al. 2014). Although it has been implemented with ABI patients, spaced retrieval training is more often directed toward older adults with cognitive impairments or dementia patients and has been successful for these groups (Censori et al. 1996; Creighton et al. 2013; Evans et al. 2020; Haslam 2017; Haslam et al. 2011). While spaced retrieval has shown success with patients in experimental settings, previous research has been criticized for the low ecological validity of the stimuli used in the studies and the role of errorless learning as part of the technique remains unclear (Creighton et al. 2013; Haslam et al. 2011).

Summary

Errorless learning, vanishing cues, and spaced retrieval strategies have shown positive outcomes in studies with memory-impaired patients. There is an advantage for errorless learning over errorful learning (Baddeley and Wilson 1994; Evans et al. 2000), for vanishing cues over standard anticipation (Glisky et al. 1986), and for spaced retrieval over uniform retrieval (Censori et al. 1996). These strategies have been designed with the intention to capitalize on preserved implicit memory abilities of memory-impaired patients (Censori et al. 1996; Haslam 2017; Kapur et al.

2004; Schacter and Glisky 1986; Wilson and Fish 2017). Therefore, it has been suggested that these techniques could be particularly beneficial for patients with severe memory impairments, who may have marked difficulties with tasks that require explicit memory (Censori et al. 1996; Clare and Jones 2008; Shigaki et al. 2014; Wilson 2002; Wilson and Fish 2017). Moreover, as these strategies include some error reduction at the learning stage, they may strengthen connections for only the correct stimulus and response associations for patients with poor error-monitoring (Clare and Jones 2008; Piras et al. 2011). However, these strategies require intensive training which can be time- and resource-consuming, requiring stimuli to be learned one at a time over multiple trials, and memory-impaired patients have required significantly more learning trials than healthy controls (Glisky and Schacter 1988; Kapur et al. 2002; Tailby and Haslam 2003). Finally, their generalizability has come into question given that the learned material is specific (e.g., word lists) that may not be relevant to everyday life needs (Creighton et al. 2013; Fish et al. 2015; Piras et al. 2011; Riley and Venn 2015; Tailby and Haslam 2003). However, to address this limitation, it has been suggested that patients may be able to quiz themselves or be quizzed by family members on learned information (e.g., phone numbers or names) or tested through the use of booklets, timers, or sliders (Evans et al. 2020; Fish et al. 2015; Moffat 1992; Sumowski et al. 2014). Further exploration of these strategies focusing on their impact and implementation in everyday life is warranted.

Compensatory approach

The compensatory approach involves using strategies and tools that alleviate the impact of memory problems in daily life and improve daily functioning without the expectation of improvement of memory functioning (Cicerone et al. 2000, 2005; Schacter and Glisky 1986; van Heugten and Wilson 2021). A compensatory approach may become the focus of memory rehabilitation when restoration of function seems to be no longer possible either through spontaneous recovery or memory training (De Luca, et al. 2018a, b; Wilson 2000). It is held that the compensatory approach can lead to improvements as a result of a structural reorganization of neural modules (das Nair and Lincoln 2012; Rothi and Horner 1983; Shigaki et al. 2014). Specifically, training patients to use compensatory strategies may result in the reorganization of neural networks to recruit undamaged circuits to compensate for the lack of activity in the damaged circuits (das Nair and Lincoln 2012; Galetto and Sacco 2017; Rothi and Horner 1983; Tate 1997). Compensatory strategies include internal and external memory aids (das Nair et al. 2016; Intons-Peterson and Fournier 1986; Wilson 2000).

Internal aids

These involve the mental manipulation of information via imagery or associations to improve retrieval at a later time (das Nair and Lincoln 2012; Haskins et al. 2012; Lewinsohn et al. 1977; O'Neil-Pirozzi et al. 2010, 2016; Perna and Perkey 2016; Wilson 1982). Internal aids include mnemonics such as chunking, rhyming, acronyms, visualization, first letter mnemonics, and chaining (Crovitz 1979; das Nair et al. 2016; Harris 1992; Lewinsohn et al. 1977; Velikonja et al. 2014). Specific strategies include the method of loci, the peg method, the face-name mnemonic technique, and the story method (Intons-Peterson and Fournier 1986; Madan 2014; Tate 1997). Across internal aids, mnemonic strategies with imagery components are the most commonly evaluated and show the most promising results (Censori et al. 1996; O'Neil-Pirozzi et al. 2016; Patten 1972; Pino 2015). Internal aids are often used as part of memory rehabilitation or training rather than as standalone memory aids (das Nair and Lincoln 2012; Leśniak et al. 2018; Lewinsohn et al. 1977; O'Neil-Pirozzi et al. 2010; Perna and Perkey 2016; Velikonja et al. 2014).

In a study by Kaschel et al. (2002), patients with mild memory impairment were taught to rapidly generate images when provided with verbal information that was either autobiographical (e.g., remember a holiday) or neutral (e.g., change a lightbulb). They were then shown videos of objects or actions and interacted with them to varying difficulty levels (ranging from holding the image in their mind to drawing the image). In comparison with a pragmatic group who received a variety of internal and external memory aid training, the imagery group showed significant improvements on immediate and delayed story recall, and an improvement in relatives' rating of everyday relevant changes (Kaschel et al. 2002). More recently, the self-imagination method, a strategy which involves visual imagery and semantic elaboration, has been developed to capitalize on preserved mnemonic mechanisms related to the self in memory-impaired individuals (Grilli and Glisky 2010, 2011). Across two studies testing the mnemonic, memory-impaired participants demonstrated improvements in recognition memory and delayed cued recall (Grilli and Glisky 2010, 2011). Additionally, these studies demonstrated an advantage for this mnemonic over others such as visual imagery, semantic elaboration alone. (Grilli and Glisky 2010, 2011). These findings were then extended to demonstrate the benefits of the self-imagination effect for a prospective memory task for memory-impaired individuals, highlighting a potential avenue for future research investigating the application of this mnemonic strategy within real-life settings (Grilli and McFarland 2011). Similarly, other researchers have demonstrated improvements in memory for memory-impaired patients using chaining, the peg method, the face-name

mnemonic technique, and first letter mnemonics (Crovitz 1979; Glasgow et al. 1977; Lewinsohn et al. 1977; Patten 1972; Wilson 1982).

Proposed criteria for the success of mnemonics in improving daily functioning are that maintenance of the strategy by the individual must be present exclusive of explicit instructions after initial learning and the strategy must be generalizable to other tasks (Leśniak et al. 2018; Schacter and Glisky 1986). It has been suggested that internal memory aids are effective because they require a deeper level of processing, encourage integration between separate pieces of information, and include internal retrieval cues (Leśniak et al. 2018; O'Neil-Pirozzi et al. 2016). There is some evidence for the effectiveness of using internal memory aids in experimental settings, but evidence regarding the generalizability to untrained tasks that affect functioning in everyday life is more limited (Censori et al. 1996; O'Neil-Pirozzi et al. 2016; Tate 1997). It is important to note that internal strategies may only be beneficial for patients with mild to moderate memory impairments because they require manipulation of information (Haskins et al. 2012; Schacter and Glisky 1986; Shigaki et al. 2014). In addition, internal aids require a certain level of self-awareness regarding memory deficits in addition to self-monitoring and self-regulation to make continued efforts to apply learned strategies in appropriate situations (Velikonja et al. 2014). Finally, examination of the potential long-term effects of internal memory strategies is warranted (O'Neil-Pirozzi et al. 2010, 2016).

External aids

These involve manipulation of the environment or the use of devices to store information that can be accessed at a later time, reducing memory demands (Harris 1980; Intons-Peterson and Fournier 1986; Wilson 2000). Environmental adaptations include labeling doors or items in the house, using arrows for directions, and strategically placing objects in specific locations relevant to when or how they are to be used (Evans et al. 2003; Jamieson et al. 2017; Kapur et al. 2002; Tate 1997). Memory aids include notebooks, calendars, personal digital assistants, and mobile phones that can be used for shopping lists or reminders for appointments or to take medications (Evans et al. 2003; Harris 1992; Kapur et al. 2004; Schacter and Glisky 1986; Velikonja et al. 2014; Wilson 2002). External aids may benefit individuals who have difficulty learning or using the previously outlined internal strategies (Kapur et al. 2002).

Sohlberg and Mateer (1989) proposed a structured, systematic approach to training memory-impaired individuals on using a memory notebook to record orientation, daily activities, appointments, transportation information, names, and feelings. In a case study, a 19-year-old patient with severe memory deficits learned the sections of the notebook in an acquisition phase, learned how to record in the book through an application phase, and finally used the notebook in naturalistic settings in an adaptation phase. Following six months of intensive training, the patient was able to independently use the notebook system. Although his profound memory and learning difficulties persisted, he required minimal daily assistance in everyday tasks and increased his production at work. The authors suggested that similar systematic training should be employed with other external aids as patients must understand how and when to use them for them to be effective (Sohlberg and Mateer 1989).

Advances in technology have allowed for further examination of systems such as NeuroPage, prosthetics, and smart house options to be used as external aids (Boman et al. 2010; Hersh and Treadgold 1994; Jamieson et al. 2017; Vasquez et al. 2021; Wilson et al. 1997). NeuroPage is a portable paging system for reminders and cues that can be personalized to each individual and circumvent the issue of forgetting to use the external memory aids such as notebooks and has demonstrated success with memory-impaired individuals (Jamieson et al. 2017; Wilson et al. 1997). However, the use of pagers in general as assistive technologies has decreased as much of their functions are now included within the capacity of mobile phones (Jamieson et al. 2017; Lannin et al. 2014; Wong et al. 2017). Since the introduction of NeuroPage, researchers have further explored digital prosthetic aids with promising generalization and long-term effects (Ferguson et al. 2015; Svoboda et al. 2012, 2015; Vasquez et al. 2021). Boman et al. (2010) examined the use of a home-based electronic memory aid based on sensors that indicate whether an activity was already completed and then provides reminders as needed. The product was found to be helpful for four out of five of the participants and highlights the possibility of using smart house technology to help in the compensation of daily functioning for ABI survivors (Boman et al. 2010). Lannin et al. (2014) demonstrated the advantages of using personal digital assistants to reduce memory failures compared to non-electric compensatory aids whereas Svoboda et al. (2012, 2015) successfully trained moderate and severe memory-impaired individuals to use personal digital assistants and mobile phones to improve daily functioning outcomes that were sustained over a long-term period. These studies have demonstrated the evolution and beneficial effects of assistive technologies that are more versatile and portable than older external aids such as notebooks and calendars (Boman et al. 2010; Jamieson et al. 2017; Lannin et al. 2014; Svoboda et al. 2012, 2015; Vasquez et al. 2021; Wong et al. 2017). However, there remains a need for extensive training to adapt usage of these devices into prosthetic aids, which must be considered when prescribing the use of external memory aids (Svoboda et al. 2015; Vasquez et al. 2021; Velikonja et al. 2014; Wong et al. 2017).

External memory aids are the dominant choice amongst persons with ABI and healthy adults (Evans et al. 2003; Harris 1980; Intons-Peterson and Fournier 1986). Presumably, external compensatory strategies are favored in comparison with internal strategies or knowledge acquisition strategies for practical reasons because people are already familiar with them, it is perhaps simpler and quicker to train people to use them, and they may be easier to use in a variety of situations (Chouliara and Lincoln 2016; Zencius et al. 1990, 1991). One survey revealed that the four most commonly used external memory aids were calendars, wall charts, notebooks, and lists (Evans et al. 2003). However, with the rise in prevalence of technology, the use of aids such as mobile phones and alarms/timers has increased (Jamieson et al. 2017; Wong et al. 2017). It has been suggested that the benefit of external memory aids comes from increased functional ability and self-confidence in patients who use them (Ferguson et al. 2015; Kapur et al. 2004). External aids have a particularly difficult limitation: patients must be aware of their memory limitations in order to be motivated to use them (Pino 2015; Shigaki et al. 2014). However, it has been acknowledged that the need to remember to use external aids may be reduced with the use of electronic aids which can be programmed to provide reminders or alarms (Jamieson et al. 2017; Lannin et al. 2014). It is important to note that the effectiveness of external aids might depend on several factors including the device, software changes that may alter the interface of technological aids, the age of the patient, the time since onset of memory impairment, and the extent to which the aids were used before impairment (Censori et al. 1996; Jamieson et al. 2017; Piras et al. 2011; Svoboda et al. 2012). Finally, although external memory aids are recommended to patients or used as part of rehabilitation programs, there is little information available as to the extent of the training required to use external aids efficiently in daily life as this may vary by each individual's needs (Haskins et al. 2012; Sohlberg 2005; Velikonja et al. 2014; T. K. Wade and Troy 2001).

Summary

There has been some success in applying internal and external memory aids to improve the daily functioning of memory-impaired individuals. It has been suggested that internal aids would be better suited to individuals with mild memory impairment, whereas external memory aids may be better suited to individuals with moderate to severe impairment (Cicerone et al. 2011, 2019). However, while patients may successfully apply these strategies when provided with instructions during rehabilitation sessions, they may face more difficulties when applying strategies independently (Censori et al. 1996; Shigaki et al. 2014; Wilson 2002). Therefore, careful consideration should be given to the strategies that best suit the needs of the memory-impaired patient.

Holistic approach

The holistic approach addresses the emotional, social, and functional consequences of ABI alongside the cognitive consequences (Ben-Yishay 2000; Prigatano 2013; van Heugten and Wilson 2021; Wilson 2013). Key factors in this approach involve (1) establishment of a therapeutic setting or community, (2) addressing knowledge of the deficit and subsequent impact on functional abilities through education, (3) addressing the cognitive deficit, usually with compensatory aids, (4) addressing the emotional and social consequences of the deficit through psychotherapy, and (5) involving family members in the rehabilitation process (Ben-Yishay 2000; Nilsson et al. 2011; Prigatano 2013; Withiel et al. 2019). This approach is underpinned by the notion that the multidimensional nature of cognition and the interaction with the other systems should be addressed together because they interact with and influence each other (Afsar et al. 2021; Ben-Yishay 2000; Perna and Harik 2020; Prigatano 2013; Wilson 2013). The ultimate goal is to address the consequences of ABI in a manner that will allow for establishment of satisfactory life through community integration, social participation, and productivity whilst managing continued limitations (Cicerone et al. 2008; Exner et al. 2021; Holleman et al. 2018; Shany-Ur et al. 2020).

The holistic approach has been examined in comparison with a standard multidisciplinary approach for individuals with TBI by Cicerone et al. (2008). In this study, half of the participants were allocated to the standard neurorehabilitation program where they received interventions targeting specific deficit areas such as cognitive functions and were primarily conducted with individual therapies with some limited options for group treatments available. The other half of the participants were allocated to the intensive cognitive rehabilitation program which were conducted in group sessions consisting of therapist and peer feedback, compensatory strategies, and an emphasis on metacognition. While both groups showed significant improvements on neuropsychological functioning measures, the holistic program resulted in a moderate positive effect on community functioning and small effect on life satisfaction, neither of which were observed with the standard program. The authors suggest that metacognition and emotional regulation aspects of the holistic program played an important role in the difference between the two programs. The results of this study highlight the beneficial effects of supporting the psychosocial, emotional, and metacognitive aspects of ABI alongside the cognitive consequences, however, it is also mentioned that further examination of the contributions of

individual components of the program is warranted (Cicerone et al. 2008).

In a study by Shany-Ur et al. (2020), ABI patients in community settings participated in a holistic program over the course of 10 months and then completed follow-up assessments at one-, two-, and three-year post-completion. Cognitive domains addressed included memory, attention, and executive functioning. Psychological interventions included individual and group therapy, and family members were involved in psychoeducational group meetings and optional family therapy. Significant improvements were found in employment rates following the program and work stability during the follow-up period. Additionally, community integration and perceived quality of life significantly improved across time. However, there was no significant difference between time points on mood disturbance, and the authors suggest that perhaps increased self-awareness of deficits because of the program resulted in lowered mood. Moreover, it was highlighted that the length of the treatment program was considerable, which may limit the generalization of the findings as rehabilitation length may differ by institution or country. Finally, most of the participants were unemployed at the time of enrolment but gained employment at a later period. This highlights an important interaction between program length and return to work, which may occur during the program for some individuals, potentially resulting in attrition. The results of this study demonstrated the beneficial and stable long-term effects of holistic neuropsychological rehabilitation but also highlighted some areas that require further consideration (Shany-Ur et al. 2020). Similar studies have found positive effects of holistic rehabilitation on psychological, emotional, and quality of life measures, although the benefits on cognitive functions have been mixed (Afsar et al. 2021; Exner et al. 2021; Holleman et al. 2018; Nilsson et al. 2011; Sarajuuri et al. 2018; Urech et al. 2020).

Summary

The benefits of the holistic approach may not only lie in the potential improvements in daily functioning, but also community participation, productivity, self-efficacy and life satisfaction (Cicerone et al. 2019; Nilsson et al. 2011; Wilson 2013). Participant perspectives have revealed that knowledge and understanding of brain functions and the impact of ABI are beneficial aspects of holistic programs because they provide participants with information that reduces stress regarding current ability levels (Chouliara and Lincoln 2016; Nilsson et al. 2011). Thus, it appears that improving self-awareness through education and feedback within the therapeutic setting while addressing the emotional, social, and behavioral consequences of ABI can promote improved functional outcomes in these areas. Although the evidence regarding the improvement of cognitive functions is more mixed, re-integration within community settings and improvements in social participation are undeniably beneficial outcomes of the holistic approach. However, there are some limitations worth noting: first, it is difficult to identify the contributions of specific aspects of the program and thus the optimal combination of strategies to form a program, second, there are considerable time and resource commitments requiring cost considerations, and finally, motivation to participate by all parties involved (patient and family members) need to be aligned to fit within the model (Chouliara and Lincoln 2016; Cicerone et al. 2008; Exner et al. 2021; Prigatano 2013). Altogether, there is good evidence that the holistic approach can improve the lives of ABI patients, and it will likely be adapted more frequently in the future with some essential considerations regarding cost, delivery, and motivation (Nilsson et al. 2011; Prigatano 2013; Wilson 2013).

Comparing approaches

Compensatory approaches are used more often than restorative approaches in memory training and rehabilitation but they are sometimes combined to form a multi-strategy program (Haskins et al. 2012; Lincoln et al. 2002; Raskin et al. 2019; Robertson 1999). It has been suggested that the preference for compensatory approaches is due to the lack of evidence supporting lasting improvement following restoration approaches (Evans et al. 2003; Robertson 1999). Similarly, limited support for the generalization of drill and practice has resulted in the exploration of the specific knowledge acquisition approach (Thoene and Glisky 1995). Finally, the emergence of the holistic approach takes into consideration emotional, social, and behavioral factors of ABI that are not commonly addressed across the other approaches (Prigatano 2013; Wilson 2013). A few studies have directly compared the different memory rehabilitation approaches.

Thoene and Glisky (1995) compared the specific knowledge acquisition approach using the vanishing cues strategy, the compensatory approach using a mnemonic strategy, and an exposure alone intervention with a video presentation on face-name recall for memory-impaired patients. The only condition in which all patients were able to reach the criterion (recalling four first and last names) was the mnemonic condition. Moreover, the participants needed significantly fewer trials to reach criterion with the mnemonic condition than with the vanishing cues or the video presentation conditions, which did not significantly differ from each other. The researchers proposed that the results of this study reflect the need to correctly match the stimulus type to the strategy type (Thoene and Glisky 1995). Specifically, the mnemonic strategy encouraged connecting the names and the faces,

whereas the vanishing cues training emphasizes learning individual items such as the names but not the connection between the names and the faces. Moreover, the abstract nature of person names was manipulated to be less abstract in the mnemonics condition where semantic associations were used to connect the name and the face, but in the vanishing cues condition, the emphasis was on learning the text. In this instance, the authors proposed that the compensatory approach was superior to the specific-knowledge acquisition approach because it was more appropriately matched to the stimulus type. Similarly, Evans et al. (2000) found that the errorless learning method is beneficial for (first letter) cued recall of names, requiring implicit memory but not for arbitrary face-name associations with free recall, requiring explicit memory. However, a combination of an imagery strategy and errorless learning led to improvements in free recall of names (Evans et al. 2000). These studies have highlighted the importance of using the memory rehabilitation approach that is most compatible with the stimulus types.

das Nair and Lincoln (2012) compared the restorative and compensatory approaches with a self-help approach. Individuals who reported memory problems due to ABI engaged in training sessions with a researcher and completed homework exercises. The restorative and compensatory experimental groups learned about internal memory aids and errorless learning techniques. The compensation group was additionally taught how to employ external memory aids. The restoration group was taught how to encode information using "Who," "What," "Why," "When," "Where," and "How" questions, attention retraining exercises, and letter and number cancellation tasks. The self-help group was taught relaxation and coping techniques but no memory strategies. The restoration and compensation groups had significantly higher scores on the Internal Memory Aids Questionnaire at five and seven-month follow-up points. However, there were no significant differences between any groups on the primary outcome measure, the Everyday Memory Questionnaire. In general, the restoration and compensation groups showed similar outcomes. The authors reported that the restoration group also developed the use of some compensatory strategies on their own, but without a baseline test of the External Memory Aids questionnaire, this can only be considered an observation by the researchers. Based on the few significant outcomes, limited sample size, and heterogeneity of the sample, the authors concluded that concrete assertions are not warranted regarding the effectiveness of the memory rehabilitation approaches in this study (das Nair and Lincoln 2012).

Withiel et al. (2019) compared the restorative approach using computer-assisted cognitive rehabilitation (CACR) to a more holistic approach involving memory skills group-based training and a waitlist control group. Community dwelling stroke survivors set memory-specific rehabilitation goals with a trained researcher before being randomly assigned to the CACR, memory skills, or control group. The CACR was conducted using Lumosity involving games targeting memory function and was completed by participants at their home with weekly phone calls with the researchers to assess compliance. The memory skills group consisted of education regarding memory, internal and external strategies, and lifestyle sessions facilitated by a neuropsychologist. There was no significant difference between the groups on individualized goal attainment at baseline. Participants in the memory skills group demonstrated significantly greater individualized goal attainment from baseline to post-intervention in comparison with the waitlist control. In addition, these gains were maintained at follow-up six weeks later where the memory skills group had significantly greater goal attainment compared to other two groups. However, the differences between the groups on objective measures of memory were more mixed with little group differences across visual and verbal learning and memory measures and limited differences on prospective measures. Subjective measures revealed a significant reduction in the frequency of everyday memory complaints for participants in the memory skills group from baseline to post-intervention but not follow-up, and the CACR group had a significant reduction in prospective memory failures post-intervention but not at follow-up. The results of this study highlight an advantage for the holistic approach in relation to waitlist control and CACR for functional improvements. However, several of the measures used in this study were subjective and may therefore be subject to biases. In addition, the memory skills group was in regular contact with other stroke survivors and the researchers, whereas the CACR and the control groups had fewer interactions, which may have influenced responses to goal attainment outcomes and subjective memory measures. The authors suggest that memory skills group provides a more holistic approach to memory rehabilitation which may better address the multifaceted nature of memory deficits following a stroke (Withiel et al. 2019). In a follow-up qualitative study involving the same participants, increased knowledge and understanding of memory functioning and strategies were reported in both groups; however, these were employed in different manners such that the CACR group developed strategies aimed at improving their experience with the training, whereas the memory skills groups developed strategies in a structured manner and then applied them to everyday situations (Withiel et al. 2020). Additionally, connecting with others is a theme that was mentioned by the memory skills but not the CACR group. This is a result of the circumstances in which the trainings were completed but highlighted the importance of social interaction, cohesion, and sharing of knowledge and experiences that may be particularly beneficial in a holistic approach (Withiel et al. 2020).

Rather than comparing approaches, some studies have examined the outcomes of *combining* different approaches or strategies within an approach. CACR has been found to have some positive effects on cognitive task outcomes when combined with traditional cognitive therapy (Ressner et al. 2018), brain stimulation (Yin et al. 2020), and virtual reality (Kim et al. 2011). It has been suggested that a combination of CACR and group-based memory training may offer the opportunity for social interaction, an important aspect often highlighted with group training, and the opportunity to address the training using technology (Leśniak et al. 2018; Withiel et al. 2019, 2020). A combination of specific knowledge acquisition and compensatory techniques was used by Svoboda et al. (2012, 2015) to successfully train memory-impaired individuals to use smartphones and personal digital assistants to improve daily functioning. In phase 1, core steps of the training included entering and saving an event in a calendar application of the device using errorless learning and vanishing cues whereby cuing support was provided when entering calendar events and gradually removed. In phase 2, new steps were added in subsequent sessions that would generalize to real-life situations and allow for continued use of the device post-intervention. The incorporation of errorless learning and vanishing cues was based on the theory that implicit memory is preserved following brain injury, so that learning of a skill remains possible, which is utilized to train usage of the technological device that can then be used as a compensatory aid. The results revealed that across the first ten training sessions, participants acquired the skills to use the calendar application with less and less support required. In addition, participants were able to use the devices in their daily lives to reduce memory mistakes, which was maintained at a long-term follow-up study (Svoboda et al. 2012, 2015; Vasquez et al. 2021). Raskin et al. (2019) found some improvements on training tasks, neuropsychological measures, and generalization measures for brain injury patients when examining a combination of visual imagery strategies under the compensatory approach and rote repetition under the restorative approach. However, there were no significant differences between post-treatment and a one-year follow-up on any of the measures, possibly suggesting that the dosage of the intervention and booster sessions may improve long-term outcomes (Raskin et al. 2019). Similar positive outcomes with combined approaches have resulted in the suggestion that an optimal approach to treating memory deficits following ABI may require a combination of approaches and strategies carefully designed to account for patient abilities and appropriately address individual needs (Lannin et al. 2014; López and Antolí 2020).

Efficacy of memory rehabilitation interventions

There is little conclusive evidence indicating whether one type of rehabilitation approach is more effective for memory rehabilitation because the appropriate approach may vary based on a multitude of patient characteristics and availability of resources (Barman et al. 2016; Cicerone et al. 2019; das Nair and Lincoln 2012). However, there is a preference for compensatory strategies in rehabilitation and many programs contain a combination of internal and external memory aids (Censori et al. 1996; Doornhein and de Haan 1998; Haskins et al. 2012; Perna and Perkey 2016; Shigaki et al. 2014). In a case study by Wilson (1982), a program developed for a memory-impaired patient included visual imagery, the peg method, and first letter mnemonics. Ryan and Ruff (1988) implemented a memory retraining intervention involving chaining, rehearsal, and visual imagery in addition to external aids. Intervention programs for TBI patients have included internal memory strategies such as clustering, chaining, and imagery techniques as supplements to external memory aids that patients were already using (O'Neil-Pirozzi et al. 2010).

Systematic reviews of cognitive rehabilitation over the past two decades have consistently recommended a combined use of internal and external compensatory strategies as memory training for patients with mild to moderate memory impairments (Cicerone et al. 2000, 2005, 2011, 2019). Errorless learning and external aids such as electronic technologies have been recommended for persons with severe memory impairment (Cicerone et al. 2005, 2011, 2019). Holistic neurorehabilitation programs may provide short and long-term benefits in cognitive, function, and psychosocial outcomes which can improve independent living, societal participation, emotional well-being, and quality of life (Cicerone et al. 2011, 2019). A review of literature on cognitive interventions after TBI by Rees et al. (2007) concluded that there is strong evidence for the use of external memory aids to improve daily functioning but not the underlying memory deficits and limited exploration of the long-term possibility of using external memory aids. It was also concluded that there is strong evidence that internal memory aids are beneficial for TBI survivors with mild but not severe impairment, but little information remains about the sustained effect (Rees et al. 2007). Following a systematic review of cognitive rehabilitation studies with stroke patients, das Nair et al. (2016) concluded that although participants in memory rehabilitation groups report better memory outcomes on subjective assessments compared to those in the control groups, these results do not persist in the long term, nor does there appear to be a cohesive effect of memory rehabilitation on objective memory tests, functional abilities, or quality of life across studies. Participants in these studies likely believe their memory has improved as they learn more about

memory and techniques they can use (das Nair et al. 2016). Thus, there is some indication that external memory aids and knowledge acquisition strategies may benefit patients with moderate to severe memory impairments, whereas internal memory aids are more suitable for those with mild memory impairments. Moreover, there is some indication that the holistic approach may promote increased participation, emotional well-being, and quality of life. Most importantly, it has been suggested that the effectiveness, long-term impacts, and interaction of rehabilitation with severity of memory impairment be further explored.

Factors that influence memory rehabilitation outcomes

In addition to cognitive impairments following ABI, deficits in metacognition and emotional disturbances including depression and anxiety can be present and impact daily functioning and community participation such as returning to work (Afsar et al. 2021; Haskins et al. 2012; Long et al. 2014; Perna and Harik 2020; Robertson and Schmitter-Edgecombe 2015). Metacognition refers to the knowledge of one's own cognitive abilities and includes self-awareness, self-monitoring, and self-regulation (Al Banna et al. 2015; Robertson and Schmitter-Edgecombe 2015; Sansonetti et al. 2021). Self-awareness is the perception and cognitive reaction to one's own abilities across different domains including cognitive, physical, social, and psychological (Long et al. 2014; Sansonetti et al. 2021). Deficits in self-awareness are correlated with cognitive deficits and an individual's level of self-awareness regarding the nature and severity of memory impairment can influence participation in daily activities such as return to work and also in cognitive rehabilitation (Al Banna et al. 2015; Berlucchi 2011; Lexell et al. 2013; Long et al. 2014; Perna and Harik 2020; Robertson and Schmitter-Edgecombe 2015). For example, individuals who are unaware of their memory deficits may not seek help, whereas those who are aware of their deficits may elect to be involved in rehabilitation programs or studies, resulting in biased samples. In a different capacity, receiving feedback and communication with others in a group setting as part of rehabilitation have been deemed factors that positively influence self-awareness (Chouliara and Lincoln 2016; Cicerone et al. 2008; Long et al. 2014; Nilsson et al. 2011).

Higher levels of metacognitive skills such as self-awareness are correlated with better task and functional outcomes, whereas impaired self-awareness is linked to poorer functional outcomes (Al Banna et al. 2015; Sansonetti et al. 2021). In addition, increased awareness of deficits due to education, social support, and feedback can provide opportunities for acceptance and understanding of the adaptations that are needed in daily life (Long et al. 2014; Nilsson et al. 2011; Sansonetti et al. 2021). However, it is important to note that the process of self-awareness through education and psychotherapy may require gradual changes and different amounts of time for different individuals (Nilsson et al. 2011; Sansonetti et al. 2021). Although self-awareness is a common component of holistic programs and infrequently an aspect of the compensatory approach, it is essential to note that some level of self-awareness is required to engage with any type of rehabilitation (Leśniak et al. 2018; Lexell et al. 2013; Urech et al. 2020; Velikonja et al. 2014). Although it has been suggested that self-awareness should be measured and addressed, there is some debate regarding the efficacy of the current measures of self-awareness and treatment interventions (Al Banna et al. 2015; Long et al. 2014; Sansonetti et al. 2021). Given that self-awareness is frequently impacted following ABI and can negatively impact functional outcomes, it should be considered an important aspect of each rehabilitation approach.

Emotional disturbances such as anxiety and depression can be prevalent and persist following ABI (Gould et al. 2014; Perna and Harik 2020; Slenders et al. 2020; Terry et al. 2019; van Heugten and Wilson 2021). Previous research has demonstrated correlations between cognitive impairments and anxiety and depression following ABI (Gould et al. 2014; Li et al. 2021; Spitz et al. 2013; Terry et al. 2019). Emotional disturbances can negatively influence social integration, return to work, and quality of life (Exner et al. 2021; Gould et al. 2014; Slenders et al. 2020). Factors such as worry, anxiety, and depression may negatively influence initial decisions to participate in memory rehabilitation. It has been found that attrition from rehabilitation studies are more likely to occur with more depressed participants and anxiety can increase as a result of finding out about one's current level of progress (Chouliara and Lincoln 2016; Miller and Radford 2014; Svoboda et al. 2015; Withiel et al. 2020).

Alternatively, rehabilitation may positively influence emotional adjustment to the impact of memory impairment (Chouliara and Lincoln 2016). For example, within a group-based setting, embarrassment may be reduced upon recognition that other individuals share similar forgetting experiences, or negative self-evaluations may be diminished upon learning about the impact of ABI on cognition (Chouliara and Lincoln 2016; Lexell et al. 2013; Withiel et al. 2020). Stress and anxiety management are likely important aspects of rehabilitation programs, and while they are incorporated within the holistic approach, they should be considered when applying any rehabilitation approach (Lexell et al. 2013; Urech et al. 2020). Although pharmacological interventions may be used to treat depression and anxiety, these issues may require further consideration (Perna and Harik 2020; Urech et al. 2020; van Heugten and Wilson 2021). Altogether, it has been suggested that incorporating several factors such as metacognition and emotional consequences

of ABI into cognitive rehabilitation will improve functional outcomes (Al Banna et al. 2015; Nilsson et al. 2011).

Limitations of current approaches

There are several general limitations to current memory rehabilitation approaches. Early restorative strategies such as drill and practice are relatively ineffective, whereas CACR has limited generalization effects at the current stage (López and Antolí 2020). Specific-knowledge acquisition strategies can be time- and resource-consuming as they require multiple learning trials, and the ecological validity of the stimuli used in these strategies is relatively low (Schacter and Glisky 1986; Wilson et al. 1994). Internal compensatory aids are often taught in controlled settings with selected stimuli, resulting in little change to daily functioning because of the difficulty of applying it in different contexts with novel stimuli (Censori et al. 1996; Kapur et al. 2002). External memory aids require patients to be aware of their deficit and remember to use the tools, which is a memory task in itself, and may require intensive training (Kapur et al. 2004; Wilson 2000). Finally, the holistic approach attempts to address multiple consequences of ABI, but the optimal combination of strategies is unclear, and the length of the programs may result in considerable time and resource requirements (Prigatano 2013; Shany-Ur et al. 2020).

There is a wide variety in the structure of memory rehabilitation programs. There is no consensus for the treatment method, frequency, or duration of treatment with some ranging from two weeks to several months and each session lasting between 30 min and two hours (das Nair et al. 2016; Dou et al. 2006; Kaschel et al. 2002; López and Antolí 2020; O'Neil-Pirozzi et al. 2010, 2016; Piras et al. 2011). Some programs provide individual sessions, whereas others involve group rehabilitation, which may result in different therapeutic effects (das Nair et al. 2016; Leśniak et al. 2018; O'Brien et al. 2013; O'Neil-Pirozzi et al. 2010; Zucchella et al. 2014). Across cognitive rehabilitation studies, there is often a mix of etiologies including TBI, stroke, and multiple sclerosis, making it difficult to draw conclusions about efficacy of rehabilitation for specific populations (das Nair and Lincoln 2012; Fetta et al. 2017; Haslam et al. 2011; Perna and Perkey 2016; Riley and Venn 2015; Wilson et al. 1994). Similarly, severity of memory impairment has either been not reported (Doornhein and de Haan 1998; Dou et al. 2006; Gasparrini and Satz 1979) or assessed with different measures, which limits the ability to assess the efficacy of strategies for across different severity levels (Evans et al. 2000; Kaschel et al. 2002; O'Neil-Pirozzi et al. 2010; Piras et al. 2011; Riley and Venn 2015; Ryan and Ruff 1988; Tailby and Haslam 2003). Additionally, subjective memory or cognitive complaints are an inclusion criterion in some studies, indicating that these studies may be biased toward individuals who are aware of their memory deficits and motivated to seek help (Nilsson et al. 2011; Wentink et al. 2016; Withiel et al. 2019). Finally, self-awareness of memory deficits along with emotional disturbances and impact on daily functioning is infrequently addressed across studies, with few studies using screening measures for self-awareness and those that include a measure having unclear definitions (Al Banna et al. 2015; Jamieson et al. 2017; Sansonetti et al. 2021; Svoboda et al. 2015). Therefore, it is difficult to compare the effect of rehabilitation programs or strategies across studies due to the variability in etiologies, assessment methods, classification of memory impairment severity, and different paradigms.

Across some studies, the differences between the three approaches have been confounded. Schacter and Glisky (1986) stated that restoration of memory function has been attempted by "repetitive drill or practice that aims to 'strengthen' damaged memory processes, or training in special memory strategies to compensate for defective processes" (p. 259). Here, both drill and practice and mnemonics were considered under the restoration approach. das Nair and Lincoln (2012) indicated that "restitution is attempted by drill and practice on focused, discrete aspects of a cognitive function" (p. 1). However, "participants in both memory intervention programs were taught the use of internal memory aids and errorless learning techniques" (das Nair and Lincoln 2012, p. 2). Thus, the restitution program included internal compensatory strategies and specific knowledge acquisition strategies. O'Neil-Pirozzi et al. (2010) created a training program of internal memory strategies, including semantic association (categorization and clustering), semantic elaboration/chaining, and imagery. However, training methods included error-free learning with fading (O'Neil-Pirozzi et al. 2010). Perna and Perkey (2016) indicated that internal memory strategies "do not aim to salvage damaged brain tissue but to promote restoration of function" based on the idea that "impaired memory will respond to mental exercise" (p. 2). Strategies in the training included visualization, first letter mnemonics, putting words into sentences or stories, and semantic clustering (Perna and Perkey 2016). Across these studies, there is some mixture of the strategies and functions of the three approaches, most notably with internal memory aids included as part of the restoration approach.

The overlaps in function and strategies may be related to the development of the approaches throughout the years. Following the negative outcomes of restoration attempts with drill and practice based on the mental muscle idea, there was a shift to focus on alleviation of memory deficits and learning specific knowledge or skills relevant to a particular domain in life (Hunkin and Parkin 1995; Schacter and Glisky 1986). However, restoration and compensation were still considered as the two main approaches to rehabilitation,

possibly due to similarities with the rehabilitation of other functions such as motor function or other cognitive functions such as attention (Cicerone et al. 2000; Kapur et al. 2002; Rees et al. 2007; Schacter and Glisky 1986). Thus, internal memory aids may have been incorporated into the restoration approach in place of drill and practice. While the approaches may be combined in rehabilitation for practical reasons, it is also essential to note that the different approaches require different training, materials, and provide different outcomes. For example, if the purpose of the rehabilitation is to provide daily functioning support, then training with external memory aids could be more appropriate. If, however, the purpose is to re-learn words, then knowledge acquisition strategies should be considered. Finally, the holistic approach may be the best placed to offer integration in community setting and for social participation. It is crucial to consider the compatibility of the rehabilitation goals with the selected memory rehabilitation approach.

Future considerations

Based on the outcomes from previous studies, some considerations for future research arise. Firstly, consideration might be given to whether etiologies should be mixed or examined separately, followed by the severity, variety, and chronicity of memory impairment within the target group (Exner et al. 2021; Fetta et al. 2017; Kapur et al. 2004; Piras et al. 2011; Tate 1997). Individuals who are at different stages of recovery, with different etiologies, and capacities following memory impairment will require different amounts of training or practice with a given task to improve and will progress at different rates (Lexell et al. 2013; Vasquez et al. 2021). Thus, training duration is not only important to plan timings of the rehabilitation, but also it is important for each individual to have enough time for the rehabilitation to be effective (Leśniak et al. 2018; Vasquez et al. 2021). Secondly, memory needs in daily life should be assessed and matched to treatment approaches because improvements on laboratory tasks may not translate to functional improvements in daily life (Kapur et al. 2004; Perna and Perkey 2016; Wilson 2002). For example, while some individuals may not be able to implement errorless learning on their own, they may be able to quiz themselves, ask family members for help, or use an external aid to remember their grocery list when given appropriate training (Evans et al. 2020; Fish et al. 2015). Similarly, self-awareness and emotional disturbances may be severely impacted following ABI and future research should include self-awareness and emotional measures and disturbances in these domains should be addressed as part of treatment (Sansonetti et al. 2021; Terry et al. 2019; Urech et al. 2020; van Heugten and Wilson 2021). Moreover, it is evident that incorporating some aspect of improving self-awareness and psychoeducation as an aspect of rehabilitation such as feedback and involving family members can improve outcomes and should thus be considered regardless of the approach (Al Banna et al. 2015; Chouliara and Lincoln 2016; Long et al. 2014; Perna and Harik 2020; Sansonetti et al. 2021). Thus, self-awareness and emotional measures should be incorporated to assess current functioning levels and deficits in these domains should be addressed with education and feedback where possible.

Qualitative studies examining patient perspectives have demonstrated the importance of group settings for social interaction, feedback from others, and ability to compare progress in a motivational or appreciative capacity (Chouliara and Lincoln 2016; Leśniak et al. 2018; Lexell et al. 2013; Nilsson et al. 2011). In particular, with the rise of CACR options available within home settings, the group-based interactions found in traditional cognitive rehabilitation settings should not be entirely excluded, as social contact is likely a crucial aspect of rehabilitation (Pertíñez and Linares 2015; Withiel et al. 2020). In addition, goal setting and personalization of the treatment appear to be increasingly important factors in memory rehabilitation (Chouliara and Lincoln 2016; De Luca, et al. 2018a, b; Pertíñez and Linares 2015; Vasquez et al. 2021; Velikonja et al. 2014). It is essential to match the needs of the individual and their ability level with the appropriate rehabilitation approach and strategies. For example, some individuals may forego using external aids or electronic assistive devices with a preference for internal strategies if they prefer to not rely on external devices or they may need to try different strategies until finding the ones that are appropriate for their abilities and routines (Boman et al. 2010; Chouliara and Lincoln 2016; Nilsson et al. 2011). Finally, there is an increasing emphasis on the need to collect qualitative data from patients undergoing memory rehabilitation programs in order to better understand patient experiences and outcomes in addition to follow-up outcomes which may differ from the results obtained using objective measures (Chouliara and Lincoln 2016; Lexell et al. 2013; Miller and Radford 2014; Sarajuuri et al. 2018; Withiel et al. 2020). Thus, future research should include qualitative measures of patient perspectives to better adapt future rehabilitation programs to suit the needs of patients.

Finally, follow-up studies should be conducted to examine the lasting impact of memory rehabilitation. For example, recent studies have found that rehabilitation following ABI had positive impacts on community integration, quality of life, and continued use of external aids for several years beyond termination of the program (Shany-Ur et al. 2020; Svoboda et al. 2015). Similar follow-up studies would be beneficial for identifying which outcomes of memory rehabilitation are maintained long-term and generalize to

functional outcomes. Thus far, memory rehabilitation has been approached through restoration of function, acquisition of specific knowledge, and compensation for memory failures. These approaches have shown some efficacy but require further examination individually and in combination to create memory rehabilitation programs that align with the needs of memory-impaired individuals. The introduction of the holistic approach has allowed for better results on psychological and emotional wellbeing factors associated with ABI but may require considerable resource and cost contributions. Several factors must be established when attempting memory rehabilitation, including the severity of the memory impairment, the needs of the patients in their everyday lives, the current memory abilities and self-awareness level of the patient, emotional disturbances, the objectives of the memory rehabilitation including the type of memory targeted, the compatibility of the stimuli and the strategies, and the potential for generalizability and long-term effects.

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Abstract

Recalling names is a difficult task in everyday life and names are often forgotten. The face-name mnemonic strategy proposes to improve name recall by assigning semantic information to face-name pairs through imagery. The technique involves three steps: transforming the name into an imageable object, selecting a prominent facial feature, and imagining the name transformation interacting with the prominent facial feature. Name recall involves mentally retracing these steps. Previous research has shown positive outcomes with this strategy, but there has been limited exploration of strategy components and potential strategy use in real life. Here, we examined the effectiveness of the face-name mnemonic technique and two simplified versions of the mnemonic on name recall. We also explored strategy compliance and potential use in real life with questionnaires. In Experiment 1, we found that the full mnemonic strategy was not more effective than the simplified versions and had limited advantage over an own best method approach where participants were instructed to remember the face-name pairs to the best of their ability. However, a simplified strategy focusing on name transformation showed more promise, which was further explored in Experiment 2. Questionnaire responses revealed that uninstructed participants used repetition, focused on distinct facial features, or related the individual in the photo to known individuals to recall names.

Keywords: face-name mnemonic; remembering names; strategy use; mnemonics

5.1 Introduction

Remembering people's names is a common task in daily life, yet we can often find ourselves having memory lapses for names in social situations. While we may frequently hear the phrase "I can recognise their face but cannot recall the name" the opposite situation, "I know the name but not the face" is unlikely (Burton et al., 2019; Clarke, 1934; Lorayne & Lucas, 1974). Although it appears as though memory is better for faces than names, there is a crucial distinction between the two tasks when learning new names in social situations; remembering faces involves recognition, whereas remembering names involves recall (Burton et al., 2019; Clarke, 1934; Faw, 1990; Watier & Collin, 2011). When names and faces are presented together in learning tasks, name recognition is often better than face recognition, yet there are few instances in social interactions where a name would need to be recognised rather than recalled (Burton et al., 2019; Clarke, 1934; MacDougall, 1904).

Past research has shown that recalling recently learned names is difficult, often with name recall being worse than other person identifying information such as occupations (Craigie & Hanley, 1997; Crook & West, 1990; James, 2004; McWeeny et al., 1987; Tauber & Rhodes, 2010). The accompanying theories suggest that names are particularly difficult to recall because of the limited or indirect connections between a name and face, or that names are arbitrary labels (Bruce & Young, 1986; Cohen, 1990; Cohen & Burke, 1993). In particular, Cohen (1990) demonstrated that name recall is similar to that of recalling meaningless non-words, and McWeeny et al. (1987) demonstrated that when names and occupations are used interchangeably for faces, name recall remains worse than that of occupations, suggesting that names are encoded as arbitrary labels. Given that failure to retrieve names in social situations can be uncomfortable or embarrassing, it is essential to consider how we can improve memory for this everyday task (Brédart, 2017). While external memory aids are often used in daily life, writing down a name might not be possible in a social situation, and doesn't aid

with matching it to the person's face the next time they are seen (Landauer & Bjork, 1977). Previous research has also demonstrated that repeating a name aloud may not improve retention in comparison to reading the name or mental repetition, possibly because only one component of the paired associates is being elaborated through production, i.e., the name (Hourihan & Smith, 2016; Wilck et al., 2022). Thus, perhaps internal memory strategies such as mnemonics might be beneficial as they have been shown to aid in connecting paired associates and can be adapted to fit different situations (Bellezza, 1981; Dirette, 2015; Roediger, 1980). Specifically, imagery mnemonics such as the method of loci and the face-name mnemonic technique have been useful in improving memory for learned information (Bellezza, 1981; Legge et al., 2012; Lorayne & Lucas, 1974; McCarty, 1980).

5.1.1 The Face-Name Mnemonic Technique

The face-name mnemonic technique has three components. These are: a name transformation to an easily imaged object, selection of a prominent facial feature, and linking the image created from the name transformation to the prominent feature in an interactive manner (Lorayne & Lucas, 1974; McCarty, 1980; Morris et al., 1978; Yesavage et al., 1983). For example, the name Gordon could be transformed into the image of a garden, a prominent feature such as a large ears can be selected, and a garden can be imagined growing through Gordon's ears (Morris et al., 1978). During recall, the prominent feature prompts retrieval of the interactive imagery, from which the name transformation can be deduced and converted to the name (McCarty, 1980).

In line with the levels of processing framework, when the name is transformed during encoding, more semantic than physical analyses of the name are conducted, allowing for a richer memory trace (Craik & Lockhart, 1972; Lockhart et al., 1976). Similarly, selecting a prominent facial feature and connecting it to the transformed name requires deeper analyses

compared to simple rehearsal (Lorayne & Lucas, 1974). Therefore, the connection between the name and face through imagery may result in improved name recall by creating richer semantic associations during encoding (Festini et al., 2013; McCluney & Krauter, 1997; Morris et al., 1978; Yesavage et al., 1983). This deeper level connection between the face and name might be best applicable where participants generate their own imagery mnemonics rather than the mnemonic components being provided by researchers. As demonstrated in previous research, recall performance has been better when participants generated mnemonic imagery compared to an own best method or repetition approach (Dunlosky & Hertzog, 1998). In a broader capacity, the generation effect has demonstrated that information is better retrieved when self-generation for cues is employed rather than reading or when provided by experimenters for words (Bertsch et al., 2007; Mäntylä & Nilsson, 1988; McCurdy et al., 2020; Slamecka & Graf, 1978).

Previous research has also demonstrated an advantage of the face-name mnemonic technique compared to an approach of remembering names to the best of one's ability (McCarty, 1980; Morris et al., 1978; Neuschatz et al., 2005). Morris et al. (1978) found significantly improved name recall for a mnemonic but not a control group whereas McCarty (1980) found that participants who were provided with all three mnemonic components significantly outperformed those who were provided with one or two. However, Patton (1994) found no difference in name recall when the mnemonic was experimenter- or participant-generated and a decline in recall during in-person conversation. Similarly, Morris et al. (2005) found no difference between a control and a mnemonic group learning names during in-person conversations. Thus, past research has demonstrated the face-name mnemonic strategy is effective in the lab, but may be more difficult to apply in-person (Carney & Levin, 2012, 2014; McCarty, 1980; Morris et al., 1978, 2005; Neuschatz et al., 2005; Patton, 1994; Yesavage et al., 1983). Several limitations may have influenced these outcomes.

5.1.2 Limitations of Previous Research

The stimuli used in past studies such as black and white photos, of only males, or photos selected from school yearbooks, may not reflect daily interactions in real life (Downes et al., 1997; McCarty, 1980; Morris et al., 1978; Yesavage et al., 1983). Similarly, surnames or names that are easily transformed into images were selected, but not all names encountered in daily interactions are easily imageable (Burton et al., 2019; Carney & Levin, 2012; Downes et al., 1997; Patton, 1994; Yesavage et al., 1983). Researchers have also imposed the strategy by providing mnemonic components to participants because of time and cognitive load constraints (Carney & Levin, 2014; Downes et al., 1997; McCarty, 1980; Morris et al., 1978). However, participants may have learned the presented information rather than how to use the strategy (Carney & Levin, 2012; McCarty, 1980; Neuschatz et al., 2005). In this case, it can be difficult to examine strategy generalisation. Based on the levels of processing framework and the generation effect, if participants create their own imagery statements, associations may be more meaningful to them, improving recall (Craik & Lockhart, 1972; Lockhart et al., 1976; McCurdy et al., 2020).

Another limitation is that participants were rarely questioned about strategy use, leaving unanswered the question of understanding and compliance with the strategy (Morris et al., 2005; Patton, 1994). Finally, the presentation duration of face-name pairs varies across studies with little consideration of how much time is needed to apply the strategy in real life situations (Carney & Levin, 2012, 2014; Dunlosky & Hertzog, 1998; Hourihan & Smith, 2016; Maxwell et al., 2014; McCarty, 1980; Morris et al., 1978, 2005; Patton, 1994). In summary, limited ecological validity, lack of clarity regarding strategy comprehension and compliance, and variable timing were limiting factors in past face-name research.

5.2 Present Study

This study examined the influence of imagery mnemonics on name recall and potential use in real life when all components are participant-generated. Across two experiments, participants either received mnemonic instructions or were instructed to remember the names to the best of their ability. To address the outlined gaps in the literature, we selected stimuli that would reflect reality as much as possible, encouraged participants to generate their own mnemonic components, manipulated stimuli presentation duration, and used questionnaires to examine strategy adherence. Colour photographs of faces were chosen from the Park Aging Mind Laboratory face database, which includes photos of adults captured at community events and excludes famous individuals and online photos (Minear & Park, 2004). Forenames of average popularity were selected from the U.S. Census Bureau (*U.S. Social Security Administration*, 2019). These stimuli reflect individuals that participants might encounter in their daily lives and participants were instructed to imagine that they were meeting the individuals in the photos at a community event. Participants also completed questionnaires regarding memory self-efficacy, strategy use during the experiment, and possibility of using the strategy in real life.

To examine the effectiveness of the mnemonic strategies, participants were given instructions and an example of how to complete the strategy and were encouraged to generate their own mnemonic components throughout the task. While McCarty (1980) claimed that all three components are necessary for the mnemonic technique to work, this might be too complicated to use in everyday life and a simplified technique involving fewer components may be useful outside of experimental settings. Additionally, it has been noted that as the amount of information to be remembered increases, so does the cognitive load (Minear & Park, 2004). Thus, here, we also explored simplified versions of the face-name mnemonic technique

focusing on individual components, the prominent facial feature, and the name transformation.

Previous studies examining name recall have either included a single session where participants learned multiple face-name associations (Maxwell et al., 2014; Morris et al., 1978; Neuschatz et al., 2005), or multiple sessions with fewer face-name associations (Hux et al., 2000; Thoene & Glisky, 1995; Yesavage et al., 1983). This study design captures aspects of both approaches in Experiment 1 by including two blocks with the same face-name pairs for training and familiarisation with the strategy procedure and a third block to examine the generalisation of strategy use to a previously unseen set of face-name pairs. Additionally, stimuli presentation times across both experiments were varied to explore how much time is needed to implement the strategy. While previous research in this field has explored the face-name mnemonic technique, there is a distinct lack of emphasis on learning and applying the strategy itself. Thus, this study examines how learning and applying mnemonic imagery strategies may impact recall in addition to exploring the generalisation of the strategy use to new face-name pairs.

We also examined compliance with the strategy similar to previous studies (Caplan et al., 2019; Dunlosky & Hertzog, 1998; Legge et al., 2012; Price et al., 2008). In a study examining the method of loci, Legge et al. (2012) analysed results with all participants and only participants who complied with strategy instructions. The outlined reasoning was that non-compliant participants would contaminate the results of the efficacy of actual strategy use and this allowed the researchers to conduct more reliable analyses. On their suggestion that studies examining mnemonics continue to examine strategy compliance, we included questionnaires asking about strategy use during the study and asked mnemonic participants whether they used the described strategies (Legge et al., 2012). The responses allowed us to

re-examine outcomes with compliant participants. This study was approved by the School of Psychology Research Ethics committee.

5.3 Experiment 1

5.3.1 Method

5.3.1.1 Participants

A target sample of 104 participants was set based on an *a-priori* power calculation using G*Power 3.1.9.7 (Faul et al., 2007) assuming a mixed ANOVA design with a medium effect size (partial eta squared) of 0.06, an alpha of .05, and power of .80. Data collection was prematurely concluded due to the COVID-19 pandemic. A total of 86 participants (62 females; *M* age = 20.35, *SD* = 2.70) completed the study.

Participants were recruited via convenience sampling, the school's Research Participation Scheme, and leaflet advertisements at the University of Nottingham. Participants either received 1.5 credits via the Research Participation Scheme, an Amazon voucher (£5 per half hour) or did a study swap with the researcher. Inclusion criteria were native English speakers aged 18-35 years old.

5.3.1.2 Materials

Photographs of adults aged 18 to 93 of various ethnic groups with neutral expressions in a front-facing profile were selected from the Park Aging Mind Laboratory face database (Minear & Park, 2004). Forenames were selected from the U.S. Census Bureau list of popular baby names by decade from the 1930s to 1990s (*U.S. Social Security Administration*, 2019). Names from the middle range of the list for each decade were selected to allow for recognisable names while avoiding high frequency names. A single version of names that have similar spelling, sounds or nicknames was chosen (McCarty, 1980). For example, only

the version of names such as “Mike” and “Michael” that appeared earlier in the list was selected and the second was replaced by another name (see Appendix A for name list). Each face was paired with one name of matching age range and gender. In total, there were five face-name pairs for practice, followed by 80 face-name pairs for the experiment task.

5.3.1.3 Design

This was a mixed design with a between-groups factor (Strategy Type) and two within-subjects factors (Presentation Duration and Block). Four strategy groups were used: (1) the uninstructed group was instructed to remember as many face-name pairs as possible, (2) the facial feature group was instructed to select a prominent facial feature and imagine the name written on the facial feature, (3) the name-transformation group was instructed to transform the name into an imageable object and imagine the person interacting with it, and (4) the full mnemonic group was instructed to transform the name, select a prominent facial feature, and imagine the name transformation interacting with the facial feature. There were three blocks, with the *same* set of 40 face-name pairs presented in random order in the first two blocks and a *different* set of 40 face-name pairs presented in random order in the third block. Presentation Duration included a fast (8 seconds) and slow (16 seconds) duration.

5.3.1.4 Experiment Aims and Hypotheses

The aims of this experiment were to examine:

1. The influence of mnemonic strategies on name recall. It was hypothesised that mean recall would be higher for the participants in the full-mnemonic strategy group compared with the facial feature, name-transformation, and uninstructed groups. Additionally, it was expected that the facial feature and name-transformation groups would significantly outperform the uninstructed group.

2. The influence of presentation duration on name recall. It was hypothesised that mean recall would be higher for face-name pairs that were shown for a slow period compared to face-name pairs shown for a fast period. Additionally, it was expected that this effect would increase with the complexity of the instructions, with the full mnemonic being the most complex.
3. The impact of repetition/practice effects on name recall. It was hypothesised that mean recall scores would increase from block one to block two.
4. The extent to which strategy use would be generalised to new face-name pairs. It was hypothesised that mean recall scores in block three would be higher than in block one. This study's design and hypotheses were preregistered; see https://osf.io/bmvz3.

5.3.1.5 Procedure

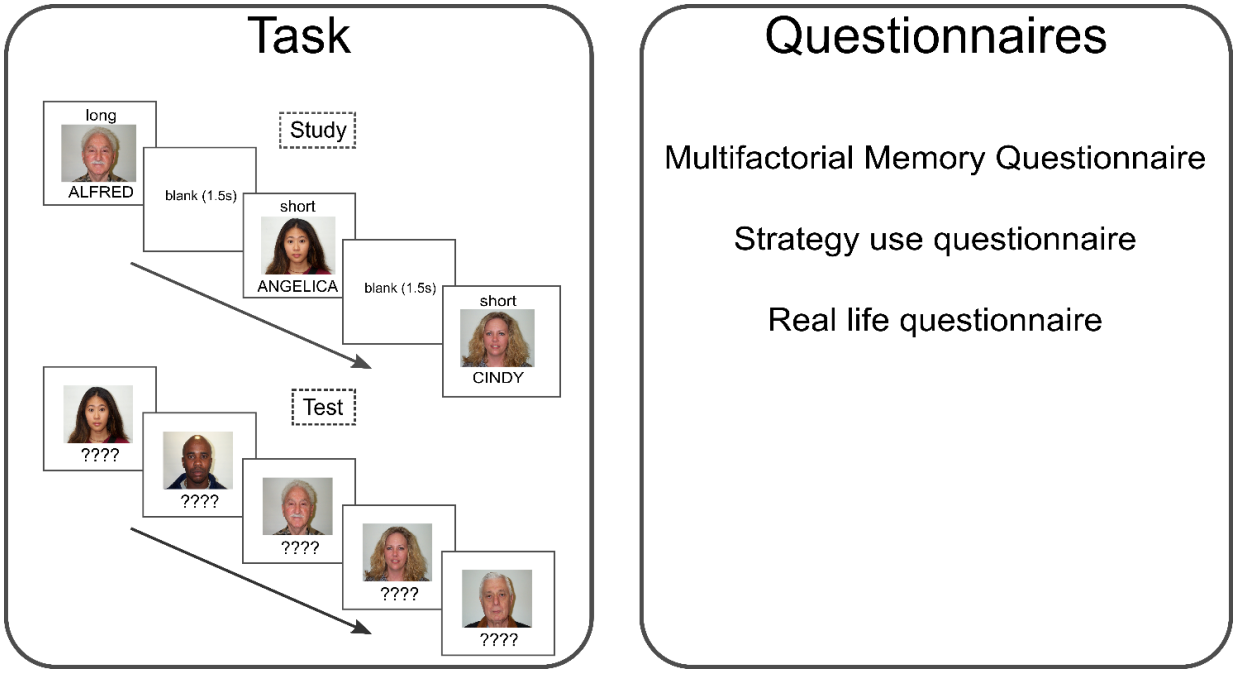
Participation time slots were randomly allocated to a strategy type and all participants in the same time slot were in the same group. At the beginning of each block, participants received instructions specific to their group. Mnemonic groups also received a written example of how to perform the strategy and were informed that the strategy was recommended by researchers to better remember names (McCarty, 1980). All participants were prompted with a scenario of attending a local community event (Neuschatz et al., 2005).

All stimuli were randomly presented using PsychoPy (Version 3.0.2) (Peirce et al., 2019). Figure 1 shows the task outline. Participants practiced the task with five face-name pairs then proceeded to the experiment proper where they viewed face-name pairs one at a time in a study phase. In the test phase, each face was randomly presented, and participants had unlimited time to type in the corresponding name. Following the experimental task, participants completed the Multifactorial Memory Questionnaire (MMQ) with questions about recent feelings about their memory, memory mistakes, and use of memory strategies

(Troyer & Rich, 2002). Then, participants completed a strategy use questionnaire about strategy use during the task and a real-life questionnaire about potential use in real life (Carney & Levin, 2014). The uninstructed group received an altered version of the questionnaires with questions about their own strategies (see Appendix B for questionnaires).

Figure 1

Task outline for Experiment 1. Each block contained a study and test phase with 40 face-name pairs. “long” represented 16 seconds and “short” represented 8 seconds presentation duration.



5.3.1.6 Data Analysis

5.3.1.6.1 *Name Recall Alternatives*. Due to possible name variations in spoken or written language, we adopted specific criteria for accepting and rejecting alternative responses to the correct answer. Responses were accepted as correct if there was a typing error or names were misspelled but retained the pronunciation. For example, if a letter was added (e.g., Grayce – Grace), there was a substitution of similar-sound letters (e.g., Cristina – Kristina), there were typing errors such as mixed order of one of the letters (e.g., Alexandre – Alexander), if one letter was missing (e.g., Hanna – Hannah), or the letter on the keyboard is adjacent to the correct letter (e.g., Rosemaru – Rosemary). Responses were incorrect if they were nicknames (e.g., Xander – Alexander) or if letters were added that change the name to a different one (e.g., Jeanne – Anne).

5.3.1.6.2 *Analysis.* Data were analysed with JASP (Version 0.16.4) (JASP Team, 2021). A mixed ANOVA was conducted with Strategy Type (uninstructed, facial feature, name-transformation, and full mnemonic) as a between-groups variable, and Presentation Duration (fast or slow) and Block (one, two, and three) as within-subjects variables. Participants were excluded based on the following criteria: (1) more than one attempt at the task, (2) not paying attention during the task, as indicated by questionnaire responses, (3) recall below 10% of the total number of items to be recalled, or (4) total recall score 2.5 or more deviations from the median absolute deviation (MAD) (Leys et al., 2013, 2019). Exclusions were completed in parallel (6 excluded), leaving 80 participants remaining (59 females; M age = 20.35, SD = 2.68). The outlined exclusion criteria differ from the pre-registered criteria because it was determined that exclusion of individuals whose memory performance indicate floor or ceiling effects is necessary to examine the effects of the memory strategies (see pre-registered analyses in Appendix C). The assumption of sphericity

was violated for Block (Mauchly's $X^2(2) = 6.11$, p = .047), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

5.3.2 Results

Significant main effects of Strategy Type ($F(3, 76) = 9.72$, $p < .001$, $\eta_p^2 = .28$) and Block ($F(1, 140.97) = 503.78$, $p < .001$, $\eta_p^2 = .87$) were qualified by a significant interaction between Strategy Type and Block ($F(5, 140) = 2.52$, $p = .027$, $\eta_p^2 = .09$). No other significant interactions were obtained. There was also a significant main effect of Presentation Duration ($F(1, 76) = 55.36$, $p < .001$, $\eta_p^2 = .42$), with higher name recall scores for stimuli that were presented for a slow duration of 16 seconds ($M = 30.34$, $SD = 10.93$) than for those presented for a fast duration of 8 seconds ($M = 26.31$, $SD = 10.06$).

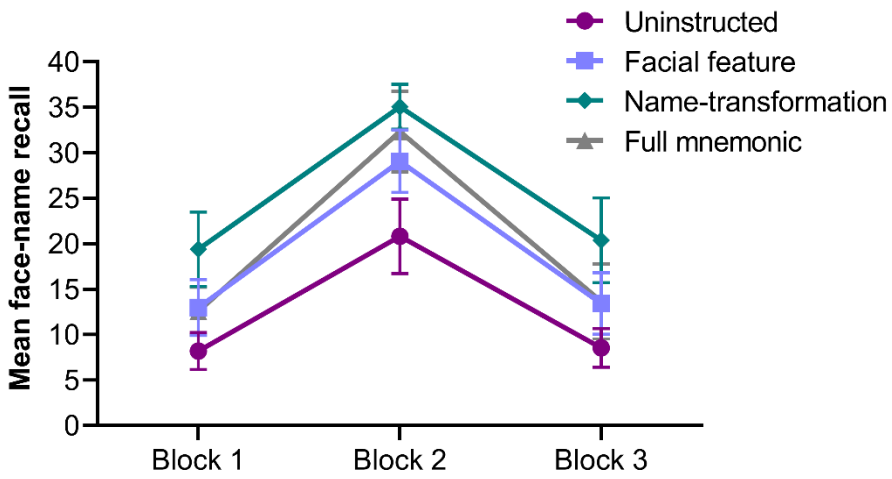
Post-hoc comparisons (Bonferroni corrected) revealed significantly higher name recall for the name-transformation group ($M = 17.71$, $SD = 7.17$) compared to the uninstructed group in block one ($M = 8.19$, $SD = 3.82$; $t(38) = 4.51$, $p = .001$, Cohen's $d = 1.35$), for the name-transformation group ($M = 32.46$, $SD = 7.40$) compared to the uninstructed group in block two ($M = 20.81$, $SD = 7.70$; $t(38) = 5.51$, $p < .001$, $d = 1.65$), and for the name-transformation group ($M = 17.63$, $SD = 8.90$) compared to the uninstructed group in block three ($M = 8.56$, $SD = 4.03$; $t(38) = 4.29$, $p = .003$, $d = 1.29$). Name recall was significantly higher for the facial feature group ($M = 30.55$, $SD = 5.96$) compared to the uninstructed group in block two ($M = 20.81$, $SD = 7.7$; $t(34) = 4.44$, $p = .001$, $d = 1.38$). The full mnemonic group ($M = 30.05$, $SD = 6.75$) significantly outperformed the uninstructed group in block two ($M = 20.81$, $SD = 7.7$; $t(34) = 4.21$, $p = .003$, $d = 1.31$). All groups showed significantly higher name recall in block two compared to block one ($p < .001$ for all groups). There was no significant difference from block one to block three for any group.

Based on the significant interaction between Strategy Type and Block, we conducted a follow-up one-way ANOVA of the increase in name recall from block one to block two across the groups. There was a significant difference between groups ($F(3,76) = 5.14$, $p = .003$, $\eta_p^2 = .17$) with a significantly larger increase from block one to block two for the full mnemonic group ($M = 18.30$, $SD = 4.39$) compared to the uninstructed group ($M = 12.63$, $SD = 5.08$).

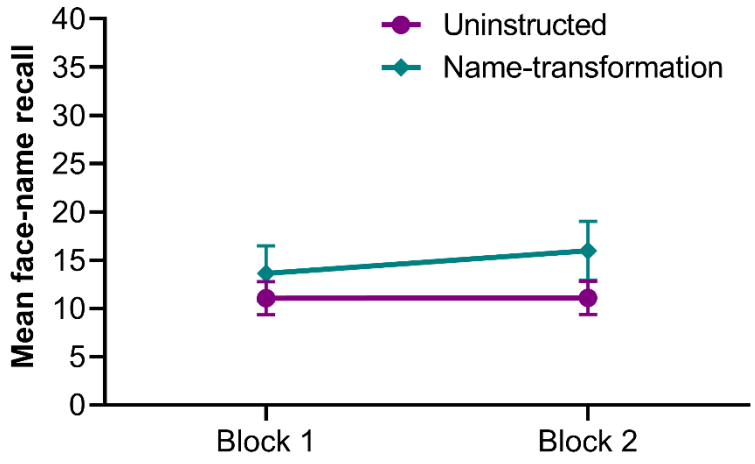
Figure 2

Mean face-name recall for each strategy group as a function of block when participants were compliant with strategy instructions for (a) Experiment 1 and (b) Experiment 2. Error bars represent 95% confidence intervals.

a. Experiment 1



b. Experiment 2



5.3.2.1 Questionnaires

MMQ results are reported in Appendix D. Figure 3a shows the frequency of responses for five of the Likert scale strategy use questions. Questions for the uninstructed group referred to their own strategy while questions for the imagery groups referred to the described strategy. See questions in Appendix B. See open-ended responses in Appendix I.

Across all groups, many participants indicated that they used a memory strategy in the task, had enough time to apply their respective strategy in the long duration, enjoyed using their strategy, and currently use or would use their strategy in real life. However, the fast duration was not sufficient for many participants. Open-ended responses revealed that uninstructed participants and mnemonic participants who did not use the described strategy focused on distinct features (e.g., “I looked out for distinct features on people’s faces e.g. earrings marks etc. and associated that with the name.”) and related the stimuli to known individuals (e.g., “I recall things that the faces reminded me of, for example faces of celebrities, movie characters, etc.”). Additionally, open-ended responses indicated that some participants in the uninstructed group did not use a particular strategy or did not consistently use a strategy throughout the experiment (e.g., “I tried to remember the faces first and hoped the name would come with it too, and tried to create stories for the people where possible.”). Participants did not alter their strategy based on duration (e.g., “I applied on both short and long presentations, but the effect is better on long presentations.”). Uninstructed participants indicated that they would be able to apply their strategy when meeting people (e.g., “Yes because I have time to develop a link with their name”) but some mnemonic participants indicated it would be difficult (e.g., “No, I would not be able to remember the associated object to the face, together with the name.”).

Figure 3b shows the responses for four of the Likert scale ease-of-use questions. Across all groups, strategy use was difficult in blocks one and three but easier in block two. The

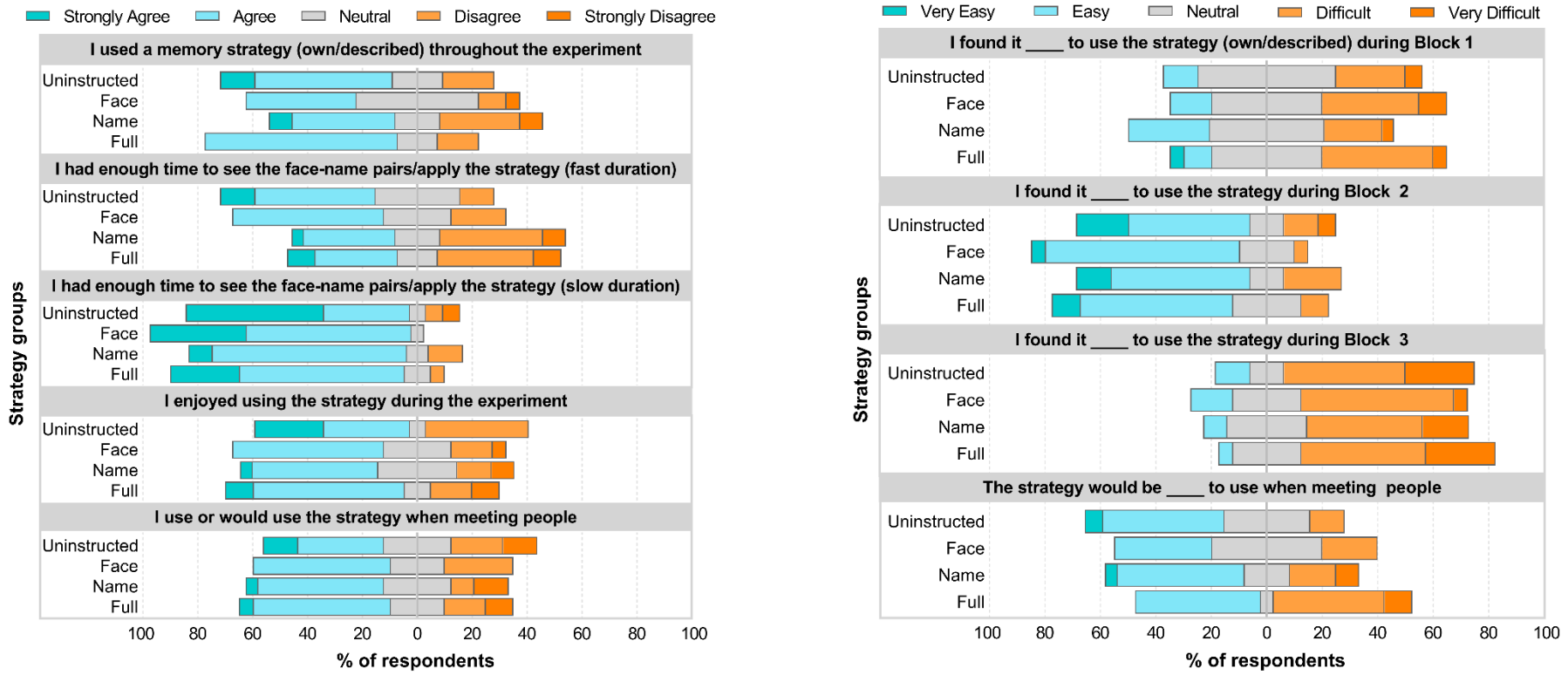
uninstructed and simplified mnemonic participants indicated that their strategy would be easy to use when meeting people, but full mnemonic participants indicated it would be difficult. According to open-ended responses, participants applied their strategy in the same way across blocks one and two (e.g., “Yes. Since it was the same face-name pairs, using the same strategy help better and improve me recalling their names.”). However, participants found the task difficult with too many face-name pairs (e.g., “When given too may name-face associations I ended up getting confused.”) or if they could not create mnemonic imagery (“It was hard to think of objects relating to their names”). Participants indicated that strategy use could be improved when meeting people by using rhyming (“Short rhymes to accompany the imagery”) or altering the mnemonic strategy (“Cut out the alternate similar word.”).

Figure 3

Experiment 1 frequency of responses for (a) five of the strategy use questions rated from *Strongly Agree – Strongly Disagree* and (b) four of the ease-of-use questions rated from *Very Easy – Very Difficult*. Face = Facial feature; Name = Name-transformation; Full = Full mnemonic. Questions have been abbreviated in figures. See full questions in Appendix B.

a. Strategy use questions

b. Ease-of-use questions



5.3.3 Discussion

Experiment 1 revealed an advantage of the name-transformation mnemonic strategy in comparison to no imagery instruction across all blocks. Additionally, name recall was better for all mnemonic groups compared to no imagery instruction after learning and practicing the strategy in block two. All groups showed a significant increase in name recall from block one to block two, which was significantly larger for the full mnemonic compared to the uninstructed group. However, there was no significant difference between block one and block three for any group. Face-name pairs were better recalled when presented for a slow duration compared to a fast duration. A compliance analysis involving only participants who adhered to strategy instructions resulted in the same outcomes (Fig. 2a; Appendix C).

In line with the first study aim, we examined the influence of mnemonic strategies on name recall with results partially supporting the mnemonic strategy hypotheses as the full mnemonic group significantly outperformed the uninstructed group, but not the other mnemonic groups in block two. This is contrary to the results obtained by McCarty (1980), where the full-mnemonic group significantly outperformed all other groups. However, in the previous study, the experimenter provided the prominent facial feature, name transformations, and interactive imagery for the face-name pairs to participants (McCarty, 1980). Thus, the full mnemonic group received more information than the other groups, which perhaps led to better performance (McCarty, 1980). In contrast, imagery was participant-generated in this study, which resulted in some overlap in the imagery used across the mnemonic groups, as mentioned in open-ended responses (Appendix I). Furthermore, all mnemonic groups significantly outperformed the uninstructed group in block two, perhaps because imagery is the crucial aspect of improving name recall rather than the number of components (Morris et al., 1978). However, only the name-transformation group significantly outperformed the uninstructed group across all three blocks. Perhaps the name-transformation strategy allows

for various scenarios with the person in the image in comparison to the facial feature and full mnemonic strategies, which require multiple uses of limited facial features (McCarty, 1980). Thus, while the full-mnemonic and facial feature strategies did not produce the expected effects, the name-transformation strategy did.

In line with expectations regarding presentation duration, mean name recall was significantly better for the slow duration compared to the fast duration. Moreover, more participants indicated that they had enough time to apply the strategy in the slow compared to the fast duration (Fig. 3a). However, contrary to expectations, the influence of the time manipulation did not vary with the complexity of the instructions. This perhaps demonstrates that all the groups had sufficient time to apply the strategy when the face-name pairs were presented for 16 seconds.

The expected effect of practice/repetition was supported as mean recall scores significantly increased from block one to block two for all groups (Dallett, 1963; Karpicke & Roediger, 2007). However, contrary to expectations, there was no significant difference in mean recall scores for any group from block one to block three. In effect, recall in block three returned to a similar level as in block one for all groups, which may have been due to fatigue or proactive interference (Weinstein et al., 2011). Moreover, participants found it difficult to apply their strategy in block three (Fig. 3b) and indicated that there were too many face-name pairs in the open-ended questionnaire responses. It is possible that training with the mnemonic strategies requires multiple sessions over time to be effectively generalised to new face-name pairs (Bellezza, 1981).

5.4 Experiment 2

Experiment 1 demonstrated an advantage for the name-transformation mnemonic strategy compared to an uninstructed approach across all three blocks. In contrast to expectations, the full mnemonic group did not outperform the other mnemonic groups, perhaps due to the complexity of the full technique (Patton, 1994). It is possible that fewer steps in the name-transformation technique with a focus on name-transformation and without repeated cues (i.e., the facial feature) were crucial aspects to improving name recall. However, Experiment 1 did not demonstrate a generalisation effect as predicted for the name-transformation group. This perhaps indicated that the strategy may be difficult to adopt when using it with new face-name pairs. It is also possible that the second block of repeated face-name pairs resulted in fatigue or proactive interference that impacted the ability to generalise the strategy use in block three. Additionally, the data collection of Experiment 1 was prematurely concluded which may have influenced the outcome. Thus, it was important to explore the efficacy of the name-transformation mnemonic strategy and the potential generalisation to new face-name pairs. Experiment 2 was designed to further examine the effects of the name-transformation strategy in comparison to an uninstructed approach in an online study with young adults (see Experiment S1 in Appendix E).

There are some changes to Experiment 2 worth noting. The blocks were reduced to two blocks with *different* face-name pairs to examine if generalisation would occur without a second familiarisation block. Removing the second block also allowed us to determine whether fatigue was a factor in the results of Experiment 1. We also used 12 seconds for all stimuli. As outlined in the introduction, this study examined different timings to determine which timing is sufficient to employ the mnemonic strategy. In Experiment 1, 16 seconds was superior to 8 seconds as expected, and the questionnaire results demonstrated that participants felt they had enough time with the longer duration so here we examined whether 12 seconds

would be sufficient. Although Experiment 1 demonstrated that 16 seconds is likely sufficient time to implement the name-transformation strategy, it may not always be possible to have this much time available in a naturalistic setting while during conversation, thus it was essential to examine whether a shorter duration would be sufficient for participants to apply the strategy.

5.4.1 Method

5.4.1.1 Participants

A target sample of 96 participants was set based on a power analysis in G*Power 3.1 assuming a mixed ANOVA design with a medium effect size (partial eta squared) of 0.06, an alpha of .05, and power of .80. A total of 110 participants (70 females, 39 males, 1 non-binary*; M* age = 29.63, *SD* = 6.02) completed the study. Participants were recruited online via Prolific and renumerated at a rate of £5/hour. Prolific filters were used to recruit participants according to the following inclusion criteria: (1) aged between 18-39 years old (2) English as a first language, and (3) currently residing in the UK.

5.4.1.2 Materials

The materials were the same as Experiment 1.

5.4.1.3 Design

This was a mixed design with a between-groups factor (Strategy Type) and a within-subjects factor (Block). Two strategy groups were used: the uninstructed group and the name-transformation group with the same instructions as in Experiment 1. Blocks one and two had 40 *different* set of face-name pairs.

5.4.1.4 Experiment Aim and Hypotheses

The aims of this experiment were to examine:

1. The influence of mnemonic strategies on name recall. It was hypothesised that mean recall will be higher for the name- group compared with the uninstructed group. It was also expected that mean recall scores for the name transformation group will have a larger increase from block one to block two compared with the uninstructed group.
2. The extent to which strategy use would be generalised to new face-name pairs. It was hypothesised that mean recall scores will increase from block one to block two for both strategy groups.

   This study's design and hypotheses were preregistered; see https://osf.io/q2kh6.

5.4.1.5 Procedure

This experiment was conducted online with consent, questionnaires and debrief procedures through Qualtrics and the experiment through Pavlovia. Participants were randomly allocated to the uninstructed or the name-transformation groups. Randomisation was completed through Qualtrics before the experiment started and participants had three attempts to answer comprehension check questions and then continued to the task (Appendix F). Along with the instructions, the name-transformation group received a visual example of how to perform the task. There was a practice block with 5 face-name pairs and two blocks with 40 *different* face-name pairs. All pairs were presented for 12 seconds with a 1 second inter-stimulus interval. All stimuli were presented using lab.js (Version 20.2.2) (Henninger et al., 2021). The strategy use and real life questionnaires were updated to reflect the changes in the task (Appendix F).

5.4.1.6 Data analysis

A mixed ANOVA was conducted with Strategy Type (uninstructed and name-transformation) as a between-groups variable, and Block (one and two) as a within-subjects variable.

Participants were excluded based on the following criteria: (1) more than one attempt at the task (2) three failed comprehension check questions (3) not paying attention as indicated by selecting 'No I did not pay attention during this study' or on questionnaire responses, (4) two or more failed attention check questions among the MMQ responses, (5) recall below 10% of the total number of items to be recalled, or (6) total recall score 2.5 or more deviations from the MAD. Exclusions were completed in parallel (18 excluded), leaving 92 participants remaining (62 females, 29 males, 1 non-binary; *M* age = 29.53, *SD* = 5.94). The outlined exclusion criteria differ from the pre-registered criteria with the inclusion of the comprehension check questions and exclusion based on total recall score 2.5 or more deviations from the MAD (see pre-registered analyses in Appendix G). Sphericity tests are not reported as there were only two levels of the repeated measures factor (Block).

5.4.2 Results

5.4.2.1 All-inclusive Analysis

The main effect of Strategy Type was significant ($F(1, 90) = 8.22$, $p = .005$, $\eta_p^2 = .08$) with higher name recall for the mnemonic group ($M = 30.13$, $SD = 15.82$) compared to the uninstructed group ($M = 22.13$, $SD = 10.19$). The main effect of Block ($F(1, 90) = 1.31$, $p = .256$, $\eta_p^2 = .01$) and the interaction between Strategy Type and Block ($F(1, 90) = 1.31$, $p = .256$, $\eta_p^2 = .01$) were not significant.

5.4.2.2 Compliance Analysis

Participants in the mnemonic group who indicated in the questionnaires that they used a different strategy than the one described, had insufficient explanation of strategy use to the extent that it was unclear if they completed the strategy, or had insufficient strategy use throughout the experiment indicating lack of engagement with the strategy were removed. Participants were excluded based on the previously outlined criteria and noncompliance with

instructions. Exclusions were completed in parallel (35 excluded), leaving 75 participants remaining (52 females, 22 males, 1 non-binary; *M* age = 29.69, *SD* = 5.86). Significant main effects of Strategy Type ($F(1, 73) = 6.21$, $p = .015$, $\eta_p^2 = .08$) and Block ($F(1, 73) = 5.50$, $p = .022$, $\eta_p^2 = .07$) were qualified by a significant interaction between Strategy Type and Block ($F(1, 73) = 5.09$, $p = .027$, $\eta_p^2 = .07$). Post-hoc comparisons (Bonferroni corrected) revealed that the mnemonic group (*M* = 15.97, *SD* = 8.31) had significantly higher name recall compared to the uninstructed group in block two (*M* = 11.09, *SD* = 5.60; $t(73) = 3.09$, $p = .016$, $d = 0.72$; Fig. 2b). There was a significant increase in name recall for the mnemonic group from block one (*M* = 13.61, *SD* = 1.40) to block two (*M* = 15.97, *SD* = 1.49; $t(30) = 3.00$, $p = .022$, $d = 0.35$; Fig. 2b). An independent samples t-test of the increase in name recall score between blocks revealed a significantly larger increase in name recall from block one to block two for the mnemonic group (*M* = 2.36, *SD* = 4.16) compared to the uninstructed group (*M* = 0.05, *SD* = 4.50; $t(73) = 2.26$, $p = .027$, $d = 0.53$).

5.4.2.3 Questionnaires

Results of the MMQ scales are reported in Appendix H. Figure 4a shows the frequency of responses across five strategy use questions. See questions in Appendix F. See open-ended responses in Appendix J.

Many participants across both groups indicated that they used a strategy in the task, had enough time to apply their respective strategy, and they enjoyed using their strategy, and could apply their strategy when meeting people. However, many participants indicated that they would not apply the mnemonic strategy in real life. Open-ended responses indicated that participants in the uninstructed group focused on distinct features and related the person in the photo to a known individual, like Experiment 1 (see examples in Experiment 1). Mnemonic group participants who didn't use the mnemonic strategy focused on distinct features and

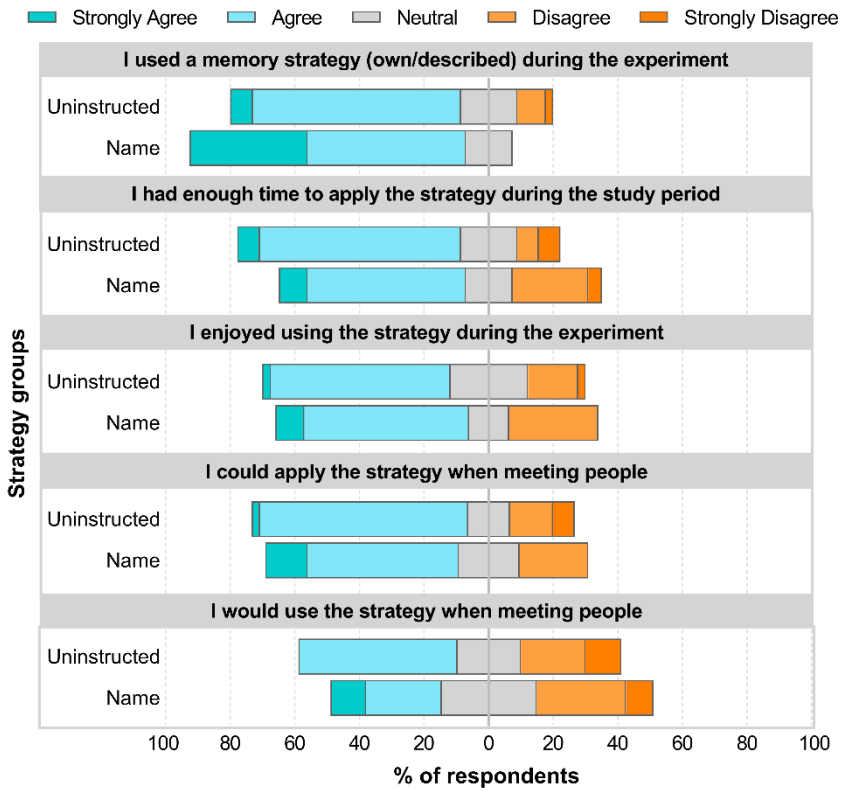
used rhyming (e.g., “I tried to rhyme the name with an object or verb I'm familiar with”). A similar number of participants in the uninstructed group indicated that their strategy would be easy and difficult to use when meeting people whereas more participants in the name-transformation group indicated that it would be difficult than easy.

Figure 4b shows the frequency of responses across three of the ease-of-use questions. Participants in both groups found the strategy difficult in blocks one and two. Although participants in the uninstructed group indicated it would be similarly easy or difficult to use when meeting people, name-transformation participants indicated that it would be difficult. Open-ended responses revealed that participants found the task difficult because there were too many face-name pairs, or had difficulty transforming the name, like in Experiment 1. According to participants in both groups, having more time (e.g., “Maybe having more time in real life with the person would make it easier”), fewer names (e.g., “Less people than the amount of pairs so far.”), or including personal details (e.g., “Adapt it to match things about their mannerisms/way they speak/characteristics.”) may make strategy use easier in real life.

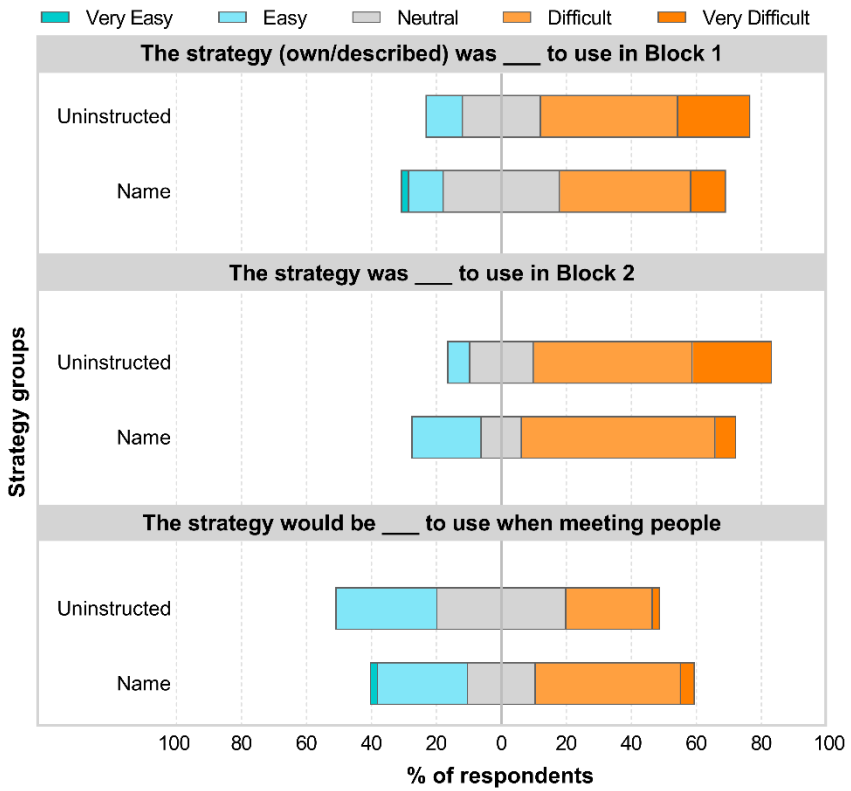
Figure 4

Experiment 2 frequency of responses for (a) five of the strategy use questions rated from *Strongly Agree – Strongly Disagree* and (b) three of the ease-of-use questions rated from *Very Easy – Very Difficult*. Name = Name-transformation. Questions have been abbreviated in figures. See full questions in Appendix F.

a. Strategy use questionnaires



b. Ease-of-use questions



5.4.3 Discussion

Experiment 2 demonstrated an advantage for the name-transformation mnemonic strategy in comparison to the uninstructed strategy. The compliance analysis revealed significantly higher name recall for the mnemonic group compared to the uninstructed group in block two, partially supporting hypothesis that the mnemonic strategy group would outperform the uninstructed group. Mean recall significantly increased from block one to block two for the mnemonic group, but not the uninstructed group, partially supporting the hypothesis of generalisation of strategy use to new face-name pairs, for the mnemonic group but not the uninstructed group. As highlighted by Morris et al. (1978), this perhaps indicates that improved name recall in block two was not simply a result of practice with the task or repetition of face-name pairs as shown in Experiment 1. As expected, the mean recall scores for the mnemonic group had a significantly larger increase from block one to block two compared to the uninstructed group (Fig. 2a). In contrast to Experiment 1 where there was no significant difference from block one to block three, these results perhaps indicates that the mnemonic can be learned and applied to new face-name pairs given enough time to apply the strategy and fewer blocks.

The strategy use questionnaires revealed that both groups used memory strategies and enjoyed using their respective strategies during the experiment (Fig. 4a). Participants indicated that they had enough time to apply the strategy for both 12 and 16 second durations across both experiments, indicating that it is possible to apply the strategy in this range. Like Experiment 1, participants found their respective strategy difficult to apply across the blocks with new face-name pairs, perhaps due to the number of face-name pairs, which were mentioned in the open-ended responses as being too many (Fig. 3a and Fig. 4a; Appendix J). Participants in Experiment 2 indicated that it would be difficult to use their respective strategy when meeting

people (Fig. 4b). This may be due to the task being completed online and thus difficulty imagining interaction with new individuals in person.

5.5 General Discussion

Failure to correctly name an individual in a social setting can be uncomfortable, embarrassing, and potentially distressful for the individual who has forgotten and the individual whose name is not recalled (Brédart, 2017; Brédart & Geurten, 2020; Hargis et al., 2020; Schwartz, 2014). As such, it is essential to examine methods to improve name recall when learning new names to reduce or prevent these failures. This study was designed to examine the effectiveness of imagery-based mnemonic strategies on name recall in comparison to an own best method approach where no imagery instruction was provided.

The results of Experiment 1 revealed better name recall for the name-transformation strategy group compared to the uninstructed strategy group across three blocks whereas the facial feature and full mnemonic groups outperformed the uninstructed group in block two with repeated face-name pairs. Experiment 2 revealed better name recall for the name-transformation group compared to the uninstructed group. These results are consistent with previous research demonstrating better name recall with an imagery-based mnemonic strategy compared to an uninstructed approach (Carney & Levin, 2014; McCarty, 1980; Morris et al., 1978). However, contrary to expectations, the full mnemonic strategy did not outperform the other mnemonic strategies and had limited efficacy compared to the uninstructed approach. It is possible that the full strategy is too complex to apply within a limited time frame or that more sessions are required to train the use of the full strategy.

This study improved upon past research by demonstrating that a simplified version of the full mnemonic strategy can be applied to forenames (McCarty, 1980; Morris et al., 1978; Patton,

1994). However, the young adult participants often found it difficult to recall names of older adults (e.g., “I found it hard to remember the names of the elderly men & women”) and individuals without distinctive features or those with similar appearances (e.g., “Some faces were similar to each other which made it harder for me to differentiate”). This is consistent with previous research demonstrating an own-age bias in face recognition and name recall and that recall is better for more distinctive faces and names compared to typical or similar stimuli (Pantelis et al., 2008; Strickland-Hughes et al., 2020; Watier & Collin, 2012; Wiese et al., 2013).

In this study, we assigned mnemonic strategies to participants but did not provide the facial features, name transformations, or imagery connections that should be used. It was expected that this would allow participants to generate their own imagery and engage more meaningfully with the stimuli than when the strategy components are provided by researchers. Interestingly, Patton (1994) found no significant difference in name recall when the full mnemonic strategy components were experimenter-generated or participant-generated even though both approaches resulted in significantly higher name recall than a pre-test. However, a compliance analysis was not conducted and it is possible that some participants diverged from the instructed mnemonic (Patton, 1994). In contrast, our compliance analyses revealed compliance rates of 64% and 68% in Experiments 1 and 2 respectively where the name-transformation group significantly outperformed the uninstructed group with participant-generated mnemonics. Thus, when participants comply with name-transformation strategy instructions, there can be improvement in name recall even within a short period of time.

This study expanded on previous research by using questionnaires to explore strategies used during the task and in real life. We found that uninstructed participants used repetition, distinct facial features/appearance, and associated the face-name pairs with known individuals

while some participants used mnemonics such as first letter mnemonics. This is in line with previous research demonstrating that participants use similar approaches to remember names (Carney & Levin, 2012; Clarke, 1934). In addition, participants across the different groups indicated that they either have no strategy or use distinct facial features, rhyming, or mental or verbal repetition when meeting people in person to recall names. However, previous research has shown a lack of support for repetition as this may not allow for a sufficient link between the face and name (Hourihan & Smith, 2016; Wilck et al., 2022).

The questionnaires revealed that even though participants in the name-transformation group enjoyed using the strategy during the task, strategy use was difficult and would be difficult to apply when meeting people (Fig. 3b and Fig. 4b). This is consistent with suggestions that applying the mnemonic to photographs and without distractions may not replicate during an in-person conversation due to the difficulty of maintaining a conversation while creating imagery (Morris et al., 2005; Patton, 1994). Moreover, participants indicated in open-ended responses that there would be more information to focus on during a conversation where limited time (e.g., “Probably not because I wouldn’t think about it in that way- I wouldn’t be able to think of imagery to use in time”) and social etiquette might prevent application of the strategy (e.g., “Possibly, although it may not be socially acceptable to stare at someone’s face for that long in real life”). In contrast, some participants indicated that factors such as personality and voice can be used to improve strategy use during in-person conversations (e.g., “I think it would be easier in real life as you can see the whole person and also their personality and body language”).

5.5.1 Limitations and Future Directions

Several limitations of this study are worth noting. Participants viewed a total of 85 face-name pairs within a limited time frame, which may have resulted in fatigue and reduced attention as

the task progressed. Although the number of face-name pairs was selected to prevent ceiling effects and examine learning across the blocks, many participants mentioned that there were too many pairs. This may explain why performance in block three returned to a similar level as in block one in Experiment 1 for all groups whereas the mnemonic group showed an increase in name recall from block one to block two in Experiment 2. The effects of fatigue may have been more detrimental in Experiment 1 due to the second block. Moreover, across both experiments, average name recall was less than 30 for new face-name pairs. It is also possible that proactive interference contributed to the lack of difference between block one and block three in Experiment 1 (Weinstein et al., 2011). Lorayne and Lucas (1974) found that students were able to successfully recall the names of twenty to forty classmates when applying the face-name mnemonic. This can be further examined in future studies by reducing the number of face-name pairs for a single session or spreading the strategy learning across multiple sessions.

In-person data collection for Experiment 1 was prematurely concluded due to the Covid-19 pandemic and the sample size was therefore lower than planned. As shifting the experiment to an online task would have considerably altered the experimental conditions, Experiment 1 was concluded. Appraisal of results should consider the lower than expected sample size which may impact the power to detect true effects. Additionally, similar to Legge et al. (2012), excluding non-compliant participants reduced the power to detect true effects in our study. However, across both experiments, there were similar rates of compliance and results showed significantly higher name recall for the name-transformation mnemonic group compared to the uninstructed group in compliance analyses. Thus, the advantage of the mnemonic imagery instruction was supported across the experiments when participants complied with instructions.

The use of photographs rather than videos or in-person conversations may have limited the ecological validity of the stimuli in this study (Crook & West, 1990; Morris et al., 2005; Patton, 1994). Although we attempted to include stimuli set that would closely reflect reality, this issue was highlighted by participants in the open-ended questionnaire responses mentioning that the strategy use would be different in-person. As mentioned in previous research, mnemonic strategy use would require concentration during conversation (Morris et al., 2005; Patton, 1994). In addition, name learning and recall in real life can be influenced by social situations and failure to recall names can result in negative social consequences, which were not reflected in this study, where there was no consequence of incorrect recall (Bahrick et al., 1975; Hargis et al., 2020). We suggest that future research either include videos of people introducing themselves or examine strategy use during in-person conversations (Crook & West, 1990; Morris et al., 2005; Patton, 1994).

In real life, multiple people can have the same name which may result in confusion when using a mnemonic strategy (Abrams & Davis, 2017; Griffin, 2010). This was not reflected in our stimuli but is an interesting avenue for further exploration as our open-ended responses showed that participants found it difficult to remember individuals with similar features and names. Finally, it has been suggested that the face-name mnemonic technique is too complex to use in conversations where another strategy like expanding rehearsal may be more effective or perhaps a combination of the face-name mnemonic technique alongside the expanding rehearsal strategy (Morris et al., 2005; Neuschatz et al., 2005; Patton, 1994). Past research has demonstrated the benefits of expanding rehearsal for name recall (Brédart, 2019; Helder & Shaughnessy, 2011; Landauer & Bjork, 1977). However, although previous authors often mention that imagery mnemonic strategies might be difficult to use in social settings because of the cognitive effort involved, there is little explanation of how the expanding rehearsal strategy should be practiced in person where the timings cannot be guaranteed when

interacting with the same person again (Carpenter & DeLosh, 2005; Landauer & Bjork, 1977). Future research can examine the extent to which the name-transformation mnemonic might be combined with expanding rehearsal to improve name recall (Neuschatz et al., 2005). In addition, it is essential to consider how other strategies such as expanding rehearsal can be effectively applied in naturalistic situations.

5.6 Conclusion

This study demonstrated limited efficacy of the full mnemonic strategy, but an advantage of the name-transformation mnemonic strategy compared to an own best method approach. Although the full mnemonic strategy may be too complex to apply when meeting individuals in-person, it is possible that a simplified approach can be used alone or in combination with other techniques such as expanding rehearsal to improve name recall (Morris et al., 2005; Neuschatz et al., 2005). However, less than 70% of the participants who completed the task complied with instructions and this should be considered in future research as some individuals may prefer not to use mnemonic strategies even if they are aware of them. As suggested by participants, additional details from in-person conversations such as personality, voice, and mannerisms may facilitate the name-transformation mnemonic to improve recall. In summary, our findings demonstrate limited efficacy of the face-name mnemonic strategy but that a simplified version focusing on name-transformations can be applied to forenames during learning to improve name recall if participants comply with strategy instructions.

5.7 References

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5.8 Appendices

Appendix A

Stimuli Name List by Age Range

Age range	20-29	30-49	50-69	70-94
	COLIN	KYLE	GREG	ALFRED
	SCOTT	CHRISTIAN	SHAWN	THEODORE
	BRENDAN	ALEXANDER	JAY	JESSE
	DEVON	GABRIEL	KELLY	EDWIN
	BRYCE	SETH	HENRY	JIM
	CHASE	RANDY	DARRELL	MARTIN
	TAYLOR	MARCUS	KURT	VINCENT
	OSCAR	DUSTIN	LEONARD	BERNARD
	TRAVIS	JARED	MATTHEW	LEE
	ETHAN	DERRICK	ERNEST	GORDON
	MADELINE	NATALIE	MONICA	ROSEMARY
	ANGELICA	ALLISON	TERRI	GLENDA
	JULIE	RHONDA	STACEY	ESTHER
	BRIANA	MOLLY	LAURIE	MARIAN
	AUTUMN	KRISTINA	JENNIFER	JEANETTE
	CYNTHIA	HANNAH	MICHELLE	WILLIE
	GRACE	ANN	MELANIE	SHERRY
	LISA	MEGAN	SALLY	BEATRICE
	HAILEY	CINDY	TRACEY	IRENE
	SIERRA	SANDRA	KIMBERLY	JEANNE
	EDUARDO	SHANNON	BEVERLY	
	BIANCA	JASMINE		

Appendix B

Experiment 1 Questionnaires

Instructions: During the experiment, you saw faces and names presented in three sections with some being presented for a short time and some presented for a long time. This questionnaire will help us better understand your strategy use during the experiment. Please read each statement carefully and think about your experience during the experiment. Circle the response that best describes your experiences or provide as much information as you can. All data collected will be anonymised and used for research purposes only. It will be stored in compliance with the Data Protection Act.

Questionnaire: Strategy use (uninstructed group)

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

1. I understood the scenario.
2. I had enough time to see the faces and names in the short presentations.
3. I had enough time to see the faces and names in the long presentations.
4. I used a memory strategy to help remember the names and faces throughout the experiment.

    a) Please describe the strategy/strategies you used during the experiment to remember the names and faces.

Options: Very Easy Easy Neutral Difficult Very Difficult

5. I found it _____ to use my strategy during SECTION 1.
6. I found it _____ to use my strategy during SECTION 2.
7. I found it _____ to use my strategy during SECTION 3.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

8. I had enough time to apply my strategy during the short presentations.
9. I had enough time to apply my strategy during the long presentations.
10. I enjoyed using my strategy during the experiment.

11. Why did you find your strategy/strategies difficult/easy to use?
12. Did you use the same strategy for the face-name pairs that were shown twice (in SECTION 1 and SECTION 2)? Why or why not?
13. Did you apply your strategy in a different way for the short and the long presentations? If yes, how?
14. Were there too many or too few face-name pairs?
15. Were there any face-name pairs you found particularly difficult to remember? Why?
16. Do you think your performance would have been better with a different strategy? Why/why not?
17. Comments about any of the questions.
18. Please list any names and the associated connections you can remember.

Name	Connection

Questionnaire: Real-life (uninstructed group)

Instructions: This questionnaire will help us better understand your use of strategies outside the lab. Please read each statement carefully and think about your strategy use outside of the lab. Circle the response that best describes your experiences.

19. The strategy I used during the experiment is the one I use when meeting people.
    Strongly Agree Agree Neutral Disagree Strongly Disagree

20. This strategy is _____ to use when meeting people.
    Very Easy Easy Neutral Difficult Very Difficult

21. Do you think you would be able to apply this strategy when meeting people at a social event? Why or why not?
22. Would any changes to the strategy you used during the experiment make it easier to use in real life?
23. Do you currently use any other techniques to remember names when meeting people? If so, what are they?
24. Comments.

Questionnaire: Strategy use (mnemonic groups)

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

1. I understood the scenario.
2. I understood the instructions about the described strategy.
3. I had enough time to learn about and understand the strategy.
4. I used the described strategy throughout the experiment.

Options: Very Easy Easy Neutral Difficult Very Difficult

5. I found it _____ to use the strategy during SECTION 1.
6. I found it _____ to use the strategy during SECTION 2.
7. I found it _____ to use the strategy during SECTION 3.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

8. I had enough time to apply the strategy during the short presentations.
9. I had enough time to apply the strategy during the long presentations.
10. I enjoyed using this strategy during the experiment.

11. Please describe how you applied the strategy during the experiment to remember the names and faces.
12. Why did you find the strategy difficult/easy to use?
13. Did you use the same imagery for the face-name pairs that were shown twice (SECTION 1 and SECTION 2)? Why or why not?
14. Did you apply the strategy in a different way for the short and the long presentations? If yes, how?
15. Were there too many or too few face-name pairs?
16. Were there any face-name pairs you found particularly difficult to remember? Why?

17. Did you use any other strategy during the experiment? If so, please describe the strategy.
18. Comments about any of the questions.
19. Please list any names and the associated imagery statements you can remember.

Name	Imagery
……	…….
……	…….

Questionnaire: Real-life (mnemonic groups)

20. I would use the described strategy when meeting people.
    Strongly Agree Agree Neutral Disagree Strongly Disagree
21. The described strategy would be _____ to use when meeting people.
    Very Easy Easy Neutral Difficult Very Difficult
22. Do you think you would be able to apply the described strategy when meeting people at a social event? Why or why not?
23. Would any changes to the described strategy make it easier to use in real life
24. Do you currently use any techniques to remember names when meeting people? If so, what are they?
25. Comments.

Appendix C

Experiment 1 Analyses

Pre-registered Analysis

In the all-inclusive analysis (see main manuscript), participants were excluded based on the following criteria: (1) more than one attempt at the task, (2) not paying attention during the task, as indicated by questionnaire responses, (3) recall below 10% of the total number of items to be recalled, or (4) total recall score 2.5 or more deviations from the median absolute deviation (MAD) (Leys et al., 2013, 2019). Exclusions were completed in parallel (6 excluded), leaving 80 participants remaining (59 females; *M* age = 20.35, *SD* = 2.68). The outlined exclusion criteria differ from the pre-registered criteria because it was determined that exclusion of individuals whose memory performance indicate floor or ceiling effects is necessary to examine the effects of the memory strategies. In contrast, in the pre-registered exclusion criteria, there was no exclusion based on recall below 10% of the total number of items to be recalled and no exclusion based on score deviation from the median. Here, we present the results based on the pre-registered exclusion criteria: (1) more than one attempt at the task or (2) not paying attention during the task, as indicated by questionnaire responses. For the pre-registration, see https://osf.io/bmvz3.

A mixed ANOVA was conducted with Strategy Type (uninstructed, facial-feature, name-transformation, and full-mnemonic) as a between-groups variable, and Presentation Duration (fast or slow) and Block (one, two, and three) as within-subjects variables. Exclusions were completed in parallel (1 excluded) based on the pre-registered criteria, leaving 85 participants remaining (61 females; *M* age = 20.38, *SD* = 2.70). The assumption of sphericity was violated for Block (Mauchly's $X^2(2) = 6.83$, $p = .033$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

Significant main effects of Strategy Type ($F(3, 81) = 4.20$, $p = .008$, $\eta_p^2 = .14$) and Block ($F(1, 149) = 505.29$, $p < .001$, $\eta_p^2 = .86$) were qualified by a significant interaction between Strategy Type and Block ($F(5, 149) = 3.41$, $p = .004$, $\eta_p^2 = .11$). No other significant interactions were obtained. Post-hoc comparisons (Bonferroni corrected) revealed that name recall was significantly higher for the name-transformation group ($M = 31.36$, $SD = 9.09$) compared to the uninstructed group ($M = 22.55$, $SD = 10.11$) in block two, $t(43) = 3.88$, $p = .012$, Cohen's $d = 1.10$. All groups showed significantly higher name recall in block two compared to block one ($p < .001$ for all groups). There was no significant difference from block one to block three for any group. There was a significant main effect of Presentation Duration ($F(1, 81) = 58.35$, $p < .001$, $\eta_p^2 = .42$), with higher name recall scores for stimuli that were presented for a slow duration of 16 seconds ($M = 30.37$, $SD = 11.84$) than for those presented for a fast duration of 8 seconds ($M = 26.33$, $SD = 10.85$).

Based on the significant interaction between Strategy Type and Block, we conducted a follow-up one-way ANOVA of the increase in name recall from block one to block two across the groups. There was a significant difference between groups ($F(3,81) = 6.25$, $p < .001$, $\eta_p^2 = .19$). Post hoc comparisons (Bonferroni corrected) revealed a significantly larger increase from block one to block two for the full mnemonic group ($M = 18.30$, $SD = 4.39$) compared to the uninstructed group ($M = 12.10$, $SD = 5.20$; $t(38) = 4.13$, $p < .001$, $d = 1.29$) and the name-transformation group ($M = 14.20$, $SD = 5.51$; $t(43) = 2.89$, $p = .031$, $d = 0.81$).

Compliance Analysis

The data were analysed with participants who adhered to the strategy instructions (Legge et al., 2012). Participants in the mnemonic groups who indicated in the questionnaires that they used a different strategy than the one described, had insufficient explanation of strategy use to the extent that it was unclear if they completed the strategy, or had insufficient strategy use

throughout the experiment indicating lack of engagement with the strategy were removed. Participants were excluded based on the previously outlined criteria in the all-inclusive analysis and noncompliance with instructions. Exclusions were completed in parallel (31 excluded), leaving 55 participants remaining (38 females; *M* age = 20.18, *SD* = 2.55). The assumption of sphericity was violated for Block (Mauchly's $X^2(2) = 6.63$, $p = .036$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

Significant main effects of Strategy Type ($F(3,51) = 13.64$, $p < .001$, $\eta_p^2 = .45$) and Block ($F(1, 90) = 417.51$, $p < .001$, $\eta_p^2 = .89$) were qualified by a significant interaction between Strategy Type and Block ($F(5, 90) = 3.35$, $p = .007$, $\eta_p^2 = .17$). No other significant interactions were obtained. Post-hoc comparisons (Bonferroni corrected) revealed that name recall was significantly higher for the name-transformation group (*M* = 19.39, *SD* = 6.78), compared to the uninstructed group in block one (*M* = 8.19, *SD* = 3.82; $t(27) = 5.10$, $p < .001$, $d = 1.74$), for the name-transformation group (*M* = 35.08, *SD* = 4.09) compared to the uninstructed group in block two (*M* = 20.81, *SD* = 7.70; $t(27) = 6.49$, $p < .001$, $d = 2.22$), and for the name-transformation group (*M* = 20.39, *SD* = 7.74) compared to the uninstructed group in block three (*M* = 8.56, *SD* = 4.03; $t(27) = 5.38$, $p < .001$, $d = 1.84$). Name recall was significantly higher for the facial feature group (*M* = 29.07, *SD* = 5.92) compared to the uninstructed group in block two (*M* = 20.81, *SD* = 7.70; $t(28) = 3.84$, $p = .017$, $d = 1.28$). Name recall was significantly higher for the full mnemonic group (*M* = 32.33, *SD* = 7.00) compared to the uninstructed group in block two (*M* = 20.81, *SD* = 7.70; $t(26) = 5.13$, $p < .001$, $d = 1.79$). All groups showed significantly higher name recall in block two compared to block one ($p < .001$ for all groups). There was no significant difference from block one to block three for any group.

There was a significant main effect of Presentation Duration ($F(1, 51) = 42.85$, $p < .001$, $\eta_p^2 = .46$), with higher name recall scores for stimuli that were presented for a slow duration ($M = 29.87$, $SD = 10.98$) than for those presented for a fast duration ($M = 25.66$, $SD = 10.09$).

Based on the significant interaction between Strategy Type and Block, we conducted a follow-up one-way ANOVA of the increase in name recall from block one to block two across the groups. There was a significant difference between groups ($F(3, 51) = 6.56$, $p < .001$, $\eta_p^2 = .28$) with a significantly larger increase from block one to block two for the full mnemonic group ($M = 19.75$, $SD = 3.93$) compared to the uninstructed group ($M = 12.63$, $SD = 5.08$).

Appendix D

Experiment 1 Multifactorial Memory Questionnaire

The scores from the each MMQ scale was scored and interpreted separately for participants in the all-inclusive analysis (N = 80). Higher scores on the satisfaction scale indicate more satisfaction whereas lower scores indicate more dissatisfaction with memory abilities. Higher scores on the ability scale indicate lower frequency whereas lower scores indicate higher frequency of memory mistakes. Higher scores on the memory strategies scale indicate higher frequency whereas lower scores indicate lower frequency of use of memory aids and strategies. There was no significant difference between the uninstructed and mnemonic groups on the satisfaction, ability, or memory strategy scales.

Experiment 1 MMQ Scales

Scale	**Uninstructed** (n = 16)		**Face** (n = 20)		**Name** (n = 24)		**Full** (n = 20)		**ANOVA**		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	η_p^2
Satisfaction	35.50	10.19	40.70	10.85	43.92	14.12	41.95	11.85	1.62	.191	.06
Ability	43.56	11.52	44.00	12.08	45.83	9.17	50.40	8.79	1.75	.165	.06
Memory Strategies	45.94	11.05	44.55	10.26	43.17	5.97	43.00	9.70	Welch 0.35	.789	.02

Note. Welch's correction used where homogeneity of variances assumption violated as indicated by Levene's test

Appendix E

Experiment S1

The results of Experiment 1 demonstrated an advantage of the imagery mnemonic strategies over the uninstructed strategy in block two, but only the name-transformation strategy group significantly outperformed the uninstructed group across all three blocks. Experiment S1 was designed to replicate this effect and compare name recall across only the name-transformation and the uninstructed strategy groups. This experiment was conducted online with undergraduate students recruited from the School of Psychology.

Method

Participants

A target sample of 96 participants was set based on an a-priori power analysis (see main manuscript). A total of 132 participants (112 females, 17 males, 3 no responses; *M* age = 19.02, *SD* = 0.93) completed the study. Participants were recruited online via the School of Psychology Research Participation Scheme and received 0.75 credits.

See Experiment 2 in the main manuscript for *Materials*, *Design,* and *Procedure*. This experiment differs from Experiment 2 as participants were randomly assigned to the group by lab.js during the task after completing the consent form in Qualtrics and there were no comprehension check questions.

Data Analysis

A mixed ANOVA was conducted with Strategy Type (uninstructed and name-transformation) as a between-groups variable, and Block (one and two) as a within-subjects variable. Participants were excluded based on the following criteria: more than one attempt at the task, not paying attention as indicated by selecting ‘No I did not pay attention during this study’ or on questionnaire responses, two or more failed attention check questions among the MMQ

responses, recall below 10% of the total score, or total recall score 2.5 or more deviations from the median absolute deviation. Exclusions were completed in parallel (27 excluded), resulting in a total of 105 participants (89 females, 13 males, 3 no responses; *M* age = 18.99, *SD* = 0.93). Exclusion criteria differ from pre-registered criteria as it was later determined that the median absolute deviation would be more appropriate than the standard deviation as the median is less affected by outliers compared to the mean and standard deviation (Leys et al., 2013, 2019). Pre-registered analysis is presented below. Sphericity tests are not reported as there were only two levels of the repeated measures factor (Block).

Results

All-inclusive Analysis

There was a significant main effect of Block ($F(1,103) = 5.82$, $p = .018$, $\eta_p^2 = .05$), with significantly higher name recall in block two ($M = 14.08$, $SD = 7.53$) compared to block one ($M = 12.51$, $SD = 5.79$). The main effect of Strategy Type ($F(1,103) = 0.61$, $p = .438$, $\eta_p^2 = .01$) and the interaction between Strategy Type and Block ($F(1,103) = 0.01$, $p = .927$, $\eta_p^2 < .001$) were not significant.

Compliance Analysis

The data were re-analysed with compliant participants. Participants were excluded for the reasons outlined above and noncompliance with strategy instructions. Exclusions were completed in parallel (58 excluded), resulting in a total of 74 participants (63 females, 9 males, 2 no responses; *M* age = 18.88, *SD* = 1.10). The main effect of Block ($F(1,72) = 2.79$, $p = .099$, $\eta_p^2 = .04$), Strategy Type ($F(1,72) = 1.02$, $p = .315$, $\eta_p^2 = .01$), and the interaction between Strategy Type and Block ($F(1,72) = 0.02$, $p = .881$, $\eta_p^2 < .001$) were not significant.

Pre-registered Analysis

Here, we present the results based on the pre-registered exclusion criteria: (1) more than one attempt at the task, (2) not paying attention as indicated by selecting 'No I did not pay attention during this study' or on questionnaire responses, (3) two or more failed attention check questions among the MMQ responses, (4) recall below 10% of the total recall score, or (5) total recall score three or more standard deviations from the group mean. Exclusions were completed in parallel (26 excluded), resulting in a total of 106 participants (90 females, 13 males, 3 no responses; *M* age = 18.99, *SD* = 0.92). In contrast to the all-inclusive analysis, ceiling effects were detected and removed using the standard deviations from the group mean in the pre-registered analysis. For the pre-registered criteria, see https://osf.io/q2kh6.

There was a significant main effect of Block ($F(1,104) = 5.97$, $p = .016$, $\eta_p^2 = .05$) with significantly higher name recall in block two ($M = 14.24$, $SD = 7.67$) compared to block one ($M = 12.66$, $SD = 5.98$). The main effect of Strategy Type ($F(1,104) = 0.23$, $p = .636$, $\eta_p^2 = .002$) and the interaction between Strategy Type and Block ($F(1,104) = 0.01$, $p = .932$, $\eta_p^2 < .001$) were not significant.

Questionnaires

Independent t-tests were used to examine group differences in the overall scores for each MMQ scale for participants in the all-inclusive analysis. There was no significant difference between the uninstructed and mnemonic groups on the satisfaction, ability, or memory strategy scales. Figure S1a shows the frequency of responses across five of strategy use questions. Strategy questions for the uninstructed group referred to their own strategy while questions for the name-transformation group referred to the described strategy. See Appendix F for questions. See Table S1 for open-ended responses.

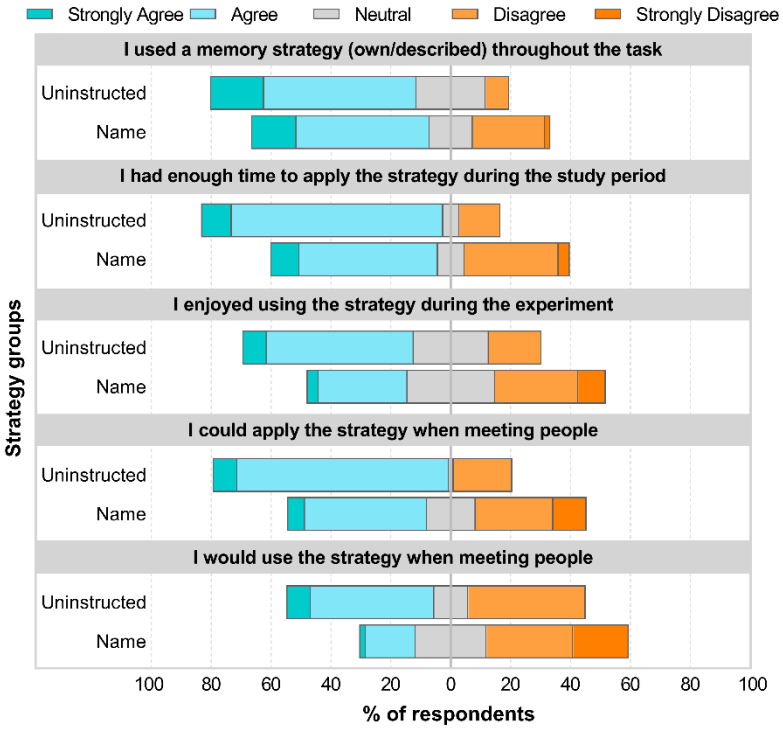
Across both groups, many participants agreed that they used a memory strategy, had enough time to apply their respective strategy during the study period, and could apply their strategy when meeting people. Participants in the uninstructed group agreed that they enjoyed using their own strategy during the task and would apply their strategy when meeting people, but many of the name-transformation participants disagreed. Open-ended responses revealed that the uninstructed participants and name-transformation participants who did not use the described strategy focused on distinct features (e.g., “if any certain prominent features stood out e.g. bright eyes.”), and related the individual in the photo to familiar individuals (e.g., “specific facial features linked me to names of people i knew”). Current strategies used when meeting people include repetition (e.g., “i repeat their name over and over in my head”), using distinct features, and no strategy (e.g., “I don't use a specific strategy.”).

Figure S1b shows the frequency of responses across three ease-of-use questions. Across both groups, participants found it difficult to apply their respective strategy. Uninstructed participants indicated it would be easy to use their own strategy when meeting people, but name-transformation participants indicated that described strategy would be difficult. Open-ended responses indicated that too many face-name pairs (e.g., “Difficult as too many words to remember”) and difficulty creating imagery (e.g., “i found it difficult due to me often being unable to come up with a suitable background to match the name with”) were factors in ease-of-use. Participants across both groups indicated that using additional personal details when meeting in-person would improve their strategies (e.g., “Could use aspects of personality/voice”).

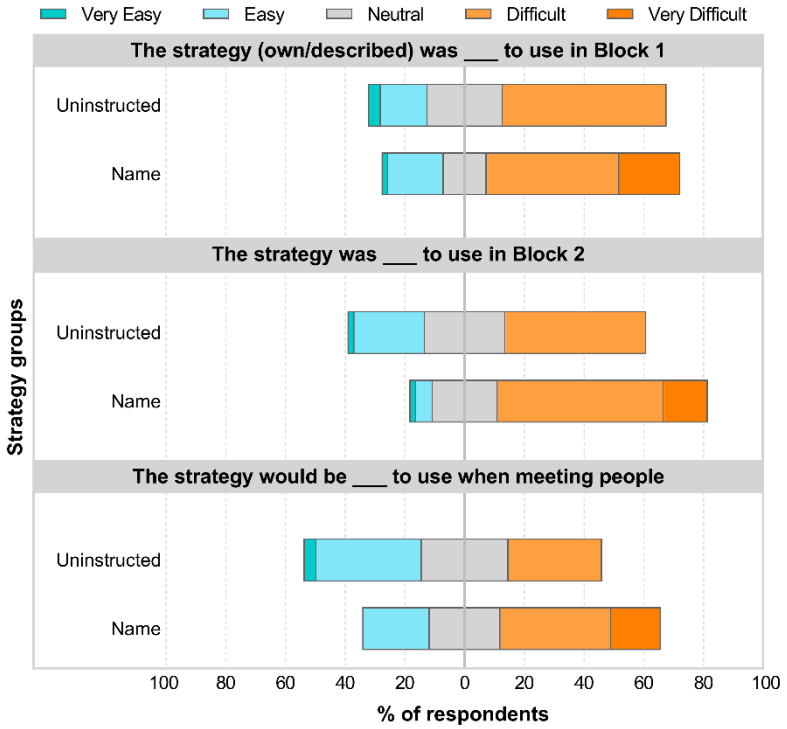
Figure S1

Experiment S1 frequency of responses for (a) five of the strategy use questions rated from *Strongly Agree – Strongly Disagree* and (b) three of the strategy ease-of-use questions rated from *Very Easy – Very Difficult*. Name = Name-transformation. Questions have been abbreviated in figure. See full questions in Appendix F.

b. Strategy use questions



b. Ease-of-use questions



Discussion

The results of this experiment demonstrated a significant improvement in name recall from block one to block two, perhaps due to practice effects. However, there was no significant difference between the uninstructed and name-transformation groups and no significant interaction between Strategy Type and Block. The results may have been due to lack of engagement with the mnemonic strategy or lack of enjoyment of use of strategy during the task in comparison to the uninstructed group (Fig. S1a). Similarly, difficulty of use of the strategy across the two blocks may have influenced the outcomes (Fig. S1b).

Questionnaire responses revealed that several factors likely influenced the outcomes of this experiment including motivation to participate, lack of attention, and lack of adherence to instructions. Motivation to participate in the study was unreliable as psychology undergraduate students were recruited from the Research Participation Scheme during the final weeks of the participation window. Specifically, the influx of participants during the last two weeks of the scheme may have been due to students attempting to complete studies with relatively high point values to complete academic requirements. This was indicated by at least one participant who typed pass for every response and selected a single answer for every multiple choice question. Lack of attention was indicated by the responses on the questionnaires, with 16 participants out of the 132 who completed the study indicating that they did not pay attention during the study, either by selecting the ‘I did not pay attention’ option or mentioning that they were distracted during the task.

As highlighted by Carney et al. (1988), the psychology students in the uninstructed group were actively engaged in psychology courses and it is possible that they had recently encountered mnemonic strategies and were applying them during the task. This was highlighted by open-ended response questions where uninstructed participants engaged with

some mnemonic strategies (e.g., “I would use a one word to describe the person which was a defining feature with the same first letter as their name e.g. Eyebrow Earl”) and mnemonic participants showed a lack of engagement with the described strategy (e.g., “specific facial features linked me to names of people i knew”).

Finally, adherence to instructions was questionable as approximately 32 participants were unable to complete the study due to use of an incompatible browser (Safari) although instructions were given to use a compatible browser (Google Chrome) and only 56% of participants who completed the study were retained in the compliance analysis. In comparison, motivation to participate in Experiment 1 was varied with Sona participants recruited throughout the year, some participants were provided with inconvenience allowances, and some completed study swaps. Moreover, as the task was completed in the lab with the researcher present, attention to the task was verified, the experiment was run on the same computers with no compatibility issues, and 64% of the participants who completed the task were retained in the compliance analysis. Thus, with these factors likely influencing the data quality of Experiment S1, the experiment was replicated with a sample of young adults recruited from Prolific (see main manuscript).

Table S1

Experiment S1 Open-Ended Responses

Question	Response (# of participants)	Example	Response (# of participants)	Example
	Uninstructed (n = 51)		Name-transformation (n = 54)	
Please explain how you remembered the face-name pairs during the experiment.	Distinct features/appearance (22)	"if any certain prominent features stood out e.g. bright eyes."	Described mnemonic (23)	"I read the name and whatever I thought of first associated with that name I would imagine with the person. i.e Seth sounds like stethoscope, so I imagined him with a stethoscope."
	Repetition (11)	"i repeated a list of names in my head"	Related to familiar individual (9)	"specific facial features linked me to names of people i knew"
	Related to familiar individual (6)	"I tried to relate faces to names of family members and friends."	Distinct features/appearance (8)	"I related letters in their names to physical features"
	First letter/naming mnemonics (5)	"I would use a one word to describe the person which was a defining feature with the same first letter as their name e.g. Eyebrow Earl"	Rhyming (6)	"rhyming words that matched their names as soon as i saw them"
	Rhyming (2)	"tried to come up with rhymes for the people and their names"	Repetition (3)	"repetition"
	Other (2)	"associated them with something"	Other (5)	"I made up stories of their lives"
	NR (3)	No response		
Uninstructed: Why did you find it easy/difficult to use your strategy?	Too many pairs (18)	"Difficult as too many words to remember"	Difficult to create link (15)	"i found it difficult due to me often being unable to come up with a suitable background to match the name with"

Name-transformation: Why did you find the described strategy easy/difficult to use?	No distinct features (11)	"Difficult because not everyone had a distinctive feature"	Too many pairs / not enough time(11)	"difficult as there were a lot of faces to remember"
	Remembered connection but not name (4)	"i kept only remembering what i'd associated with rather than the picture themselves"	Easier to remember names (9)	"As soon as I saw their face I would remember the scenario which lead me to remember their name."
	Easy with enough time/practice (4)	"Once I got used to the task it was easier to come up with things I could remember"	Forgot connection/name (6)	"Difficult as I remembered a lot of the associated words but forgot the linked name"
	Strategy didn't work (3)	"it didn't work"	Not familiar with strategy (3)	"I found it difficult as I don't usually use that strategy when remembering a lot mentally"
	Couldn't relate to familiar individual (2)	"I found it easy when the faces and names actually matched up to something or someone I was thinking of but difficult when I couldn't relate the person to anything."	Difficult (3)	"difficult"
	Other (5)	"I clearly have a poorer memory than i thought"	Similar appearance (2)	"I felt after a few I couldn't remember the previous names, and some were too similar."
	NR (4)	No response	Other (5)	"it makes it more serious"
Uninstructed: Were any of the face-name pairs particularly difficult to remember?	Older adults (11)	"I found a lot of the older face-name pairs difficult to remember as there was a lot of them to distinguish"	Yes/most/ all (12)	"Yes, a lot of them were"
	Similar features (10)	"those where the faces were similar to ones shown before"	Older adults (10)	"the elder people were difficult to differentiate"
Name-transformation: Were any of the face-name pairs particularly difficult to remember?	Yes (8)	"many"	Similar features (9)	"Some of the people faces were very similar which made it much harder to differentiate between them."
	Uncommon names (4)	"yes the ones that were more unusual names"	No (6)	"not necessarily"

	Common names (2)	“shorter ones that were classic English names”	Uncommon names (4)	“less common names, e.g. eduardo.”
	No (3)	“no”	Names that were difficult to transform (3)	“Ones that I could not easily link to anything.”
	Middle of the block (2)	“Those in the middle of the trial”	Common names (2)	“names which were more common, or matched the gender of the picture, were harder to remember.”
	Unsure/can’t remember (2)	“i cant remember if there were”	Gender neutral names (2)	“the gender neutral names”
	Other (4)	“yes the men”	Other (4)	“Can't remember”
	NR (5)	No response	NR (2)	No response
Uninstructed: Would any changes to the strategy make it easier to use in real life? Name-transformation: Would any changes to the described strategy make it easier to use in real life?	Include additional details (12)	“Would also be able to add things such as their accent and mannerisms”	Include additional details (11)	“Could use aspects of personality/voice”
	No (11)	“Not that i can think of”	No (10)	“Non that I can think of.”
	Conversation (5)	“Having a conversation with them i think would help”	Unsure (7)	“not sure”
	Fewer people/more time (4)	“when it is less people to remember then the rhymes will not blur together”	Rhyming (4)	“rhyming would be an easier option”
	Repetition (4)	“maybe mentally reciting instead of saying it out loud”	Different associations (3)	“General associations with name rather than something which sounds similar”
	Unsure (2)	“Unsure.”	Relate to scenario (2)	“i would find relating the face to a scenario would be easier than placing them in a scene”
	Other (7)	“Actually hearing the name instead of reading it would help”	Fewer pairs/more time (2)	“Would be easier if there were less faces to remember”
	NR (6)	No response	Relate to familiar individual (2)	“link people to other people i know”
			Other (5)	“link people to other people i know”
			NR (8)	No response

How do you remember names when meeting people?	Repetition (24)	“i repeat their name over and over in my head”	Repetition (22)	“Repeat it to myself many times”
	Relate to conversation/environment (7)	“pair their face with their name and recall conversations or events when that name was used.”	No strategy (8)	“I don't use a specific strategy.”
	Distinct feature/appearance (6)	“Associated names with notable features they possess.”	Appearance/features (6)	“associating their name with things that stand out about them”
	Personality (4)	“according to their personality”	Relate to familiar individuals (6)	“I try to associate them with people I already know with the same name.”
	No strategy (3)	“i dont im bad at remembering names”	Environment/conversation (6)	“Associating them to where they were, how we met etc.”
	Other (5)	“using adjectives that start with the same letter as the person's name”	Other (5)	“Just pictures in my mind”
	NR (2)	No response	NR (1)	No response

Note. Participants included from all-inclusive analysis (*N* = 105)

Appendix F

Experiment 2 Questionnaires

Comprehension Check Questions

Uninstructed group

Instructions: Please answer the following questions about the task. Please note that if the responses are incorrect you will be redirected to the instructions to read them again.

1. What will happen in this study?
    a. You will see face-name pairs and have a chance to study and remember them.
    b. You will study faces and later select the ones you recognise from several options.
    c. You will see a list of words and have a chance to study and remember them.
2. What were you asked to do in this study?
    a. Do your best to remember the face-name pairs that are presented.
    b. Rate the approachability of the faces that are presented.
    c. Do your best to remember a list of words that are presented.
3. What is the scenario you were asked to imagine during this study?
    a. You are at a local event where you will be meeting people. It is important that you remember their names.
    b. You are shopping at a supermarket. You will need to remember a list of items to purchase.
    c. You are at an event for your work. You will need to remember the names of your colleagues.

Mnemonic group

Instructions: Please answer the following questions about the task. Please note that if the responses are incorrect you will be redirected to the instructions to read them again.

1. What were you asked to do in this study?
    a. Use a mnemonic strategy to remember the face-name pairs that are presented.
    b. Rate the approachability of the faces that are presented.
    c. Do your best to remember a list of words that are presented.
2. What is the scenario you were asked to imagine during this study?
    a. You are at a local event where you will be meeting people. It is important that you remember their names.

b. You are shopping at a supermarket. You will need to remember a list of items to purchase.
c. You are at an event for your work. You will need to remember the names of your colleagues.

3. What is the mnemonic strategy you were asked to use in this study?
    a. Transform the name into an object you can easily imagine then imagine it interacting with the person in the image.
    b. Create a rhyme and link the names together based on the order in which they are presented.
    c. Create a story linking words together using a list that is presented.

Experiment S1 and Experiment 2 Questionnaires

Questionnaire: Strategy use (uninstructed group)

Instructions: This questionnaire will help us understand strategy use during the experiment. Please read each statement carefully and click the response that best describes your experience during the experiment or provide as much information as you can.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

1. I understood the scenario.
2. I understood the instructions.
3. I used a memory strategy to help remember names and faces during the experiment.
4. Please explain how you remembered the face-name pairs during the experiment.

Options: Very Easy Easy Neutral Difficult Very Difficult

5. I found it _____ to use my strategy during **block 1**.
6. I found it _____ to use my strategy during **block 2**.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

7. I had enough time to apply my strategy during the study period.
8. I enjoyed using my strategy during the experiment.
9. Why did you find it easy/difficult to use your strategy?
10. Were any of the face-name pairs particularly difficult to remember?
11. Please list any names you remembered and how you remembered them (e.g. rehearsal, clothing, etc.). You can list up to 10.

Name	How you remembered this name

Questionnaire: Real-life (Uninstructed)

Instructions: This questionnaire will help us understand strategy use in real life. Please read each statement carefully.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

1. I could apply the strategy I used during the experiment when meeting people in real life.
2. I would use the strategy I used during the experiment when meeting people in real life.
3. This strategy would be ___ to use when meeting people in real life.

Very Easy Easy Neutral Difficult Very Difficult
4. Would any changes to the strategy you used during the experiment make it easier to use in real life?
5. How do you remember names when meeting people?

Questionnaire: Strategy use (Name-transformation group)

Instructions: This questionnaire will help us understand strategy use during the experiment. Please read each statement carefully and click the response that best describes your experience during the experiment or provide as much information as you can.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
1. I understood the scenario.
2. I understood the instructions about the described strategy.
3. I used the described strategy throughout the experiment.

Options: Very Easy Easy Neutral Difficult Very Difficult
4. I found it _____ to use the described strategy during **block 1.**
5. I found it _____ to use the described strategy during **block 2**.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
6. I had enough time to apply the described strategy during the study period.
7. I enjoyed using the described strategy during the experiment.
8. Please explain how you remembered the face-name pairs during the experiment.
9. Why did you find the described strategy easy/difficult to use?

10. Were any of the face-name pairs particularly difficult to remember?
11. Please list any names you remembered and how you remembered them. You can list up to 10.

Name	How you remembered this name

Questionnaire: Real-life (Name-transformation group)

Instructions: This questionnaire will help us understand strategy use in real life. Please read each statement carefully.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
1. I could apply the described strategy when meeting people in real life.
2. I would use the described strategy when meeting people in real life.
3. The described strategy would be _____ to use when meeting people in real life.
Very Easy Easy Neutral Difficult Very Difficult
4. Would any changes to the described strategy make it easier to use in real life?
5. How do you remember names when meeting people?

Appendix G

Experiment 2 Pre-Registered Analysis

In the all-inclusive analysis (see main manuscript), participants were excluded based on the following criteria: (1) more than one attempt at the task (2) three failed comprehension check questions (3) not paying attention as indicated by selecting 'No I did not pay attention during this study' or on questionnaire responses, (4) two or more failed attention check questions among the MMQ responses, (5) recall below 10% of the total recall score, or (6) total recall score 2.5 or more deviations from the MAD. Exclusions were completed in parallel (18 excluded), resulting in a total of 92 participants (62 females, 29 males, 1 non-binary; *M* age = 29.53, *SD* = 5.94). In the pre-registered exclusion criteria, there was no exclusion for comprehension check questions and the exclusion of participants with ceiling effects was based on standard deviation from the group mean as it was later determined that the median absolute deviation would be more appropriate than the standard deviation as the median is less affected by outliers compared to the mean and standard deviation (Leys et al., 2013, 2019).

Here, we present the results based on the pre-registered exclusion criteria: (1) more than one attempt at the task, (2) not paying attention as indicated by selecting 'No I did not pay attention during this study' or on questionnaire responses, (3) two or more failed attention check questions among the MMQ responses, (4) recall below 10% of the total recall score, or (5) total recall score three or more standard deviations from the group mean. Exclusions based on pre-registered criteria were completed in parallel (14 excluded), resulting in a total of 96 participants (64 females, 31 males, 1 non-binary; *M* age = 29.47, *SD* = 5.94). Sphericity tests are not reported as there were only two levels of the repeated measures factor (Block). For the pre-registered criteria, see https://osf.io/q2kh6.

A mixed ANOVA was conducted with Strategy Type (uninstructed, name-transformation) as a between-groups variable, and Block (one, two) as a within-subjects variable. The main effect of Block ($F(1,94) = 0.67$, $p = .415$, $\eta_p^2 = .01$), Strategy Type ($F(1,94) = 3.34$, $p = .071$, $\eta_p^2 = .03$), and the interaction between Block and Strategy Type ($F(1,94) = 2.19$, $p = .142$, $\eta_p^2 = .02$) were not significant.

Appendix H

Experiment 2 Multifactorial Memory Questionnaire

The scores from the each of the MMQ scales were scored and interpreted separately for participants included in the all-inclusive analysis (N = 92). Independent t-tests were used to examine group differences in the overall scores for each scale. There were no significant differences between the uninstructed and mnemonic groups on any of the scales.

Experiment 2 MMQ scales

Scale	Uninstructed (n = 45)		Name-transformation (n = 47)		Test		
	M	*SD*	*M*	*SD*	Test	*p*	Effect size
Satisfaction	45.31	14.71	47.19	11.72	U = 1004.50	.681	-.05
Ability	51.53	15.57	50.53	11.17	t = 0.36	.723	0.07
Memory Strategies	34.11	14.82	37.55	10.65	Welch's t = 1.28	.206	0.27

Note. Mann-Whitney U-test used where assumption of normality was violated. Effect size for Mann-Whitney U-test is Rank-Biserial Correlation. Welch's t-test used where assumption of homogeneity was violated. Effect size for t-test is Cohen's d.

Appendix I

Experiment 1 Open-ended Questionnaire Responses

Uninstructed Group Responses

Question	Response (# of participants)	Example
Please describe the strategy/strategies you used during the experiment to remember the names and faces	Focused on distinct features (7)	"I looked out for distinct features on people's faces e.g. earrings marks etc. and associated that with the name."
	Related to familiar individual (4)	"Linking the names to some of my friends' faces (if they have the same name)"
	Imagined conversation/story (2)	"I initiate fake conversations related to their attire, hairstyle or exchange of names.
	Repetition/ rhyming (2)	"Repetition of names and faces, and tried to link names/parts of names with aspects of the persons photo"
	Other (1)	"Would try and find something about them that matched the first letter of their name (e.g. Sam – Spotty)"
Why did you find your strategy/strategies difficult/easy to use?	Too many pairs (5)	"When given too may name-face associations I ended up getting confused."
	Easier with distinct features (4)	"Made recall easier as I could associated with a distinctive feature of the person"
	Imagery improved recall (2)	"Having something to visualize things or saying things to myself in my head, as well as creating links, made the face-name matches more memorable and easier to recall"
	Other (5)	"I couldn't remember the names even though I recognized the faces"
Did you use the same strategy for the face-name pairs that were shown twice (in SECTION 1 and SECTION 2)? Why or why not?	Yes – strategy was effective (12)	"Yes. I tried to recall the first time how I remember names, then the second time I will use the same method"
	Depending on prior recall (2)	"Somewhat, I changed my strategy a bit and just focused on remembering the names which I couldn't recall in section 1's test but used that strategy to do so."
	Other (2)	"I just remembered the names in section 2 from the faces I could not remember in section1."
Did you apply your strategy in a different way for the short and the long presentations? If yes, how?	No (13)	"I applied the same strategy to both time frames."
	Yes (3)	"For the longer presentations I tried to close my eyes for longer as to not blur in all the sequential pictures into one in my head and to avoid forgetting each individual face.."
Were there too many or too few face-name pairs?	Too many (16)	"I found there was quite a lot to remember and couldn't remember all of them, even when given another opportunity in section two."

Were there any face-name pairs you found particularly difficult to remember? Why?	Similar appearance (7)	"The ones with similar features were difficult to remember."
	Older adults (6)	"Older people were harder to remember potentially as they look more similar than younger people"
	Unusual names (3)	"When the spelling or pronunciation of the name was obscure.
Do you think your performance would have been better with a different strategy? Why/why not?	Yes (8)	"Yes, maybe if I tried to remember the names instead of the faces I could link them up easier"
	No (7)	"Probably not, I thought this was the most effective way for me, there were just so many faces"
	Other (1)	"I am not sure which other strategy could I have used."
Do you think you would be able to apply this strategy when meeting people at a social event? Why or why not?	Yes (9)	"Yes because I have time to develop a link with their name"
	No (4)	"No. When meeting people, I often recognised them by the way they speak and I remember their voice."
	Other (3)	"Depends how big the social event is , if hundreds of people then no but if smaller then yes"
Would any changes to the strategy you used during the experiment make it easier to use in real life?	Yes (8)	"Rather than focusing on facial features, I would try to remember some aspect of their personality or a conversation I've had with them."
	No (8)	"No, in real life I repeatedly say the name in my head, or aloud for a moment to try and make sure I remember"
Do you currently use any other techniques to remember names when meeting people? If so, what are they?	No (7)	"Not really. Either I remember the name or I simply ask again."
	Distinct features/conversation (5)	"Have a distinct conversation about something with them – make it easy to associate and can talk about that conversation with them again if needs be"
	Repetition (3)	"Basic mental repetition after speaking to them"
	NR (1)	No response

Note. Uninstructed group participants from all-inclusive analysis included (n = 16)

Mnemonic Groups Responses

Question	Response (# participants)	Example	Response (# participants)	Example	Response (# participants)	Example
	Facial feature (*n* = 20)		**Name-transformation** (*n* = 24)		**Full mnemonic** (*n* = 20)	
Please describe how you applied the strategy during the experiment to remember the names and faces.	Described mnemonic (13)	"Focused on the name emerging from the most prominent facial feature"	Described mnemonic (13)	"Thought of an object relating to their name and pictured them using the object e.g. martin opening a tin can"	Described mnemonic (13)	"I tried to take a part of the name that can be used in a word for object or item and then tried to link it to the most prominent facial feature of the person shown"
	Related to familiar individual (4)	"I recall things that the faces reminded me of, for example faces of celebrities, movie characters, etc."	Distinct features (7)	"If they wore something in particular or had unique features, I would try to relate that to their name, but this wasn't very successful."	Distinct feature (3)	"I will relate the names, hairstyle, skin colour and shirt or accessories wore with the faces shown in the picture."
	Other (3)	"I will try to make a storyline when I saw the person's name and face."	Related to familiar individual (3)	"I associated the face and name with something or someone I already know and who the person on the image reminded me of, using more the face than the name."	Related to familiar individual (2)	"Tried to associate names with people I already knew and see if they had very similar/different facial features"
			Other (1)	"Tried to pair the word to the face in relation to the faces appearance- so a long face or long/big ears was linked to names that had long written above."	Other (2)	"I tried to follow the instructions and think of a word that was similar to the name but I found that very hard to think on the spot like that."
Why did you find the strategy difficult/easy to use?	Helped recall names better (8)	"It instantly helped me recall their names without any second thoughts"	Difficult to transform name (11)	"It was hard to think of objects relating to their names"	Distinctive features (6)	"It was only easy when they had a clear feature, and vice versa when they didn't"
	Similar features – difficult to distinguish (8)	"Difficult as many faces seemed similar to each other (eg complexion, eye colour)"	Easy for distinguishing features, difficult for	"In some cases it was easy and in other cases it was hard, it depended on the word and the face."	Difficult to create name transformations/ imagery (9)	"I found it difficult because I couldn't think of objects that sounded like the name in the time given"

			similar people (6)			
	Other (4)	"It was hard as I have never used a strategy like that, and I slowly changed the strategy to suit myself."	Better association between name and face (4)	"It makes me associate the names with the faces better, hence, I could recognise their faces easily"	Too many pairs/ too similar/ not enough time (5)	"40 is a long list of people/phrases/code-words to remember!"
			Other (3)	"After number of associations all of them become similar and harder to differentiate"		
Did you use the same imagery for the face-name pairs that were shown twice (SECTION 1 and SECTION 2)? Why or why not?	Yes (15)	"Yes. Since it was the same face-name pairs, using the same strategy help better and improve me recalling their names."	Yes (15)	"Yes because it just came straight back into my mind."	Yes (15)	"Yes. It was easier to elaborate on previously constructed linkages. And if there were ones I had on lock down, I could rehearse newer learned ones more."
	No (2)	"No because I noticed more details the second time"	No (7)	"I did not because each face reminded me of someone or something different."	No (3)	"No, I tried a different method because the imagery didn't work out too well for me."
	Other (2)	"For the ones that I remembered in Section 1, I applied the same associations. For the ones I had forgotten, I tried to elaborate more or change my descriptions to memorise better."	Other (2)	"Sometimes. There were some faces I continued using the imagery for but there were also some faces that I felt I was familiar with enough to be able to simply remember (Probably because I had seen them more than once)"	Other (3)	"I did for the ones I had remembered before. For the ones I forgotten I created new ones in the hopes it would help me recall better."
	NR (1)	No response				
Did you apply the strategy in a	No (14)	"No difference. Time was sufficient."	No (19)	"Not really, I just felt more time pressured with the short	No (17)	"I applied on both short and long presentations, but the

different way for the short and the long presentations? If yes, how?				ones to come up with an image"		effect is better on long presentations."
	Yes (6)	"If short presentations, I will only have enough time to remember one imagery. If long presentations, I can memorise two or more characteristics."	Yes (5)	"Yes. For the longer ones, I would link an object/person to the face and repeatedly remind myself of the image."	Yes (2)	"I apply the strategy mostly in the long presentations because I have enough time to relate something with the face and name."
Were there too many or too few face-name pairs?	Too many (16)	"Too many in that names were confused in memory."	Too many (19)	"Too many face-name pairs. Gets quite confusing."	Too many (16)	"Too many for me to remember even with the use of a strategy."
	Acceptable amount (4)	"40 was an acceptable amount of face-name pairs"	Acceptable amount (5)	"I think there was a good amount."	Acceptable amount (4)	"I think it was an adequate amount to test your memory"
Were there any face-name pairs you found particularly difficult to remember? Why?	Older people (8)	"I found it harder to remember older people, especially the men because it was hard to differentiate between them"	Similar/ no distinguishing features (11)	"Some faces were similar to each other which made it harder for me to differentiate"	No distinguishing feature/similar faces (10)	"The faces which did not have any particularly distinctive features."
	Similar faces/ common names (6)	"There were a few of them that looked similar, hence it was harder to remember."	Older people (6)	"Older people were the hardest to remember. Not sure why."	Older people (7)	"I found the elderly faces harder to remember because they all looked quite similar to me."
	Name and face mismatch (3)	"If the name didn't seem to fit the face."	Difficult names to transform (6)	"Names that were difficult to rhyme with or that didn't have a word that was similar."	Other (3)	"No, it's just the matter of time."
	Other (3)	"Did not have enough time to come out of something that will help me better remember their name."	Uncommon names (2)	"Yes, because some of the name is very special and I have never heard of it."		

			Other (1)	"Section 3 face-name pairs were harder as my brain was already getting tired and couldn't remember anything."		
Did you use any other strategy during the experiment? If so, please describe the strategy	Related to familiar person (9)	"Linking the names and faces to people I already know, and finding a similarity in features"	Related to familiar person (11)	"Related the person to someone I know who shares that name."	Relate to familiar person (7)	"Liking the faces and names to people I know."
	Added details to strategy (3)	"Added voices and other details other than just word association"	Focused on a unique name/feature (5)	"I found an item or feature of the face to remember/associate the name to."	Focused on prominent feature (2)	"Repetition of the name whilst looking at the most prominent facial feature"
	No (3)	"No, I didn't."	No (4)	n/A	No (3)	"No other strategy was used."
	Other (5)	"I tried using their clothing to remember their name and it worked at times."	Repetition (2)	"Repeating the names over and over and then trying to put them in order"	Imagined conversation (4)	"I imagine a conversation with them and try to replay it in my head when recalling."
			Other (2)	"Yes, at times some faces reminded myself of my past experiences which are really easy to recall in my long term memory."	Other (4)	"For most I didn't really use a strategy and instead just tried to remember them off the top of my head."
Do you think you would be able to apply the described strategy when meeting people at a social event? Why or why not?	No (9)	"No I find it time-consuming to do so."	No (9)	"No, I would not be able to remember the associated object to the face, together with the name."	No (8)	"Probably not because I wouldn't think about it in that way- I wouldn't be able to think of imagery to use in time"
	Yes (7)	"Yes, because everyone has a unique face so finding a feature that stands out would work well."	Yes (9)	"Yes because you could also use it to apply to their mannerisms or something they said or what they were wearing."	Yes (9)	"Yes, it is efficient and does not take a long time to do."

	Other (2)	"People at social events are animated- it is very likely that other characteristics of theirs would contribute to remembering their name"	Other (5)	"Probably, unless the people look similar or aren't distuinguishable, then I would remember details anout them like what they do, where they are from and what we talked about"	Other (4)	"Possibly, although it may not be socially acceptable to stare at someone's face for that long in real life"
	NR (2)	No response	NR (1)	No response		
Question	**Response**	**Example**	**Response**	**Example**	**Response**	**Example**
	Facial feature		**Name-transformation**		**Full mnemonic**	
Would any changes to the described strategy make it easier to use in real life?	Yes (8)	"Yes, maybe associate each name to a unique story."	Yes (13)	"Short rhymes to accompany the imagery"	Yes (8)	"Cut out the alternate similar word."
	No (7)	"No"	No (8)	"I don't think so. I think this is along the lines of what I tend to do in real life."	No (6)	"Can't think of any."
	Other (4)	"Talking more to an individual"	Other (1)	"I am not sure."	Other (5)	"I don't think it'd work at all in real life."
	NR (1)	No response	NR (2)	No response	NR (2)	No response
Do you currently use any techniques to remember names when meeting people? If so, what are they?	No (12)	"No specific strategy."	No (6)	"No. If I constantly see someone, I'll eventually remember their name."	No (6)	No I generally remember names if I get to talk to the person or see them on a regular basis
	Repetition (3)	"No just repetition in my head"	Focus on prominent features (4)	"Finding prominent features to associate the name to."	Prominent feature (5)	"Try to focus on particular features of them and their hair"
	Same as in experiment (2)	"Sometimes I have used the strategy used in the experiment."	Rhyming (3)	"Make up rhymes"	Relate to familiar individual (2)	"I associate their name with people that I already know and rehearsal."

	Other (2)	“I try to recall their life story or personality if anything.”	Similar to mnemonic (3)	“The same thing, association and imagery of associated things.”	Repetition (2)	“Mostly repeat their name multiple times in my head whilst they’re talking (this strategy will be a lot better)!”
	NR (1)	No response	Learn details about person/ scenario (5)	“Remember details and details that are the same as me, and repetition”	Other (4)	“I try to associate their names with where they are from, however when I meet people I don’t always use techniques, the conversations usually help with remembering names.”
			Relate to familiar individual (2)	“If they remind me of someone else I know then I associate them with that person.”	NR (1)	No response
			NR (1)	No response		

Note. Participants from all-inclusive analysis.

Appendix J

Experiment 2 Open-ended Responses

Question	Response (# of participants)	Example	Response (# of participants)	Example
	Uninstructed (*n* = 45)		**Name-transformation** (*n* = 47)	
Please explain how you remembered the face-name pairs during the experiment.	Distinct features/ appearance (27)	"Tried to find a memorable feature of the person or something that linked to their name"	Described mnemonic (30)	"I paired each name with an object and imagined the person interacting with the object"
	Related to familiar individual (10)	"I tried to resemble them to characters i already know/celebrities."	Distinct features (6)	"looked for a distinct feature then matched with something from my memories"
	Repetition (4)	"I repeated the names in my head as they were shown on the screen."	Rhyming (4)	"I tried to rhyme the name with an object or verb I'm familiar with"
	Other (4)	"I just said the name out-loud and tried to remember the faces."	Association with location (2)	"I tried to associate each name with a location, which I found difficult to do or think of locations for all of them."
			Other (5)	"I tried to associate hair colour and eye colour with people I know."
Uninstructed: Why did you find it easy/difficult to use your strategy?	Too many pairs /not enough time (21)	"There were just far too many to remember at a time."	Name-transformation/imagery difficult (15)	"I found it difficult because I ended up spending more time trying to come up with a word/situation than I did trying to remember the person's face."
Name-transformation: Why did you find the described strategy easy/difficult to use?	Distinctive features easier (8)	"Some people had distinctive features that made them easier to remember"	Too many pairs (10)	"It was easier at first, but 40 names was too much. It's difficult to memorise the names of that many people"

	Mixed up names and faces (3)	“It felt easy initially but it felt like i started to mix up certain faces and names and i lost track of it by the end”	Easier with distinct features (4)	“It was easier to remember some of the people by their defining features.”
	Strategy didn’t work (3)	“I found it easy to use the stragegy. It just didnt seem to work very well.”	Difficult to recall names (4)	“I found I could often remember the setting much easier than the name.”
	Remembered faces not names (2)	“I forgot what their names were I just remembered who they look like not who they are.”	Easier with practice (3)	“It was hard at first but after a bit of practice is got easier”
	Difficult to memorise (2)	“Some people's faces were not easy to memorise at all.”	Easy (2)	“easy”
	Other (6)	“I have bad memory”	Difficult (2)	“Difficult.”
			Used strategy before (2)	“I have used it before to remember things”
			Other (5)	“the described strategy was unhelpfull to me. I used my own way to remember”
Were any of the face-name pairs particularly difficult to remember?	Older adults (13)	“I found it hard to remember the names of the elderly men & women”	Yes (16)	“Yes, some were more difficult than others”
	Most/all (10)	“almost all of them were difficult because there wasn't enough time.”	Similar appearance/ no distinguishing features (9)	“I can't remember which ones i would have got wrong but i would say it was if the picture had no defining features in it, it made is harder to remember.”
	No distinctive features/similar (7)	“A lot of them. Mainly people with no distinctive features.”	Older adults (8)	“A lot of the older people looked quite similar so it was difficult to distinguish between those people.”

	Uncommon names (4)	"Yes - ones where the names were less familiar and I couldn't make a connection with anyone."	Names that are difficult to transform/rhyme (6)	"Ones with names that were more difficult to think of a similar sounding object"
	Yes (4)	"some were, yes"	No (4)	"none in particular"
	No (3)	"None spring to mind"	Other (4)	"The people that pulled surprised facial expressions in their photo's made it hard to focus on their name."
	Mismatched gender (2)	"Men with womens names"	NR (1)	No response
	Other (2)	"Hard to say if I don't remember them. The task was difficult in general."		
	Response (# of participants)	**Example**	**Response (# of participants)**	**Example**
	Uninstructed		**Name-transformation**	
Would any changes to the strategy make it easier to use in real life?	No (13)	"not that i can think of"	Rhyming/other name transformations (12)	"We don't always need to associate a name to an object, it could be a colour, a verb or something else."
	More time/fewer people (9)	"Maybe having more time in real life with the person would make it easier"	No (8)	"No changes"
	Include personal details (7)	"Adapt it to match things about their mannerisms/way they speak/characteristics."	Fewer people/more time (6)	"Less people than the amount of pairs so far."
	Repetition (3)	"I'd repeat the association over and over again until it sticks."	Include person details (5)	"I think it would be easier in real life as you can see the whole person and also their personality and body language"

	Not repeat names (3)	“Wouldn't repeat the name in my head, it wouldn't be possible while talking to someone at an event.”	Unsure (3)	“Not sure”
	Name tags (3)	“Make them wear name badges to begin with!”	Other (10)	“In real life there are factors of nerves when meeting new people that can result in forgetting names.”
	Other (5)	“Possibly, depends on the situation though.”	NR (3)	No response
How do you remember names when meeting people?	No method (17)	“i just try to remember it. no real strategy”	Repetition (16)	“By repeating the person's name throughout conversation.”
	Repetition (12)	“I try repeating them over and over in my head or make any connections if there are any”	No strategy (12)	“i don't have a specific method”
	Person/situation details (6)	“Often by getting to know what they do in life, getting a bit of a backstory about them.”	Appearance/ distinct features (6)	“based on appearance”
	Distinct features (4)	“I notice any distinguishing features and accents and then try to remember them that way.”	Relate to familiar individual (4)	“I usually try to think of someone else with that name, either a celebrity or someone I know.”
	Relate to familiar individual (2)	“If the name is the same as someone I already know or have known, I'll think of that person and try to connect the name that way.”	Occupation/context details (3)	“Try and ask them an opening question such as where do you work and then tie it to that to remember their names”
	Other (4)	“I usually hear their name spoken out loud by other people.”	Other (6)	“I usually try to make a nickname up for them (in my head!).”

6 The effect of age and strategy instruction on memory for face-name pairs

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Abstract

Remembering names is an important aspect of everyday life, but failure to remember them can result in frustration and negative self-evaluation of memory abilities. This can be particularly detrimental for older adults who face negative stereotypes about memory and aging. The face-name mnemonic strategy proposes to enhance encoding of face-name pairs using three components: a name-transformation, a prominent facial feature, and interactive imagery. Name recall involves mentally retracing these steps. With young adults, use of a simplified version of the face-name mnemonic, the name-transformation strategy, resulted in better name recall than an uninstructed condition. In the present study, we examined the influence of strategy instruction (mnemonic or uninstructed) and age (40-80) on name recall. Contrary to our expectations, age and strategy instruction did not significantly contribute to name recall scores. Responses to a strategy use questionnaire indicated that middle-aged and older adults are already using strategies to improve memory in everyday life.

6.1 Introduction

Remembering person names is a challenging task for adults across all ages and we are often able to recall other personal information such as occupations more easily than names (Cavanaugh et al., 1983; Cohen & Faulkner, 1986; Reese & Cherry, 2004). Numerous studies have demonstrated the difficulty of retrieving familiar names in daily life and recently learned names in experimental tasks (Burke et al., 1991; Cavanaugh et al., 1983; Crook & West, 1990; Parikh et al., 2016). Moreover, recalling a name without recalling other biographical information is relatively rare, indicating that names are particularly difficult to retrieve (Cohen, 1990; McWeeny et al., 1987; Old & Naveh-Benjamin, 2012). Name recall failures can be annoying, frustrating, or embarrassing, and may negatively impact interpersonal relations (Brédart, 2017; Brédart & Vanootighem, 2022; Hargis et al., 2020; Lovelace & Twohig, 1990). Retrieval failures can also influence negative self-evaluations of general memory ability, particularly for individuals who are concerned about their memory (Cavanaugh et al., 1983; Hargis et al., 2020; Parikh et al., 2016). It has been suggested that forgetting instances and name recall difficulty increase with age and is a common subjective memory complaint among older adults (Bolla et al., 1991; Burmester et al., 2015; Cargin et al., 2008; Condret-Santi et al., 2013; Hertzog et al., 2019; James, 2006).

6.1.1 Name Recall and Aging

Previous research has shown little differences between young and middle-aged adults and little to no decline in name recall during the middle-aged years for recently learned names (Cohen & Faulkner, 1986; Crook & West, 1990). In contrast, Yesavage and Rose (1984) found that young adults significantly outperformed middle-aged adults on a recall test before and after using a mnemonic strategy to improve recall. Some research has also demonstrated better name recall of recently learned for middle-aged adults compared to older adults (Cohen & Faulkner, 1986; Tse et al., 2010). However, past literature on aging and name recall has

generally focused on comparisons of young and older adults (Brédart & Vanootighem, 2022; Kljajevic & Erramuzpe, 2018). Further research would be beneficial for clarifying these discrepancies.

Like younger adults, older adults are aware of the difficulty of remembering names (Hargis et al., 2020; Maylor, 1990; Reese & Cherry, 2004). Additionally, past research has shown that older adults have more difficulty retrieving recently learned names than younger adults (Almond & Morrison, 2017; Cohen & Faulkner, 1986; Enriquez-Geppert et al., 2021; Fogler et al., 2010; Hargis & Castel, 2017; Troyer et al., 2006). However, like younger adults, older adults' recall of occupations is better than that of names (Bruyer et al., 1992; Cohen & Faulkner, 1986; Hargis & Castel, 2017; James, 2004). Moreover, the *Baker-baker* paradox holds for older adults as well, where recall is better for occupations than names when the same word is used for both (Bruyer et al., 1992; McWeeny et al., 1987; Rendell et al., 2005). Some studies have found greater age-related impairment in name recall compared to occupation or common nouns, suggesting that name recall is disproportionately affected by aging (James, 2004, 2006; Old & Naveh-Benjamin, 2012). In contrast, others have shown that name recall is worse than recall of other information across adults of all ages, suggesting that a general age-related memory decline rather than a disproportionate impairment in name recall (Burke et al., 2000; Cohen & Faulkner, 1986; Rendell et al., 2005).

Several theoretical models have proposed that indirect connections between names and faces, the arbitrary or meaningless nature of proper names, and limited connections between names and semantic information are factors in name recall difficulty (Bruce & Young, 1986; Cohen, 1990; Cohen & Burke, 1993; Semenza, 2009). Aging and name recall is often examined under the Node Structure Theory (NST), which proposes that word learning and recall involves a semantic system representing the meaning of words in propositional nodes and a

phonological system representing the sounds of words in syllable and phonological nodes (Burke et al., 1991, 2000; Cohen & Burke, 1993; James & Fogler, 2007). The two systems are connected through the lexical nodes that represent the words, and connections between nodes allow for priming and consequently activation and availability of node contents (Burke et al., 1991, 2000; James & Fogler, 2007). The NST supports the transmission deficit hypothesis, where weak inter-node connections from aging may result in a transmission deficit between nodes or systems and consequently, more difficulty learning (Burke et al., 1991, 2000; James & Fogler, 2007). Evidence supporting this comes from studies where older adults have more difficulty learning new names compared to younger adults and are able to produce fewer phonological attributes of the name (Cohen & Faulkner, 1986; Fogler et al., 2010; Fraas et al., 2002; James, 2004; Ouyang et al., 2020). Furthermore, person names have fewer connections between the semantic system nodes than common nouns, resulting in less priming (Burke et al., 2000; James & Fogler, 2007). Consistent with this proposal, previous research has demonstrated better recall of common nouns and occupations compared to proper names (Cohen & Faulkner, 1986; Evrard, 2002; Festini et al., 2013; Montemurro et al., 2019; Rastle & Burke, 1996).

6.1.2 Improving Name Recall

Improving name recall is often an aspect of memory rehabilitation or training programmes for older adults to address this common concern (Fairchild & Scogin, 2010; Gross et al., 2012; Thana-Udom et al., 2021; Woolverton et al., 2001). Strategies for improving name recall include using internal memory aids such as mnemonics or external memory aids such as the internet or asking others (Brédart, 2019; Cavanaugh et al., 1983; Glisky & Glisky, 2008). Although external memory aids are often preferred, these may be difficult to access and use in social situations, whereas internal strategies to improve encoding and later recall can be used at any time (Bolla et al., 1991; Cavanaugh et al., 1983; Hertzog et al., 2019; Reese & Cherry,

2004). Furthermore, previous research has demonstrated the benefits of mnemonic training for adults of all ages (Glisky & Glisky, 2008; Verhaeghen et al., 1992).

The face-name mnemonic technique has been proposed as a method of improving name recall through imagery and involves three steps: a name-transformation, selection of a prominent facial feature, and linking the name-transformation to the prominent facial feature (Lorayne & Lucas, 1974; McCarty, 1980; Morris et al., 1978). Past research has shown an advantage for the face-name mnemonic technique for young, middle-aged, and older adults compared to when no imagery instruction is provided (Li et al., 2016; McCarty, 1980; Morris et al., 1978; Neuschatz et al., 2005; Patton, 1994; Pike et al., 2018; Troyer et al., 2006; Yesavage et al., 1983; Yesavage & Rose, 1984). Yesavage and Rose (1984) examined age differences in the use of the face-name mnemonic with young, middle-aged and older adults. Although the young and middle-aged groups significantly outperformed the older adults, all groups showed significant improvement from pre-test to post-test. Moreover, as there were no significant differences between the groups on recall improvement from pre- to post-test, the authors suggested that the face-name mnemonic increased name recall performance for all three groups to a similar degree (Yesavage & Rose, 1984).

It has been proposed that name recall can be improved for older adults if they are aware that they will later be tested on their memory, semantic information is attached to the name, and mnemonic information is self-generated rather than provided by experimenters (Fogler et al., 2010; Old & Naveh-Benjamin, 2012; Pike et al., 2018; Troyer et al., 2006). Additionally, previous research has demonstrated that the generation effect, whereby memory is better when self-generated information is used to aid recall rather than experimenter-provided information holds for older adults as well as younger adults (McCurdy et al., 2020; Slamecka & Graf, 1978). In a previous study (Chapter 5; Gopi, Wilding, et al., 2022), we found that a

simplified version of the face-name mnemonic technique, the name-transformation mnemonic technique, resulted in better name recall compared to an uninstructed approach in which participants were asked to remember the face-name pairs to the best of their ability. The name-transformation technique involves transformation of the name into an imageable object and imagining the individual interacting with the object. Based on these results and previous research suggesting that the face-name mnemonic may be too complex to use, we expected that the name-transformation strategy may be beneficial for middle-aged and older adults (Patton, 1994).

6.1.3 Online Aging Research

As this study was conducted online, it is worth noting some aspects of cognitive aging research that may differ between online and in-person studies. Although much of the past research examining name recall with aging populations has been conducted in-person, the use of online sampling has been increasing, and even more so due to the Covid-19 pandemic (Chandler & Shapiro, 2016; Greene & Naveh-Benjamin, 2022; Ogletree & Katz, 2021). Thus, it is important to consider the potential limitations and benefits to conducting online cognitive aging research (Chandler & Shapiro, 2016; de Bernardo & Curtis, 2013).

Older adults who participate in online studies may have more education, higher income, and be younger than those who do not participate or those who would participate in person (de Bernardo & Curtis, 2013; Greene & Naveh-Benjamin, 2022; Nahm et al., 2011; Ogletree & Katz, 2021). The results based on such a sample may not represent the population and therefore should be interpreted with caution (Chandler & Shapiro, 2016; Ogletree & Katz, 2021). Although previous research has shown that data quality can remain the same or be improved with online sampling for younger adults, it is unclear whether this will be the same for middle-aged and older adults (Casler et al., 2013; Greene & Naveh-Benjamin, 2022).

Finally, while participants can ask questions to clarify the task in person, online asynchronous studies do not readily allow for such opportunities (Gopi, Zhang, et al., 2022; Greene & Naveh-Benjamin, 2022). As such, it is important to include repeated instructions and manipulation checks to ensure comprehension of the instructions (Casler et al., 2013; Greene & Naveh-Benjamin, 2022).

There are also substantial benefits to conducting research online. Online studies may allow individuals to participate from a comfortable location, reduce cost expenses of travelling, and can allow participants to engage at a time that is convenient for them (Casler et al., 2013; Clifford & Jerit, 2014; Gopi, Zhang, et al., 2022; Greene & Naveh-Benjamin, 2022; Nahm et al., 2011). This can provide access to a wider range of older adults who might not have otherwise been able to attend in-person laboratory experiments. Furthermore, online platforms such as Prolific allow the filtering of participants based on previously answered questions, reducing the need to perform a separate screening to ensure inclusion criteria are met (Casler et al., 2013). Given recent advances in technology literacy and comfort, researchers have suggested that it is feasible to conduct online studies with older adult populations (de Bernardo & Curtis, 2013; Greene & Naveh-Benjamin, 2022).

6.2 Present Study

This study examined the influence of aging and mnemonic instruction on name recall. Middle-aged and older adults completed an experiment on their computer and either received mnemonic instructions or were instructed to remember the face-name pairs to the best of their ability. The study was also designed to address limitations of past research including stimuli sets with limited ecological validity, experimenter-generated mnemonics, and limited understanding of mnemonic strategy use during the task (McCarty, 1980; Morris et al., 1978, 2005; Patton, 1994). Like our previous study, we included stimuli that would reflect reality

where the face-name pairs resemble individuals the participants might encounter in real life, encouraged participants to generate their own mnemonic imagery throughout the task, and included questionnaires to examine strategy use during the task and potential use in real life (Gopi, Wilding, et al., 2022a). Moreover, we only included compliant participants in the analyses as this allows for comparison of actual strategy use with control conditions rather than conducting analyses that are contaminated with noncompliant participant data as well (Legge et al., 2012). In our previous study, we found that once noncompliant participants were excluded, we were able to observe the actual effects of the mnemonic strategy (Gopi, Wilding, et al., 2022a). Therefore, we examined the results of those who complied with strategy instructions.

There were two research aims: (1) to examine the influence of age on name recall. It was hypothesised that mean recall will decline as age increases. (2) To examine the influence of strategy instruction on name recall. It was hypothesised that mean recall will be higher for the name transformation group compared with the uninstructed group. The design and hypotheses were preregistered; see https://osf.io/wgph6.

6.3 Method

6.3.1 Participants

A target sample of 141 compliant participants was established based on an *a priori* power calculation using G*Power 3.1.9.7 (Faul et al., 2007) for a multiple regression model with three predictors (age, strategy instruction, and interaction) assuming a small effect size based on previous research ($f^2 = 0.06$), $\alpha = 0.05$, $1 - \beta = 0.80$, and accounting for 76% compliance based on previous compliance analysis.

The inclusion criteria were fluent English speakers in the UK aged 40 to 80 years with no cognitive impairment or dementia. Participants were filtered by Prolific using the following questions: (1) Which of the following languages are you fluent in? (2) In what country do you currently reside? (3) What is your date of birth? (4) Have you ever been diagnosed with mild cognitive impairment or dementia?

A total of 254 participants (144 females; *M* age = 60.49, *SD* = 11.19) completed the study online via Prolific and renumerated at a rate of £5 per hour. This study was approved by the School of Psychology Research Ethics committee.

6.3.2 Materials

Photographs of men and women aged 18 to 93 of various ethnic groups with neutral expressions were selected from the Park Aging Mind Laboratory face database (Minear & Park, 2004). Names were selected from the Office for National Statistics top 100 baby names in England and Wales by decade from the 1930s to 1990s (*Top 100 Baby Names in England and Wales: Historical Data - Office for National Statistics*, n.d.). Names from the middle range of the list were selected. A single version of names that have similar spellings, sounds, or nicknames was chosen and the duplicate name was replaced (Appendix A). Each face was paired with one name of the same age range and gender. In total, there were three face-name pairs for practice and 60 pairs for the experiment task.

6.3.3 Design

This design had two factors, a nominal factor (Strategy Group) and a continuous factor (Age) with name recall as the dependent variable. There were two strategy groups: the uninstructed group was instructed to remember as many face-name pairs as possible, and the name-

transformation group was instructed to transform the name into an imageable object and imagine the person in the image interacting with the transformation.

6.3.4 Procedure

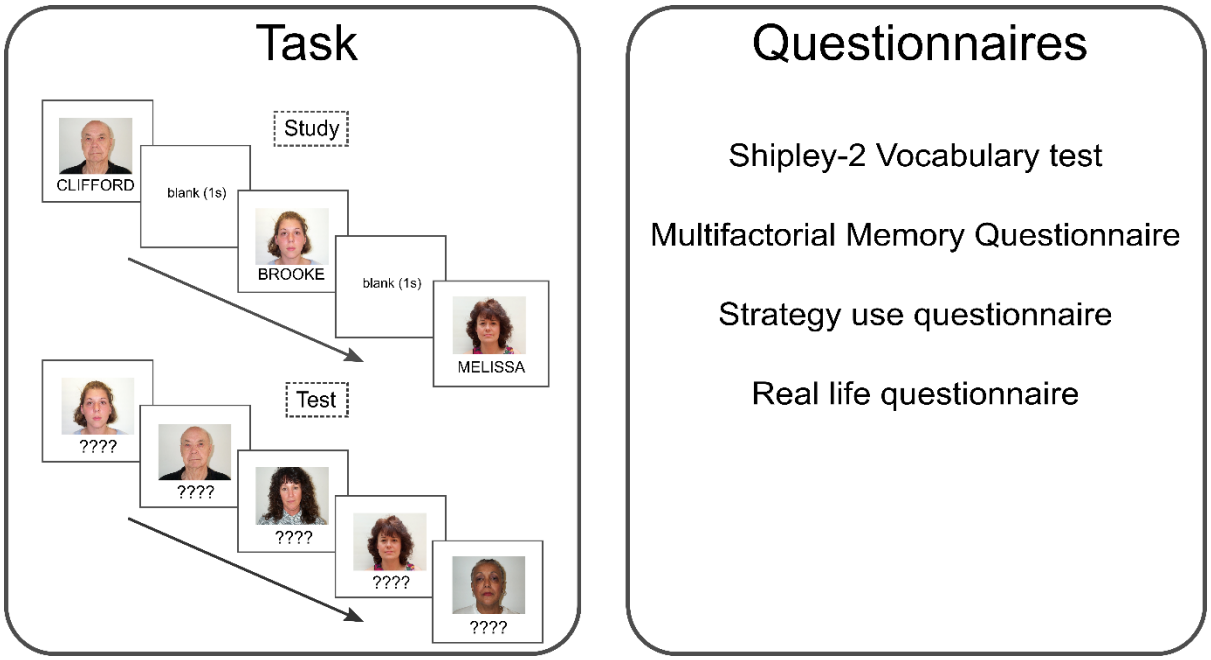
The consent, questionnaires and debrief procedures were conducted through Qualtrics and the experiment through Pavlovia. Participants were randomly allocated to the uninstructed or the name-transformation groups through Qualtrics before the experiment and had three attempts to answer comprehension check questions and then continued to the task (Appendix B). All participants were prompted with a scenario of attending a community event at a local venue and were informed that they would need to remember the names of the individuals in the photos (Neuschatz et al., 2005). At the beginning of each block, participants received instructions specific to their strategy group. Along with the instructions, the name-transformation group received a visual example of how to perform the task.

Figure 1 shows the outline of the task. Participants practiced the task with three face-name pairs. There were two blocks each with 30 different face-name pairs that were randomly selected. All face-name pairs were presented for 12 seconds with a 1 second inter-stimulus interval. This timing was selected to maintain a similar design with Experiment 2 of the young adults' study (**Chapter 5**), allowing for examination of whether 12 seconds would be sufficient for all adults across all ages to engage with the strategy. Additionally, there were practical considerations, such as maintaining a short length of the total experiment duration for middle-aged and older adults who might have experienced discomfort or fatigue if engaging with a lengthy task. After all face-name pairs were presented in each block, each face was presented in a random order and participants had unlimited time to type in the corresponding name. All stimuli were presented using lab.js (Version 20.2.3) (Henninger et al., 2021).

Following block 2, participants completed the Shipley-2 vocabulary test and the Multifactorial Memory Questionnaire (MMQ) with questions about feelings about their memory, memory mistakes, and the use of memory strategies in daily life (Shipley, 1940; Troyer & Rich, 2002). The Shipley-2 vocabulary test was included as a measure of cognitive ability to examine whether this factor differed across strategy groups (Table 1). Finally, participants completed questionnaires about strategy use during the task and the likelihood of using the strategy in real life. The uninstructed group received a modified version of the strategy use and real-life application questionnaires (Appendix B).

Figure 1

Experiment task outline. Each block contained a study and test phase with 30 different face-name pairs displayed for 12 seconds.



6.3.5 Data Analysis

6.3.5.1 Name Recall Alternatives

The same criteria from our previous study were used for accepting and rejecting responses (Gopi, Wilding, et al., 2022a). As before, names were accepted where the pronunciation remained the same with typing errors if a letter was added (e.g., Aimee – Aimmee), there was a substitution of similar-sound letters (e.g., Holly – Hollie), the order of one of the letters was mixed (e.g., Damien – Damein), one letter was missing (e.g., Danny – Dany), or the letter on the keyboard is adjacent to the correct letter (e.g., Andrea – Amdrea). Responses were incorrect if they were nicknames (e.g., Clifford – Cliff) or if letters were added that change the name to a different one (e.g., Julia – Juliet).

6.3.5.2 Analysis

Data were analysed with JASP (Version 0.16.4) (JASP Team, 2021). A multiple regression model was fitted with Strategy Group, Age, and an interaction as coefficients with total name recall as the dependent variable. Participants were excluded based on the following criteria: (1) more than one attempt at the task (2) three failed comprehension check questions (3) not paying attention as indicated by selecting 'No I did not pay attention during this study' or on questionnaire responses, (4) two or more failed attention check questions among MMQ responses, (5) recall below 10% of the total number of items to be recalled, (6) total recall score 2.5 or more deviations from the median absolute deviation, or (7) non-compliance with strategy instructions. Participants in the mnemonic group who indicated in the questionnaires that they used a different strategy than the one described, had insufficient explanation of strategy use to the extent that it is unclear as to whether they completed the strategy, or had insufficient strategy use throughout the experiment indicating lack of engagement with the strategy were considered noncompliant. After exclusions (110 excluded), a total of 144

participants remained (83 females; *M* age = 58.75, *SD* = 11.52). Demographic data for compliant participants are shown in Table 1.

Table 1

Demographic data for compliant middle-aged and older adults across strategy groups.

	Middle-aged		**Older**	
	Uninstructed (*n* = 38)	Name-transformation (*n* = 34)	Uninstructed (*n* = 43)	Name-transformation (*n* = 29)
Age *M* (*SD*)	49.11 (6.68)	48.82 (5.51)	68.93 (6.51)	67.93 (5.25)
Shipley-2 *M* (*SD*)	34.63 (3.19)	34.97 (3.90)	35.86 (2.83)	37.07 (2.00)
Education level frequency				
No formal qualifications	1 (3%)	0	0	0
Secondary education (GED/GCSE)	4 (11%)	2 (6%)	10 (23%)	5 (17%)
High school diploma/A-levels	1 (3%)	3 (9%)	4 (9%)	4 (14%)
Technical/community college	3 (8%)	6 (18%)	8 (19%)	1 (3%)
Undergraduate degree (BA/BSc/other)	13 (34%)	10 (29%)	16 (37%)	13 (45%)
Graduate degree (MA/MSc/MPhil/other)	15 (39%)	11 (32%)	5 (12%)	4 (14%)
Doctorate degree (PhD/other)	1 (3%)	2 (6%)	0	2 (7%)

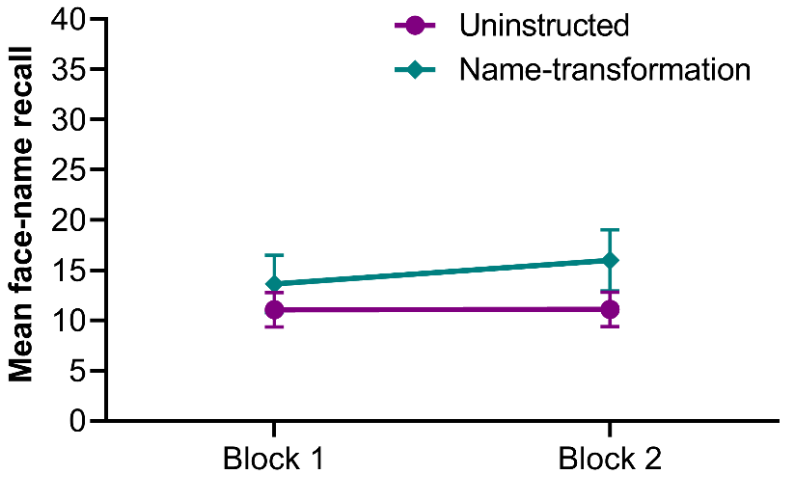
6.4 Results

Fitted regression model: name recall = 27.13 – 7.15 (Strategy Group) – 0.02 (Age) + 0.13 (Strategy Group x Age). The overall regression was not statistically significant ($R^2 = 0.01$, $F(3, 140) = 0.25$, $p = .861$). Strategy Group ($\beta = 7.15$, $p = .454$) and Age ($\beta = 0.02$, $p = .815$) did not significantly predict name recall. The interaction between Strategy Group and Age was not statistically significant ($\beta = 0.13$, $p = .430$). See exploratory analyses in Appendix C.

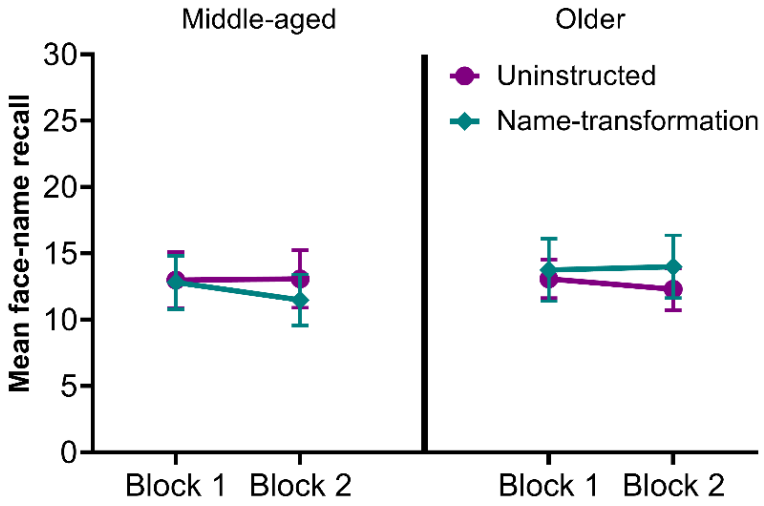
Figure 2

Face-name recall for each strategy group as a function of block when participants were compliant with strategy instructions for (a) Experiment 2 of our previous study with young adults (Gopi, Wilding, et al., 2022a) and (b) The experiment in this study with middle-aged and older adults. Error bars represent 95% confidence intervals.

a. Young adults



b. Middle-aged and older adults



6.4.1 Questionnaires

Across all retained participants (*N* = 144), MMQ, strategy use, and real-life questionnaires were examined for each strategy group.

6.4.1.1 MMQ

The scores of each MMQ scale were scored and interpreted separately. There were no significant differences between the uninstructed and mnemonic groups on total satisfaction with memory, self-reported memory ability, or memory strategy use. The full results are reported in Appendix D.

6.4.1.2 Strategy use questionnaire

Figure 3a shows the frequency of responses for five of the strategy use questions for middle-aged adults. Strategy questions for the uninstructed group referred to use of their own strategy during the task while questions for the imagery groups referred to use of the described strategy. See Appendix B for questions. See Appendix E for open-ended responses.

Many participants in both groups indicated that they used a strategy, had enough time to apply the strategy during the study period, and that enjoyed using their respective strategy. Many participants in both groups agreed that they could apply the strategy and would use their strategy when meeting people. Open-ended responses indicated that participants in the uninstructed group linked the person in the photo to known individuals or focused on distinct features (e.g., “Tried to equate them with someone else I remember or another name I remember.”). Uninstructed participants found most face-name pairs or older adults to be particularly difficult to recall (e.g., “a lot of the older ones were really hard”) whereas mnemonic participants found most pairs or names that are difficult to transform particularly difficult to recall (e.g., “Those where it wasn't obvious what object you could use, those

where the most difficult."). Current strategies used to recall names in real life for the uninstructed participants included repetition and focusing on person/situation details (e.g., "Usually by associating where I met them or something else other than what they look it, eg Pet shop Shirley, she works in the Pet Shop") whereas mnemonic participants indicated that they use repetition or do not remember the names (e.g., "I don't. I am terrible with names, but great with faces.").

Figure 3b shows the frequency of responses of the strategy groups for five of the strategy use questions for older adults. Many participants in both groups indicated that they used a memory strategy had enough time to apply the strategy during the study period and that they enjoyed using their respective strategy. Many participants in both groups agreed than disagreed that they could apply the strategy when meeting people and that they would use their respective strategy when meeting people. Open-ended responses indicated that uninstructed participants used distinct features/appearance or related the individual in the photo to known individuals (e.g., "I tried to remember something unusual about them ie ring in eyebrow, moustache."). Participants across both groups indicated that most of the face-name pairs were difficult to remember as well as those who had no distinguishing features (e.g., "people with no one memorable feature"). Current strategies to remember names when meeting people include repetition, focusing on person/situation details, and focusing on distinct features for both groups (e.g., "After speaking to them I remember where they live or what they do.").

6.4.1.3 Real-life questionnaire

Figure 4a shows the frequency of responses across three of the ease-of-use questions for middle-aged adults. Many participants in both groups found the strategy difficult to use across blocks. Uninstructed participants indicated that their strategy would be easy to use when

meeting people whereas mnemonic group participants were equally likely to indicate that the strategy would be easy or difficult to use when meeting people. Based on the open-ended responses, uninstructed participants found it difficult to use their strategy as there were too many face-name pairs or not enough time (e.g., “The more faces I saw the harder it became, my brain became a bit overwhelmed with faces and names, I struggle with names but remember faces well.”) whereas mnemonic participants found it difficult to apply the strategy or transform the names (see example above). Additionally, uninstructed participants do not believe changes to their strategy would make it easier to use in real life or they were unsure. Mnemonic participants did not believe any changes would make the strategy easier to use in real life or that additional person details could improve strategy use (e.g., “maybe connecting their names to something more personal to yourself”).

Figure 4b shows the frequency of responses to three of the ease-of-use questions for older adults. Many participants in both groups found the strategy difficult to use across the blocks. Across both groups, participants were equally likely to indicate that their respective strategy would be easy or difficult to use when meeting people. Uninstructed participants found it difficult to use the strategy during the task as there were too many face-name pairs, or they couldn’t remember or got confused (e.g., “Just couldnt remember”) whereas mnemonic participants found it difficult to apply the strategy or transform the name (e.g., “Trying to find object/words to associate the names was difficult.”). Participants in both groups suggested not to change or including personal details to improve their strategy when meeting people in real life (e.g., “In real life, I'd have other cues such as mannerisms which would make it easier”).

Figure 3

Frequency of responses for five of the strategy use questions rated from *Strongly Agree – Strongly Disagree* for (a) middle-aged adults and (b) older adults). Name = Name-transformation. Questions have been abbreviated in the figure. See the full questions in Appendix B.

a. Middle-aged adults

b. Older adults

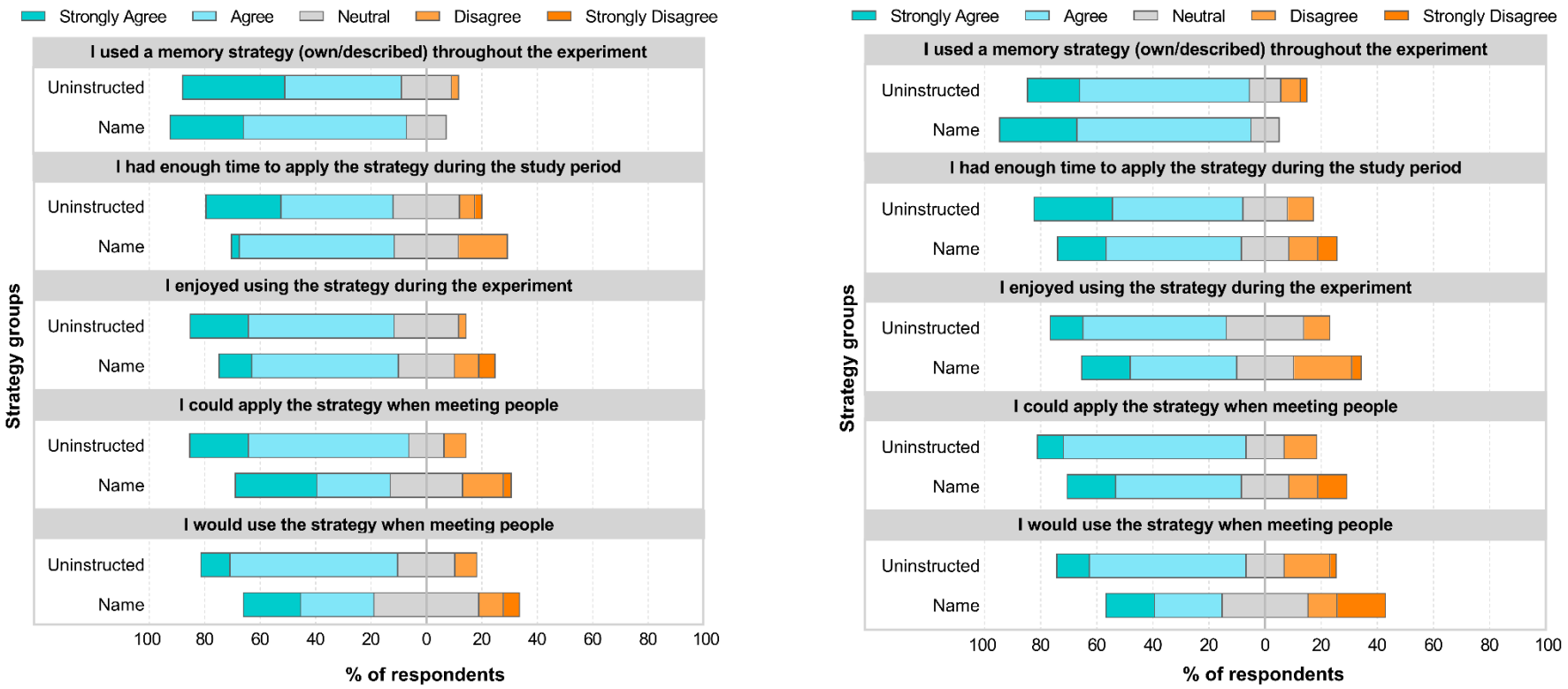
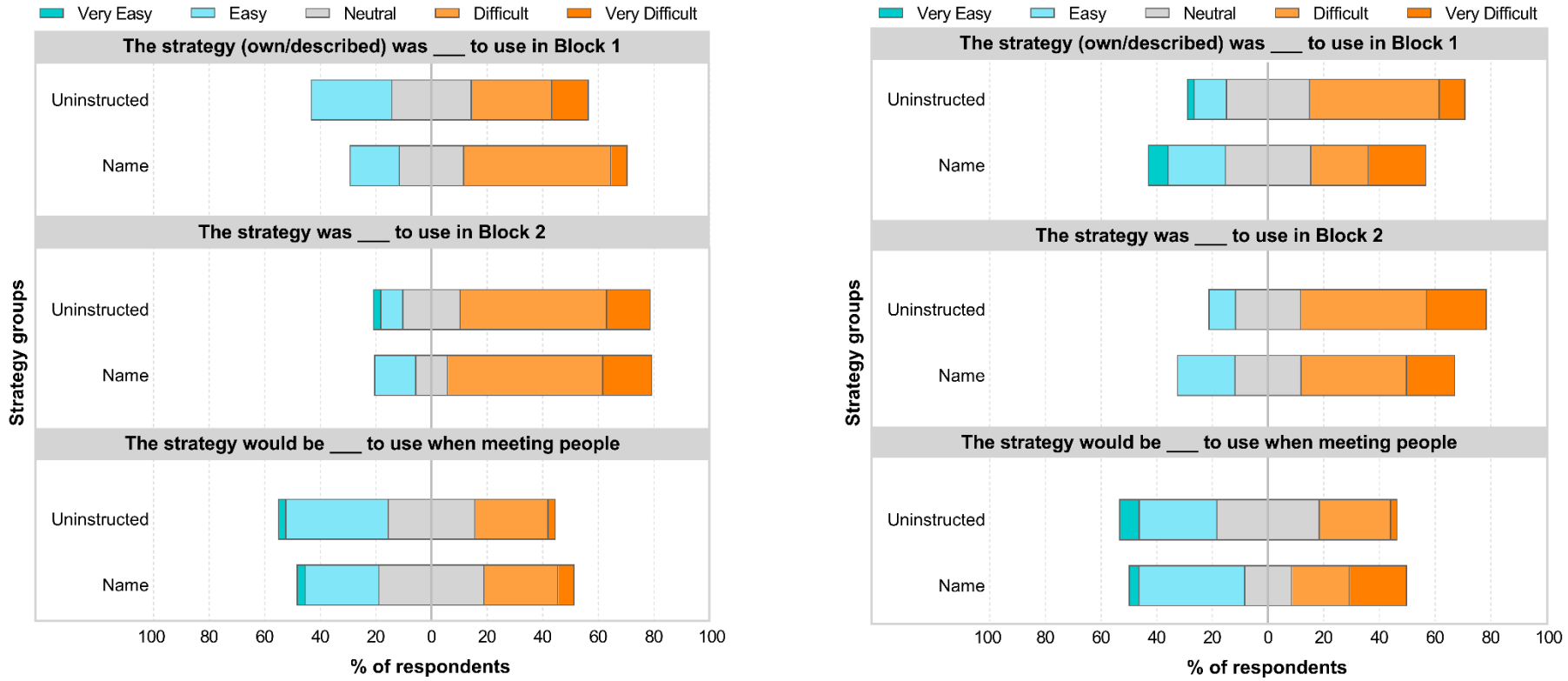


Figure 4

Frequency of responses for three of the ease-of-use questions rated from *Very Easy* – *Very Difficult* for (a) middle-aged adults and (b) older adults. Name = Name-transformation. Questions have been abbreviated in the figure. See the full questions in Appendix B.

a. Middle-aged adults

b. Older adults



6.5 Discussion

This study examined the influence of aging and strategy use on name recall. The aging hypothesis was not supported as mean recall did not decline with increasing age. In fact, young adults from our previous study, middle-aged, and older adults had similar levels of average name recall across the two blocks (Fig. 2). This is contrary to past research showing worse name recall for older adults compared to young and middle-aged adults (Cohen & Faulkner, 1986; Crook & West, 1990; Yesavage & Rose, 1984).

Several reasons are possible for this outcome. As the previous studies were conducted in laboratory settings, stereotype threat regarding memory and experimenter presence may have contributed to the difference in recall (Ryan & Campbell, 2021). In contrast, this study was conducted asynchronously online and thus stereotype threat may have been reduced for older adults. It is also possible that older adults were motivated to perform well on the task, as it was advertised as a memory study. Research has shown that the motivation of older adults to participate in cognitive studies may be related to trying to reduce stereotype threat, understand their cognitive health, or improve their abilities (Carr et al., 2022; A. D. Ryan & Campbell, 2021). Thus, perhaps stereotype threat and motivation are important factors that should be considered in future online studies of cognitive aging.

The mnemonic strategy hypothesis was not supported as mean recall was not higher for the name transformation group compared to the uninstructed group (Fig. 2b). This is contrary to the outcome of previous research demonstrating a benefit of mnemonic strategies for middle-aged and older adults (Yesavage et al., 1983; Yesavage & Rose, 1984). Furthermore, this is contrary to our previous research demonstrating a benefit of the name-transformation mnemonic strategy over an uninstructed approach for younger adults (Fig. 2a; Gopi, Wilding,

et al., 2022). Open-ended responses revealed that middle-aged and older adults already use strategies in their daily life and used these during the task. Uninstructed participants mentioned the use of a variety of strategies including first letter and visual imagery mnemonics (e.g., “I tried to link something to their name though sometimes I could only remember the first letter. So I might focus on the eyes and say 'mad max' etc or try to imagine them in a situation”). Similarly, a recent study of the face-name mnemonic technique with older adults found that control participants were found to be using a technique similar to that in the experimental condition (Klaming et al., 2022).

This study had a compliance rate of 57%, where participants in the mnemonic group were excluded for noncompliance with the strategy instruction, often due to using a different strategy than described. Given that middle-aged and older adults are likely already using memory strategies in their daily life, their motivation to learn and adopt a new strategy may have been lower than that of the young adults in our previous study (Cavanaugh et al., 1983; Pike et al., 2018; Troyer, 2001). In a similar capacity, the use of external memory aids is more prevalent than the use of internal memory aids among older adults, and some participants mentioned writing down names to help them remember in daily life and during the task (Hertzog et al., 2019). Although the participants who mentioned writing down names were removed, we did not ask about the use of external aids during the task, and it is possible that more participants used this method during the task.

Past research has shown that while the use of external memory aids increases with age and are generally preferred, the use of internal memory aids decreases with age (Bouazzaoui et al., 2010; Cavanaugh et al., 1983; Dixon & Hultsch, 1983; Hertzog et al., 2019; Reese & Cherry, 2004). Furthermore, a recent study found that when older adults were asked to remember face-name pairs in a naturalistic setting, they often took notes (Pike et al., 2022) This is

potentially due to the amount of effort required to learn and apply internal strategies. Perhaps middle-aged and older adults did not see enough of a real world benefit to expend the effort to learn and use the mnemonic strategy (Ryan & Campbell, 2021). Thus, participants may have either lacked the motivation to learn and use a new strategy, or they engaged minimally with the mnemonic strategy as they are more often using external memory aids in daily life.

The results of the MMQ did not show significant differences between the uninstructed and mnemonic groups for all participants. The results of the strategy use questionnaires revealed that middle-aged and older adults in both strategy groups agreed that they used a strategy during the task (Fig. 3). Participants in the uninstructed group used strategies such as relating the person in the photo to known individuals or focusing on distinct features or appearance, which is in line with previous research (Saczynski et al., 2007). There was also enough time to apply their strategy and participants enjoyed using their respective strategy, although there was some disagreement from the mnemonic group, suggesting that perhaps more time is required to meaningfully engage with the strategy for these age groups. Finally, although participants generally agreed that they could and would apply their respective strategy when meeting people, several participants in the mnemonic group disagreed (Fig. 3). This is perhaps due to the difficulty of use of the strategy (Fig. 4).

Open-ended responses revealed that in-person meetings would likely have more factors than just a name and face presented that can either be used to improve the mnemonic application or may be too distracting to apply the mnemonic (Appendix E). This reflects the results of previous research that has demonstrated little efficacy of face-name mnemonics in real life (Morris et al., 2005; Patton, 1994). Moreover, it has been suggested that the face-name mnemonic technique may be too difficult to complete when meeting people in person with limited time and ongoing interactions (Patton, 1994; Yesavage et al., 1983). In this study, the

two strategy groups had similar experiences during the task, but perhaps the mnemonic strategy is less likely to be used in real life by middle-aged and older adults due to the difficulty in learning and applying the strategy.

Recent research has found that the face-name mnemonic may be too complex for older adults, which may also be the case with the name-transformation technique (Klaming et al., 2022; Thana-Udom et al., 2021). Furthermore, older adults find internal strategies to be less effective than younger adults (Lineweaver et al., 2021). This is perhaps due to the effort required with limited time to learn and apply the strategy and may explain the lower compliance rates compared to our previous study with young adults (Gopi, Wilding, et al., 2022a). In contrast, some strategies that require less effort to encode and retrieve the information such as expanding rehearsal have shown positive outcomes for face-name recall (Landauer & Bjork, 1977; Morris et al., 2005; Neuschatz et al., 2005; Pike et al., 2018). Additionally, Neuschatz et al. (2005) found that combining the face-name mnemonic and expanding rehearsal was advantageous over spaced retrieval alone for young adults. Thus, perhaps future studies should examine the age at which it would be best to train the use of mnemonics or the combination of mnemonics and rehearsal for middle-aged and older adults (Brédart, 2019).

6.5.1 Limitations and Future Directions

Several limitations of this study are worth noting. Although we intended to use stimuli that would reflect reality as much as possible, the use of photos and printed names on a screen cannot directly imitate in-person interactions, as mentioned in open-ended responses. In addition, mnemonics used in the laboratory with laboratory-relevant stimuli may not be relevant in everyday settings and are perhaps limited to the research situations (Troyer, 2001). This has been demonstrated in past research where the memory strategies were effective in

laboratory setting but limited in naturalistic situations (Morris et al., 2005; Patton, 1994; Pike et al., 2018). However, it is still worthwhile to examine the use of techniques that may improve memory, but perhaps future research should consider how to improve ecological validity of stimuli such as using videos or virtual reality scenarios and to use strategies that will be applicable in daily life.

Another limitation is that the experiment was conducted in one session with a relatively large number of stimuli. This may have resulted in fatigue, boredom, or difficulty applying the mnemonic strategy to multiple face-name pairs. Past research has demonstrated that fatigue was a factor that influenced the occurrence of name recall failures (Brédart & Vanootighem, 2022; Cavanaugh et al., 1983; Cohen & Faulkner, 1986). Furthermore, given that there was no monitoring by an experimenter, it is possible that participants were more distracted during the task than they would have been had the task been carried out in person, as demonstrated in previous research (Clifford & Jerit, 2014). This should be addressed in future research by reducing the number of stimuli presented or conducting the experiment across multiple sessions. The length of the task and the number of stimuli may also have been factors in the low compliance rate with the mnemonic strategy. Future research can employ subjective and objective measures of compliance throughout the task, as has been done in previous studies (Caplan et al., 2019; Legge et al., 2012; Sahadevan et al., 2021).

6.6 Conclusion

The results of this study did not support an age-related decline in memory for recently learned face-name pairs or an advantage of the name-transformation mnemonic strategy over an uninstructed approach for middle-aged and older adults. We found that middle-aged and older adults may already be using their own strategies in daily life and perhaps are less motivated to learn and use a new intensive technique. It is possible that fatigue, motivation, and effort

required to engage with the task in an online setting contributed to the lack of differences found in this study. Perhaps mnemonic techniques such as these should be taught at an earlier stage where participants are motivated to learn strategies and can adopt strategy use into daily life over time, whereas improving name recall in aging populations might focus more on combining mnemonics and expanding rehearsal to optimise performance.

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6.8 Appendices

Appendix A

Name List

Age range	18-29	30-49	50-69	70-94
	BRANDON	AIMEE	ANDREA	ALISON
	BROOKE	ALEX	DEBRA	ALLAN
	CALLUM	CARLY	DIANE	CLIFFORD
	CAMERON	DAMIEN	DOMINIC	EILEEN
	DAVID	DANNY	DUNCAN	HARRY
	GABRIELLE	GRACE	GAVIN	HEATHER
	ISABEL	HOLLY	KAREN	JULIA
	JASMINE	JACQUELINE	LEE	MARILYN
	JORDAN	JOSH	MATTHEW	MARTIN
	KYLE	LEANNE	NEIL	NICHOLAS
	NATHAN	LUKE	PAMELA	ROY
	RACHEL	MAX	PATRICIA	RUTH
	RUBY	MELISSA	SIMON	SHIRLEY
	SAMANTHA	MICHAEL	TINA	TREVOR
	SPENCER	SOPHIE	WAYNE	VERONICA

Appendix B

Questionnaires

Comprehension Check Questionnaires

Uninstructed group

Instructions: Please answer the following questions about the task. Please note that if the responses are incorrect you will be redirected to the instructions to read them again.

4. What will happen in this study?
    a. You will see face-name pairs and have a chance to study and remember them.
    b. You will study faces and later select the ones you recognise from several options.
    c. You will see a list of words and have a chance to study and remember them.
5. What were you asked to do in this study?
    a. Do your best to remember the face-name pairs that are presented.
    b. Rate the approachability of the faces that are presented.
    c. Do your best to remember a list of words that are presented.
6. What is the scenario you were asked to imagine during this study?
    a. You are at a local event where you will be meeting people. It is important that you remember their names.
    b. You are shopping at a supermarket. You will need to remember a list of items to purchase.
    c. You are at an event for your work. You will need to remember the names of your colleagues.

Mnemonic group

Instructions: Please answer the following questions about the task. Please note that if the responses are incorrect you will be redirected to the instructions to read them again.

4. What were you asked to do in this study?
    a. Use a mnemonic strategy to remember the face-name pairs that are presented.
    b. Rate the approachability of the faces that are presented.
    c. Do your best to remember a list of words that are presented.
5. What is the scenario you were asked to imagine during this study?
    a. You are at a local event where you will be meeting people. It is important that you remember their names.

b. You are shopping at a supermarket. You will need to remember a list of items to purchase.
c. You are at an event for your work. You will need to remember the names of your colleagues.

6. What is the mnemonic strategy you were asked to use in this study?
    a. Transform the name into an object you can easily imagine then imagine it interacting with the person in the image.
    b. Create a rhyme and link the names together based on the order in which they are presented.
    c. Create a story linking words together using a list that is presented.

Experiment Questionnaires

Instructions: This questionnaire will help us understand strategy use during the experiment. Please read each statement carefully and click the response that best describes your experience during the experiment or provide as much information as you can.

Questionnaire: Strategy use (uninstructed group)

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
25. I understood the scenario.
26. I understood the instructions.
27. I used a memory strategy to help remember names and faces during the experiment.
28. Please explain how you remembered the face-name pairs during the experiment.

Options: Very Easy Easy Neutral Difficult Very Difficult
29. I found it _____ to use my strategy during **block** 1.
30. I found it _____ to use my strategy during **block** 2.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
31. I had enough time to apply my strategy during the study period.
32. I enjoyed using my strategy during the experiment.

33. Why did you find it easy/difficult to use your strategy?
34. Were any of the face-name pairs particularly difficult to remember?
35. Please list any of the names you remembered and how you remembered them. You can list up to 10.

Name	How you remembered this name

Questionnaire: Real-life (uninstructed group)

Instructions: This questionnaire will help us understand strategy use in real life. Please read each statement carefully.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
36. I could apply the strategy I used during the experiment when meeting people in real life.
37. I would use the strategy I used during the experiment when meeting people in real life.

Options: Very Easy Easy Neutral Difficult Very Difficult

38. This strategy would be _____ to use when meeting people in real life.
39. Would any changes to the strategy you used during the experiment make it easier to use in real life?
40. How do you remember names when meeting people?

Questionnaire: Strategy use (name-transformation group)

Instructions: This questionnaire will help us understand strategy use during the experiment. Please read each statement carefully and click the response that best describes your experience during the experiment or provide as much information as you can.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
26. I understood the scenario.
27. I understood the instructions about the described strategy.
28. I used the described strategy throughout the experiment.

Options: Very Easy Easy Neutral Difficult Very Difficult

29. I found it _____ to use the strategy during **block** 1.
30. I found it _____ to use the strategy during **block** 2.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree
31. I had enough time to apply the described strategy during the study period.
32. I enjoyed using the described strategy during the experiment.

33. Please explain how you remembered the face-name pairs during the experiment.
34. Why did you find the described strategy easy/difficult to use?
35. Were any of the face-name pairs particularly difficult to remember?
36. Please list any names you remembered and how you remembered them. You can list up to

Name	How you remembered this name
……	…….
……	…….

Questionnaire: Real-life (name-transformation group)

Instructions: This questionnaire will help us understand strategy use in real life. Please read each statement carefully.

Options: Strongly Agree Agree Neutral Disagree Strongly Disagree

37. I could apply the described strategy when meeting people in real life.
38. I would use the described strategy when meeting people in real life.
39. The described strategy would be _____ to use when meeting people in real life.

Very Easy Easy Neutral Difficult Very Difficult

40. Would any changes to the described strategy make it easier to use in real life?
41. How do you remember names when meeting people?

Appendix C

Exploratory Analyses

Exploratory analyses were conducted to examine the influence of Strategy Group on name recall across the two blocks for middle aged (aged 40-59) and older adults (aged 60-80) separately. Figure 2b shows the mean recall for each strategy and age group in the two blocks. A repeated measures ANOVA of Strategy Group and Block revealed nonsignificant main effects of Strategy Group ($F(1,70) = 0.43$, $p = .516$, $\eta_p^2 = .01$), Block ($F(1,70) = 1.46$, $p = .231$, $\eta_p^2 = .02$), and a nonsignificant interaction between Strategy Group and Block ($F(1,70) = 1.86$, $p = .177$, $\eta_p^2 = .03$) for middle-aged adults. There were nonsignificant main effects of Strategy Group ($F(1,70) = 0.97$, $p = .328$, $\eta_p^2 = .01$), Block ($F(1,70) = 0.25$, $p = .617$, $\eta_p^2 = .004$), and a nonsignificant interaction between Strategy Group and Block ($F(1,70) = 0.89$, $p = .348$, $\eta_p^2 = .01$) for older adults.

Appendix D

MMQ Results

Higher scores on the satisfaction scale indicate more satisfaction with memory abilities. Higher scores on the ability scale indicate lower frequency of memory mistakes. Higher scores on the memory strategies scale indicate higher frequency of use of memory aids and strategies.

MMQ Scales

Scale	**Uninstructed** (n = 81)		**Name-transformation** (n = 63)		**Test**		
All-inclusive	*M*	*SD*	*M*	*SD*	Test	*p*	Effect size
Satisfaction	46.86	10.60	44.71	12.33	t = 1.12	.263	0.19
Ability	55.74	9.15	53.27	13.11	Welch's t = 1.27	.206	0.22
Memory Strategies	35.59	13.27	34.05	12.11	t = 0.72	.473	0.12

Note. Welch's t-test used where assumption of homogeneity was violated. Effect size for t-test is Cohen's d.

A series of two-way ANOVAs were performed to examine the effect of Strategy Group (uninstructed and mnemonic) and Age Group (middle-aged or older adults) on total scores for the Ability, Satisfaction, and Strategy Use scales of the MMQ. For the Ability scale, the main effect of Strategy Group (F(1,140) = 1.55, p = .216, η_p^2 = .011) and Age Group (F(1,140) = 1.34, p = .250, η_p^2 = .009) were not significant. The interaction between Strategy Group and Age Group was significant (F(1,140) = 5.10, p = .035, η_p^2 = .035). Post hoc tests (Bonferroni corrected) revealed the uninstructed middle-aged group had a higher total score (M = 56.82, SD = 8.11) compared to the mnemonic middle-aged group (M = 50.38, SD = 13.81). However, this did not reach significance (t(68) = 2.50, p = .082, Cohen's d = 0.59).

For the Satisfaction scale, the main effect of Strategy Group ($F(1,140) = 1.13$, $p = .289$, $\eta_p^2 = .008$), Age Group ($F(1,140) = 0.40$, $p = .527$, $\eta_p^2 = .003$), and the interaction between Strategy Group and Age Group ($F(1,140) = 0.76$, $p = .386$, $\eta_p^2 = .005$) were not significant.

For the Strategy Use scale, the main effect of Strategy Group ($F(1,140) = 0.70$, $p = .406$, $\eta_p^2 = .005$) and Age Group ($F(1,140) = 1.55$, $p = .216$, $\eta_p^2 = .011$) were not significant. The interaction between Strategy Group and Age Group was significant ($F(1,140) = 4.70$, $p = .032$, $\eta_p^2 = .032$). Post hoc tests (Bonferroni corrected) revealed the mnemonic middle-aged group had a higher total score ($M = 37.38$, $SD = 11.81$) compared to the mnemonic older adult group ($M = 30.14$, $SD = 11.44$). However, this did not reach significance ($t(59) = 2.27$, $p = .148$, $d = 0.57$). Additionally, the uninstructed older adult group ($M = 36.51$, $SD = 13.29$) had a higher total score compared to the mnemonic older adult group ($M = 30.14$, $SD = 11.44$). However, this did not reach significance ($t(68) = 2.10$, $p = .224$, $d = 0.51$).

Appendix E

Open-ended Responses for Middle-aged Adults

Question	Response (# of participants)	Example	Response (# of participants)	Example
	Uninstructed (*n* = 38)		**Mnemonic** (*n* = 34)	
Please explain how you remembered the face-name pairs during the experiment.	Related to familiar individual (19)	"Tried to equate them with someone else I remember or another name I remember."	Described mnemonic (34)	"Changed letters in the names to make a familiar object and then imagined that person with the object"
	Distinct features/ appearance (14)	"I tried to remember one feature, eg heart earrings and repeated it lots of times with the name until the picture changed to the next one."		"picked an object that was similar to the name, then pictured the personteracting with that object"
	Mnemonic/ word association (4)	"I tried to associate some aspect of the person with something else within my experience or pick out some aspect of their features. As far as the features goes it can sound a little bit rude but something like a red nose is quite distinctive. (Trevor the red nosed reindeer) Or dreadlocks (I dread Samantha.) This works quite well for me when I meet a few people at a time but I really struggled with how many people there were!"		"Try to change name into similar word and put person together with that word"
	No response (1)	"im not sure"		"by imagining each face in a scenario or with an object that I related to that name."

Why did you find it easy/difficult to use the strategy?	Too many pairs /not enough time (16)	“The more faces I saw the harder it became, my brain became a bit overwhelmed with faces and names, I struggle with names but remember faces well.”	Difficult to apply strategy/transform name (17)	“I couldn't think of an object that would represent their name always which made it difficult to use.”
	Difficult when there were not enough distinctive features (5)	“There were not so many stand out differences between the faces”	Helped to link the names and faces together (7)	“could imagine them in a setting”
	Couldn’t apply strategy/ difficult to apply (6)	“I found it difficult if the names didn't apply to people I already knew”	Too many pairs/ not enough time (5)	“Too many faces to remember in a short period of time”
	Easy to apply strategy (4)	“It was easy because I know people with same names”	NR (1)	No response
	Other (8)	“It's all I could think of.”	Other (4)	“I found it difficult to use initially as this is not the way I normally use to remember things”
Were any of the face-name pairs particularly difficult to remember?	Yes/most (10)	“they were all equally hard for me”	Yes /most (15)	“the majority”
	Older adults (10)	“a lot of the older ones were really hard”	Names that are difficult to transform/rhyme (4)	“Those where it wasn't obvious what object you could use, those where the most difficult.”
	No distinguishing feature/ common names (7)	“I struggled of the people were of a similar demographic and looked quite bland, with no standout features.”	Similar appearance/ no distinguishing features (3)	“faces that didn't have any stand out features”
	No (6)	“none in particular”	Older adults (2)	“Yes - older people I struggled more with”
	NR (1)	No response	No (2)	“No it was more getting used to the strategy”

	Other (4)	“Ones with odd names, like jaqueline or Deborah, for whom I could not come up with fictional characters”	Men (2)	“MEN MORE THAN WOMEN”
			NR (2)	
			Other (3)	“Any with three syllables.”
	Response (# of participants)		**Response (# of participants)**	
Would any changes to the strategy make it easier to use in real life?	No (11)	“No”	No (8)	“To be honest, for me, i dont think so.”
	Unsure (5)	“Don't know”	Add person details (6)	“maybe connecting their names to something more personal to yourself”
	Use distinct/additional features (4)	“I would use identifying features as an additional reminder”	Rhyming (4)	“If it was always a rhyme that would help”
	Conversation (3)	“I think if you could talk to them and get an impression of their personality and get a fact about them that would help to reinforce their name.”	More time/practice (4)	“Time to think”
	Relate to familiar individual (2)	“Trying to link them to other people I know with the same name”	Unsure	“Don't know”
	Yes (2)	“Yes”	NR (2)	
	Other (11)	“i try to avoid this sort of scenario in real life or people wear name badges”	Other (7)	“Having some way of remembering people whose names you can't easily associate with an object they can interact with”

How do you remember names when meeting people?	Repetition (9)	"I make a point of repeating their name, and using it in the conversation, that way when i recall the conversation i had with them i can picture their face and recall the name quite well"	Repetition (9)	"just repeat their name over in head to remember with face"
	Person/situation details (5)	"Usually by associating where I met them or something else other than what they look it, eg Pet shop Shirley, she works in the Pet Shop"	Don't remember (8)	"I don't. I am terrible with names, but great with faces."
	No strategy (5)	"I don't consciously have a strategy"	Mnemonics (4)	"Think of an object / place and link the name"
	Distinct features (5)	"I'm not very good at it (!) but I tend to look for defining features or accents, especially when there is a large group."	Distinct features (4)	"I remember a certain feature about them (scar, beauty mark, freckles, curls etc)"
	Relate to familiar individual (4)	"Try to associate them with someone bearing the name i alreay know, or try to create a memory around the person"	Relate to familiar individual (3)	"A bit odd, but I try and associate them with other people I know."
	Associations (3)	"Sometimes, name association helps a lot or I just keep asking and explain I'm not great at it, most people understand and appreciate the truth."	No strategy (3)	"Just try to use simple memory."
	Other (7)	"I always find it difficult so I can't offer any input"	NR (1)	No response
			Other (2)	"If the name is unusual/interesting I can usually remember it. I have occasionally applied ways to remember a bit like in this task. If not, I just don't!"

Open-ended Responses for Older Adults

Question	Response (# of participants)	Example	Response (# of participants)	Example
	Uninstructed (*n* = 43)		**Mnemonic** (*n* = 29)	
Please explain how you remembered the face-name pairs during the experiment.	Distinct features/appearance (21)	"I tried to remember something unusual about them ie ring in eyebrow, moustache."	Described mnemonic (29)	"I thought of the name as something similar and then imagined that person in that situation"
	Related to familiar individuals (12)	"thought of people I already knew by that name and tried to connect a similar feature"		"I pictured them doing something as a word associated with their name"
	Rhyming (3)	"Tried to remember a rhyme - eg Patricia in pink"		"I associated objects or situations will each face-name"
	Mnemonic/word association (3)	"I tried to link something to their name though sometimes I could only remember the first letter. So I might focus on the eyes and say 'mad max' etc or try to imagine them in a situation"		"Sometimes I was able to link a situation like the person's name to a place or site, other times to another name (Marylin - Marylin Monroe came first, then the lady in Hollywood under the sign)"
	Other (5)	"it was quite difficult not sure if the pairing was correct but tried my best"		"By using the method suggested, but I feel I was unsuccesful most of the time!"
Why did you find it easy/difficult to use the strategy?	Too many pairs (10)	"Found it difficult because of so many pairs to remember"	Difficult to apply strategy (15)	"Trying to find object/words to associate the names was difficult."
	Couldn't remember/confused (6)	"Just couldnt remember"	Too many pairs/ not enough time (3)	"A lot of people to remember soa difficult task"

	No distinguishing feature (5)	“Couldn't always find a relevant feature”	Helped to link the names and faces together (4)	“It helped to connect names to thing and then join them together as an image”
	Difficult to apply strategy (5)	“didn't always apply”	Use this strategy before (2)	“I tend to use this strategy myself as I have found remembering names increasingly difficult with age.”
	Easy to apply strategy (3)	“In part 1 I made a story up about each individual which made it easier to recall the names.”	Other (4)	“at 72 I have problems with short-term memory. Any strategy would be difficult”
	Only strategy available (2)	“the only way i could do it”		
	Easier with practice (2)	“i got more attuned after the 1st block to remember certain things”		
	Other (8)	“I would have like to have heard them speaking or moving - it was hard just looking at a face and name”		
Were any of the face-name pairs particularly difficult to remember?	Yes/most (18)	“Yes, most of them”	Yes /most(12)	“Most of them!”
	No distinguishing features (8)	“people with no one memorable feature”	Similar appearance/ no distinguishing features (5)	
	Older adults (5)	“older men”	Names that are difficult to transform/rhyme (3)	“I found it a bit harder with names that weren't easy to associate with other things.”
	No (4)	“Not that I noticed.”	Older adults (3)	“Nearly all of them were - but probably most difficult with older male faces.”
	NR (1)	No response	No (2)	“No.”

	Other (7)	"Not Sure as I do not know what were right or wrong"	NR (1)	No response
			Other (3)	"Some of the people with different colour skin were hard to remember. I should have been more adventorous with the words I chose."
	Response (# of participants)	**Example**	**Response (# of participants)**	**Example**
Would any changes to the strategy make it easier to use in real life?	No (18)	"None that I can think of"	No (11)	"I can't think of any"
	Include personal details (8)	"In real life, I'd have other cues such as mannerisms which woul.d make it easier"	Add person details/distinct features (8)	"I'd have more than a face to go on - voive, personality, movements, height, size"
	Using distinct features (4)	"maybe remembering a key facial feature"	Rhyming/alliteration (3)	"give the alternative to link alliteration to names (Polly-Molly) or link to people you know/famous people (Marylin-Marylin Monroe)"
	Unsure (3)	"Not sure"	Haven't/wouldn't use (3)	"I just dont thikI would do this - I might use another strategy eg repeating and Rhyming their name with something"
	Yes/probably (2)	"Yes"	Unsure (2)	"Not sure."
	Fewer people/more time (2)	"I would have longer to remember"	Other (2)	"I would make the connections humorous or even shocking"
	NR (1)	No response		

	Other (5)	“make a connection between name and something known”		
How do you remember names when meeting people?	Repetition (8)	“Keep repeating the name to myself”	Repetition (6)	“repeat over and over”
	Person/situation details (8)	“After speaking to them I remember where they live or what they do.”	Relate to familiar individual (4)	“I usually think of someone else with the same name.”
	Distinct features (7)	“match the name to something distinctive about the person in my mind”	Distinct features (4)	“Picking out a particular trait (hair like soft heather-Heather) or alliteration (Molly-Jolly) or place (Roy - Roy Rodgers on a horse)”
	Don’t remember (5)	“I do not, I am and always have been very poor at remembering names.”	Person/context details (4)	“I don't use just the look of the face to remember them. I use their personalities, their speech, their facial movements, and all kinds of things.”
	Relate to familiar individual (2)	“I try to associate the name with an image, eg a film star”	Mnemonics (3)	“see above - 2 links. It's also easier If I can spell the name (or harder if I can't imagine the spelling)”
	Associations (2)	“Sometimes word association with an aspect of face, voice or appearance.”	Don’t remember/difficult (2)	“All too often, I don't”
	Other (6)	“you known them you have worked with them you have met them”	Other (6)	“I write them down where possible.”

7 General discussion

7.1 Discussion

Memory is an important aspect of daily life and memory ability can be impacted by various factors such as aging or acquired brain injury. The research in this thesis contributed to our understanding of memory ability evaluation, clinical practices of memory assessment to treatment after stroke, and memory rehabilitation strategies. Through a series of literature reviews, empirical studies, and an online survey, we found that memory can be evaluated using various objective and subjective measures which can be combined to reveal a memory profile in clinical settings (**Chapters 2 and 3**) and to examine individual differences in memory ability and perceptions of memory in research settings (**Chapter 2**). We also found that a multitude of strategies are currently in use across clinical and research settings to treat memory impairment resulting from acquired brain injury such as stroke (**Chapters 3 and 4**). When examining a commonly used internal memory strategy, we found it had limited efficacy for improving name recall but that a simplified version showed more promise for young adults (**Chapter 5**). However, we found no indication that this mnemonic would benefit middle-aged and older adults (**Chapter 6**).

Here I provide an overview and implications of the findings and present possibilities for future research.

7.2 Overview of Findings and Implications

7.2.1 Memory Evaluation

In the metamemory questionnaires literature review in **Chapter 2** (Gopi & Madan, 2022), I examined three categories of questionnaires currently in use. Self-efficacy questionnaires are targeted to understanding perceived ability in particular situations, complaints questionnaires focus on memory failures, and multidimensional questionnaires are used to comprehensively examine multiple facets of memory (Gilewski & Zelinski, 1986; Herrmann, 1982; Sunderland

et al., 1983). The review revealed that individual difference factors including knowledge/beliefs about memory, ability to evaluate memory, recent metamemory experiences, and affect can influence subjective memory evaluation (Cavanaugh et al., 1998; Spano et al., 2020). Moreover, there is often little correlation between subjective and objective memory measures, perhaps because these measures examine different aspects of memory (Schmidt et al., 2001).

This literature review was valuable for defining the categories of questionnaires, although there is some overlap among questionnaires, and outlining questionnaires within each category along with their characteristics. The review can benefit those who are selecting questionnaires for use in research and clinical settings as questionnaires are not interchangeable and require different considerations based on the target population and aspect of memory being examined. Moreover, the review outlined the individual differences that should be considered when assessing responses. In summary, we found that memory questionnaires are useful measures of subjective memory but may need to be approached with some caution.

7.2.2 Memory after Stroke

The survey of healthcare professionals in **Chapter 3** revealed that memory is often assessed and treated alongside other cognitive functions across the stroke care pathway by the multidisciplinary stroke team, in line with clinical guidelines (Intercollegiate Stroke Working Party, 2016; NICE, 2013). Short-term memory, prospective memory, and learning deficits are frequently observed among patients and memory impairments moderately impact ability to complete activities of daily living, consistent with previous research (Fitri et al., 2020; Tang et al., 2020). Moreover, patients experience frustration and negative self-evaluation due to

memory impairment whereas some experience motivation to improve their memory. We also found that memory impairment is often treated with compensatory and knowledge acquisition memory strategies incorporated into daily work with patients or with targeted memory rehabilitation and is considered moderately effective.

These results improve our understanding of current clinical practices of memory assessment to treatment after stroke. Specifically, although memory is assessed using cognitive measures, there was little indication that targeted memory assessments are conducted even at the rehabilitation stage. The results also showed that memory impairment is relatively common among patients and should therefore be seriously considered by healthcare professionals even if physical and other cognitive deficits are more visible. Moreover, given the impact of memory impairment on mood and activities of daily living, these factors should be addressed alongside memory impairment. The survey also provided insight into the use of various memory strategies to improve daily life of patients in line with clinical guideline suggestions. This was corroborated by the results of the memory rehabilitation literature review in **Chapter 4** that revealed a wide variety of strategies that are available for use with acquired brain injury patients. The results of this survey can be useful for researchers and clinicians investigating memory rehabilitation and improving clinical practice to follow evidence-based guidelines.

7.2.3 Memory Rehabilitation Approaches

The memory rehabilitation literature review in **Chapter 4** (Gopi et al., 2022) revealed four main approaches to memory rehabilitation that are currently in use for acquired brain injury, each involving distinct strategies. The restorative approach is aimed at retraining some lost memory function via computer based cognitive retraining (Spreij et al., 2014). The acquisition

of specific knowledge with errorless learning and spaced retrieval is based on the idea that spared implicit memory can be capitalised on to learn specific information (Kessels & de Haan, 2003). To improve daily functioning, the compensatory approach involves the use of external and internal memory aids has been consistently recommended and used in memory rehabilitation (Wilson, 2000). More recently, the holistic approach emerged consisting of memory strategy training, psychotherapy, and education to improve cognition and psychosocial deficits (Prigatano, 2013).

This review was beneficial for clarifying the outlined approaches, their respective strategies, and underlying mechanisms. It revealed that there is no standardised approach to memory rehabilitation after acquired brain injury and rehabilitation is likely to consist of multiple strategies, sometimes depending on patient needs and abilities. This was supported by previous research indicating that several factors should be considered when designing a memory rehabilitation programme such as the severity of memory deficits, lesion locations, and time since stroke (Cicerone et al., 2019; Zucchella et al., 2014). Furthermore, the review highlighted several factors that may influence rehabilitation outcomes including metacognition and emotional disturbances that are worth examining alongside memory deficits (Al Banna et al., 2015; Perna & Harik, 2020). The results of this review were in line with the results from **Chapter 3**, where healthcare professionals indicated that stroke patients experience mood disturbances related to memory deficits and that treatments often include multiple strategies. Additionally, the strategies outlined under the knowledge acquisition and compensatory approaches in the literature review were used by healthcare professionals in the stroke survey. Thus, the memory rehabilitation literature review provides a resource for researchers and clinicians to understand the memory rehabilitation approaches and strategies that can be used in improving memory after acquired brain injury.

7.2.4 Mnemonics and Name Recall

A series of experiments with young adults in **Chapter 5** (Gopi, Wilding, et al., 2022a) did not support the benefits of the full face-name mnemonic technique found in past literature (McCarty, 1980; Morris et al., 1978). However, we found an advantage of a simplified version of the mnemonic focusing on transforming names and interactive imagery for recalling recently learned names compared to no imagery instruction. This name-transformation strategy was successful in aiding name recall across three blocks in Experiment 1. Experiment 2 supported the advantage of the name-transformation strategy over the uninstructed strategy when participants complied with the instructions. In addition, there was a significant increase in name recall from block one to block two for the mnemonic group participants, indicating the generalisation of strategy use to new names is possible.

The results of this study support the use of the name-transformation mnemonic to improve name recall if participants comply with the instructions and generate their own imagery. This is in contrast to previous research where the face-name mnemonic strategy components were imposed by researchers who suggested that the mnemonic may be too complex to apply within time-limited situations (Patton, 1994). Additionally, the responses on questionnaires that we developed to examine strategy use during the task revealed that many participants did not comply with the strategy instructions, and that some participants would not be able or willing to use the strategy in real life, indicating that mnemonic strategies may not be applicable for all individuals. Nevertheless, the name-transformation mnemonic strategy shows promise for improving name recall for young adults.

7.2.5 Aging, Mnemonics, and Name Recall

An experiment in **Chapter 6** did not support the advantage of the name-transformation mnemonic technique over an uninstructed approach for middle-aged and older adults. This was contrary to our expectations based on the results of the previous study with young adults in **Chapter 5** as well as previous research demonstrating improvements in name recall using the full face-name mnemonic strategy for middle-aged and older adults (Yesavage et al., 1983; Yesavage & Rose, 1984). Similarly, there was no influence of age on name recall, where we expected a decline in name recall with increasing age (Crook & West, 1990; Yesavage & Rose, 1984). However, the questionnaires revealed that participants were already using strategies to improve memory during the task, some of which were external memory aids and mnemonic strategies. Similar results have been shown in previous research (Klaming et al., 2022).

The compliance rate of the aging study was lower than that of the young adult study, perhaps because the mnemonic strategy required too much effort to learn and apply or was too complex. This is in line with previous research indicating that mnemonic strategies may require more effort than is deemed to be necessary for older adults (Lineweaver et al., 2021). It is also possible that the time in this study was too limited for middle-aged and older adults to learn and apply the strategy to a considerable number of face-name pairs. Thus, motivation and experimental design factors may have influenced outcomes in this study. Further work should be done to examine the extent to which mnemonic strategies are useful for middle-aged and older adults.

7.2.6 Connecting Themes across Chapters

Although the chapters in this thesis addressed different gaps in the literature regarding memory ability, rehabilitation, and strategies, there were some common themes across the chapters that are worth noting. Firstly, the use of subjective memory measures to examine memory ability is an important aspect of memory evaluation. The memory questionnaires literature review (**Chapter 2**) demonstrated that a wide variety of standardised questionnaires are available for use with different target groups including stroke patients. However, the stroke survey (**Chapter 3**) revealed that healthcare professionals are regularly using non-standardised measures such as interviews and observations of patient behaviour to assess memory ability and failures. It would perhaps be more beneficial to include standardised measures in clinical settings to would allow for better comparisons across patients. Additionally, the rehabilitation programmes highlighted in **Chapter 4** often include neuropsychological assessments used for comparing pre- and post-treatment outcomes, but as mentioned in **Chapter 2**, these objective measures may not always reflect memory in daily life. Thus, perhaps including metamemory questionnaires in rehabilitation programmes to examine pre-post treatment changes in subjective memory might be beneficial in determining the real world impact of various rehabilitation strategies.

The chapters of this thesis demonstrated that memory strategies are commonly used to improve ability in daily life. The stroke survey (**Chapter 3**) and memory rehabilitation literature review (**Chapter 4**) revealed that external memory aids such as mobile phones are prevalent across healthy adults and patient populations. Additionally, as shown in the memory questionnaires literature review (**Chapter 2**), the use of internal and external memory aids is often an aspect of metamemory questionnaires. Finally, the results of the open-ended questionnaires in **Chapters 5 and 6** revealed that internal mnemonic strategies can be

implemented by young adults and that middle-aged and older adults have used various internal strategies to aid in daily tasks such as name recall that they continue to use in relevant situations. Thus, it is evident that various memory strategies are used across different populations and that these are worth examining in the context of how they can most effectively be combined to improve memory impairment in rehabilitation.

7.3 Future Considerations

The work in this thesis improved our knowledge regarding subjective memory measures, clinical practices, memory rehabilitation, and the efficacy of mnemonics for remembering names. However, there remains some unanswered questions that warrant further exploration in the future.

7.3.1 Memory Rehabilitation

The use of knowledge acquisition techniques and compensatory strategies in clinical practice warrants further examination. The memory rehabilitation literature review (**Chapter 4**) revealed that errorless learning and spaced retrieval are beneficial for learning specific information but is unlikely to generalise to other information and the stroke survey (**Chapter 3**) demonstrated that healthcare professionals use these techniques in everyday work with patients. However, it is unclear which information is prioritised to be learned, how errorless learning is implemented in clinical settings where there are distractions, and which materials are used to administer the time-intensive techniques. These factors are likely to be different from research based settings. Additionally, the memory rehabilitation literature review and stroke survey demonstrated that external compensatory aids are commonly used throughout research and clinical settings. However, there has been little information revealed about the training provided to patients to learn or relearn to use these instruments, particularly those that

are technological. Moreover, recent research has indicated that healthcare professionals may have limited training and knowledge of the applicability of these tools (Baptista et al., 2022).

It is worth noting that the dosage and assessment of progression in memory rehabilitation remains unclear. While rehabilitation programmes in research settings often have a time-limited scope, the same may not be true for clinical settings, where rehabilitation may vary by patient needs and staff resources (Jeffares et al., 2021). The stroke survey revealed that progress is often measured based on goal setting, patient observations, and subjective reports from patients and relatives. However, caution is warranted when using subjective measures as previous research has demonstrated improvements in mood or on subjective reports following rehabilitation without improvements in cognition (das Nair et al., 2016). Thus, subjective reports may not reflect actual improvement and treatment may be terminated prematurely. Further examination is therefore warranted regarding the dosage of memory rehabilitation treatment and consequently progress measurement in clinical settings.

Based on the memory rehabilitation literature review (**Chapter 4**) and the stroke survey (**Chapter 3**), a more detailed survey of healthcare professionals or a focus/nominal group can help to clarify these outlined issues. Recent studies have shed light on cognitive rehabilitation practices within a variety of clinical settings, yet it appears as though different cognitive domain impairments are examined under one category, leaving questions about the treatment of memory (Jeffares et al., 2021; Nowell et al., 2020). While the stroke survey was beneficial for demonstrating how memory is addressed along the stroke care pathway and the literature review revealed a wide variety of treatment methods are available, further examination of how these two factors interact within clinical settings is warranted.

7.3.2 Efficacy of Mnemonic Strategies

The applicability of the name-transformation mnemonic technique should be further examined in naturalistic settings. Previous research has shown little support for efficacy of the face-name mnemonic strategy in naturalistic settings (Morris et al., 2005; Patton, 1994). However, adherence to the strategy was not measured and the imposition of the strategy may have influenced these outcomes. Future research can expand on our study by examining the impact of the name-transformation mnemonic strategy across healthy young adults when meeting people in a naturalistic setting with questionnaires to assess compliance and strategy use during the task. Additionally, it would be important to examine the timing that is required to effectively apply the strategy in person as our results demonstrated that it was possible for participants to apply the strategy within 12 to 16 seconds in a computer-based task.

In a different capacity, the dosage of the strategy training and long-term follow-ups should be explored, as it has been suggested that a mnemonic should be applicable long-term for it to be useful in everyday life (McCarty, 1980). In Experiment 1 of **Chapter 5**, there was no generalisation effect to new names, yet in Experiment 2, name recall for the mnemonic group significantly improved from block one to block two with new face-name pairs. This is perhaps due to the second repetition block of Experiment 1 resulting in fatigue. Thus, an experiment can be conducted with fewer face-name pairs with varying lengths of training time to train the strategy use for those who comply with instructions. In addition, a follow-up recall test after one week could be conducted to examine the long-term effects of the strategy training, extending the 24-hour follow up conducted by Patton (1994).

The influence of aging and mnemonics on name recall should also be further explored. Our results showed that middle-aged and older adults already use their own strategies and were

less likely to comply with mnemonic instructions compared to young adults. It is possible that as the task was online and not reflective enough of real life experiences with recalling names, participants may not have been sufficiently motivated to learn and apply a new strategy. It is also possible that the mnemonic is too complex and requires too much effort to apply and that the strategy used in the experiments will require more training or some modification to be applicable for middle-aged and older adults (Klaming et al., 2022; Morris et al., 2005). Like Experiment 1 in **Chapter 5**, an experiment could be designed to examine multiple mnemonic strategies with varying levels of intensity for middle-aged and older adults. Similarly, the training dosage required to learn and apply the strategy may be longer than that required for younger adults and could be further examined by spreading the training across multiple days.

As mentioned in **Chapter 1**, memory rehabilitation and training programmes often include mnemonic or visualisation strategies for the recall of face-name pairs. In **Chapter 5** and **Chapter 6**, we found that mnemonic imagery techniques can be beneficial for young adults who comply with the strategy whereas middle-aged and older adults may find them difficult to learn and apply. However, further research is necessary to examine how factors such as motivation and ability to learn a new strategy can influence participation and outcomes on such tasks. For example, stroke patients may encounter difficulties recalling names in everyday life and a mnemonic strategy may help them to improve name recall once re-introduced to familiar individuals or introduced to new individuals such as healthcare professionals. This would be a different motivation for learning the strategy compared to the healthy older adults in our aging study in **Chapter 6**. In a different capacity, the benefits of combining mnemonics with other strategies such as spaced retrieval are worth exploring across healthy adults and stroke patients. This was highlighted in **Chapter 4**, where previous research examining memory rehabilitation often combined different approaches such as

errorless learning and external memory aids and would be an interesting avenue for future research to examine the intersection of how strategies from different approaches might be best applied to improve outcomes for patients.

7.4 Covid-19 Impact Statement

The Covid-19 pandemic lockdown in March 2020 started during the second year of the PhD programme and resulted in changes to the research progress. Data collection for Experiment 1 in **Chapter 5** was prematurely concluded with a total of 86 participants where the initial target was 104. The experiment design and data collection for Experiment 2 was delayed as it was initially expected to be conducted in person but was then adapted to be conducted online. contradicting the benefits of the full face-name mnemonic technique found in past literature (McCarty, 1980; Morris et al., 1978). See the **Appendix chapter** for considerations made while shifting from in-person to online data collection. The stroke survey was initially designed to consist of in-person nominal group meetings with healthcare professionals across the country but was converted to an online survey. Altogether, all research was shifted to be conducted online.

7.5 Clinical Research Engagement

During the PhD, I engaged with several aspects of clinical research to gain a broader perspective of research approaches and clinical stroke-related research. I presented research plans at the annual stroke research workshop in 2019 to stroke patients and their family as part of a collaboration with the School of Medicine and the Nottingham Stroke Research Partnership Group. Questions were asked regarding the strategy distribution to the wider stroke community, misnaming familiar individuals, and accounting for multiple memory disorders. Comments were provided regarding the helpfulness of the research, name repetition, and transfer of the task to real life situations. In 2019, I participated in an intensive

stroke MSc module regarding outdoor mobility, communication, transferring evidence into practice, and cognition after stroke. I also participated in stroke seminar series where researchers provided updates of their current work and plans for progression including outcomes of the Stroke Recovery and Rehabilitation Roundtable, stroke clinical guidelines, and the Priority Setting Partnership for stroke. The meetings were shifted online in 2021, where I presented the stroke survey results. These experiences were beneficial for bridging the academic and clinical approach to stroke research and for understanding some of the considerations that are required when conducting research with a clinical patient group.

7.6 Summary

Memory impairment due to stroke can negatively impact memory ability and thus everyday activities. **Chapter 2** of this thesis demonstrated the importance and applicability of subjective memory measures as part of memory assessment. **Chapters 3** and **4** clarified the approaches and strategies that are used in improving memory and functional outcomes for acquired brain injury patients in research and clinical settings. **Chapter 5** provided support for the use of imagery based mnemonic strategies for improving name recall for young adults. **Chapter 6** demonstrated that learning and applying imagery mnemonics may be more difficult for middle-aged and older adults who are already using memory strategies. Taken together, these literature reviews and empirical studies advance our understanding of current memory rehabilitation options after acquired brain injury and provide a basis for future research to further develop along these lines.

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8 Appendix

This appendix chapter describes some of the benefits and challenges we encountered while shifting from in-person to online research during the pandemic. In particular, the face-name experiments were altered to be conducted with online participants through the University of Nottingham Research Participation Scheme and Prolific. The purpose of the case study was to describe some considerations that should be made by researchers who are shifting cognitive aging research online.

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Benefits and Challenges in Pivoting to Online When Studying the Cognitive Aging of Memory

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Abstract

This case study discusses challenges and advantages associated with pivoting from lab-based to online research. We outline three experimental studies related to memory and cognitive aging that were shifted online due to the pandemic. Across these projects, we experienced difficulties in experiment implementation, participant recruitment, procedure compliance, and conference presentations. However, we also found noteworthy advantages to conducting experiments online across these four aspects of the research process. Based on our experiences, we outline solutions we used to remedy the problems we encountered and suggest essential considerations for researchers moving their research from the lab to online.

Learning Outcomes

By the end of this case, students should be able to:

- Evaluate the challenges and limitations in implementing an online experiment in comparison to a lab-based experiment
- Justify the advantages of online recruitment and essential considerations when selecting and using online recruitment platforms
- Contrast different scheduling requirements for lab-based and online recruitment while implementing procedures for engagement monitoring
- Critique the opportunities associated with online, hybrid, and in-person conferences

Project Overview and Context

This case study outlines three research projects that examined cognitive aging and memory which were impacted by changes to the research process when moving from lab-based to online research. Previous research has established that age-related changes in brain structure and function correlate with age-related changes in cognition. Within the scope of normal cognitive aging, there are declines in cognitive functions such as attention, language, and memory (Harada et al., 2013). Memory complaints are common among older adults, and memory deficits can negatively affect participation in activities of daily living (Rotenberg et al., 2019). While semantic memory—memory for general knowledge such as world facts and word meanings—generally remains intact over time, deficits in remembering recently learned information (e.g., names or words) and working memory (ability to temporarily hold and manipulate information) are associated with increasing age. It is therefore essential to examine the extent to which memory is impacted during cognitive aging and explore options to reduce the negative consequences of memory deficits. The three outlined projects were designed to address these topics.

The first project examined a strategy to reduce memory failures in everyday life when trying to remember people's names; the second project explored the impact of the type of memory task on how adults across all

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ages learn and remember. The third project examined the effect of emotion on the learning of associations between images. These projects were initially conceptualized with the expectation of recruiting adults to perform experiments in a lab. However, because of the pandemic, they were adapted to be conducted online. During this process, we found several noteworthy challenges and advantages in the experiment implementation, data collection, and dissemination stages of research that were common across the three outlined projects.

Section Summary

- This case study covers three research projects concerning cognitive aging and memory.
- The three outlined projects were adapted to online research during the pandemic, and the associated challenges and learning opportunities will be highlighted in this case study.

Research Design

These research projects explored the influence of specific factors on memory across adults of all ages using similar methodologies: the first examined how memory strategies can influence name recall; the second examined the impact of task switching and speed of processing on word recall, and the third explored influences of emotion on associated images. During the shift from lab-based to online research, we experienced similar challenges across these projects, but we also encountered unique experiences that led to different considerations and solutions for each project. Moreover, we found benefits such as learning opportunities and skill development as researchers. Highlighting our individual and collective experiences and solutions can provide comprehensive considerations for other researchers attempting to conduct similar online studies.

The first study examined the effectiveness of a mnemonic strategy to improve the learning of face-name associations. Mnemonic strategies are techniques used to mentally manipulate to-be-remembered information to improve recall at a later time (Scruggs et al., 2010). Here we examined name recall using a face-name mnemonic. Instead of recruiting participants locally from the community as initially planned, we used an online platform—Prolific. During the experiment, participants saw images of faces and names below them on their computer screen and were instructed to remember these face-name associations. Half of the participants were instructed to remember the face-name associations using a described mnemonic strategy. The strategy involved two steps: imagining the name transformed into an object, for example, the name "Gordon" transformed into the word "garden," and then imagining the person in the image interacting with that object, for example, Gordon is in a garden. The other half of the participants were instructed to simply remember the face-name pairs to the best of their ability. Afterward, participants saw each face again and had to type in the name. Participants completed two sessions of viewing the face-name pairs and recalling the names and then answered some questionnaires about their memory and experiences during the task in an online survey platform–Qualtrics. The study was designed to be completed within 45 minutes.

The second study examined the impact of task load on memory. Task load is a multilevel construct

representing the "load" imposed on learners' cognitive systems during a task. Older adults have diminished engagement in learning and memory tasks compared to younger adults due to reduced working memory capacity and difficulty ignoring irrelevant information (van Gerven et al., 2000). Therefore, it is important to understand how task load can be manipulated to facilitate learning and memory in this population. Here we manipulated task load through task difficulty. In the experiment, participants viewed short lists of intentionally to-be-remembered words, which were interleaved with a secondary judgment task. In the secondary task, participants viewed and responded to an alternating sequence of numbers and letters. When a number was presented, participants were instructed to press a specified key on the keyboard to indicate whether the number was odd or even; when a letter was presented, participants compared it to the letter presented two times prior, that is, a 1-back task, and pressed a key to indicate whether the same letter had been shown again. To manipulate task load, we varied the presentation pace of the interleaving task to create two levels—*slow* presentation for *low* load, which allowed adequate time for participants to respond, whereas *fast* presentation required *high* load, as participants had less time to respond. All participants completed both task load conditions and recalled the words they saw at the end of each condition. The task was designed to take 30 minutes to complete.

The third study examined how forming associations with emotional images might change pleasantness ratings of the associated information. Prior studies have demonstrated that negative emotional images are remembered better than emotionally neutral images; however, they also lead to worse memory for associations (Madan et al., 2012). Here we are interested in if there would also be changes in pleasantness ratings due to this association learning. We asked participants to "Remember that these images go together," where the left image was either a negative or neutral scene and the right image was always a neutral object. After an initial study phase, participants were presented with each scene again and were asked to choose the associated object from five options, all of which had been shown in the study phase, as a test of associative memory. In the last phase, participants were shown each of the objects and asked to make a pleasantness rating on a six-point scale. Participants were undergraduate students, and the task was designed to be completed within an hour.

Section Summary

- The first project examined the effectiveness of a mnemonic strategy on name recall.
- The second project examined the impact of task difficulty on memory.
- The third project examined the effects of emotion on associated pictures.

Research Practicalities

All three projects began being planned as in-person research studies but had to shift to being conducted online. Therefore, several necessary changes were made to the design, implementation, and dissemination of the research. We will discuss the challenges and advantages of the online research process involving experiment implementation, participant recruitment, procedure compliance, and conference presentations.

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Experiment Implementation

To run an experimental research study, it first needs to be programmed to display information to participants at precise times and record responses from participants. When conducting research in the lab, we programmed experiments using PsychoPy, a software package developed for building behavioral experiments (Peirce et al., 2019). This involved using a "builder" where we selected certain features of the experiment to be displayed on the screen such as images and text. There was also a "coder" where we used the Python programming language to input additional aspects that were not available or more complex than the builder interface allowed. When redesigning our experiments to run online, we encountered several challenges including (1) managing different programming languages and software, (2) browser compatibility, and (3) limited control over experiment implementation. On the other hand, we also experienced advantages including learning a new programming language and related skill development as a researcher.

For online research, experiments need to be made available to participants on their own computers at home while maintaining the structure and stimuli as with in-person experiments. In our studies, we changed from programming the experiments using Python to using JavaScript, which can run in an internet browser. Several options are available for making such alterations including the translation feature of PsychoPy, which automatically changes some Python code to JavaScript, and dedicated online experiment builders such as Gorilla, PsychoJS, or lab.js. We used two of these approaches for the outlined projects. For the face-name association study, we used the lab.js builder and coder; for the task load and emotional image studies, we used the semi-automated PsychoPy translation feature for PsychoJS conversion. In the first study, we determined that a "start from scratch" approach would best allow us to incorporate both image (faces) and text (names) stimuli that were displayed together during the task. It was also important for participants to view their responses as they typed them on the screen. The challenge here was in changing the programming language from Python to JavaScript. For example, while there was a "textbox" component of the PsychoPy builder where names could be typed in and displayed on the screen, this was not as readily available in lab.js. To solve this issue, we used an HTML form where the names were typed in and submitted as a form response for each face, but this required additional JavaScript code to present the images in the correct position while allowing text responses to be typed and viewed on screen. In the second and third studies, the semi-automated translation feature for PsychoJS provided a sufficient starting base that we then built upon to produce the final experiment code. However, the challenge was insufficient translations, and thus, we needed to manually rewrite complex aspects of the code from Python to JavaScript. Across these cases, it was vital for us to revert to an initial learning stage to produce the correct code by following the introductory documentation and examples provided by the respective software used. This required additional time commitments that resulted in prolonged overall study completion times.

The second challenge of experiment implementation came during data collection, where we found that some internet browsers, such as Safari, were incompatible with the programmed experiment. Unfortunately, this issue was not captured during experiment development as we did not typically use this browser. Since Safari is not as frequently used as other browsers, we decided to include a disclaimer at the beginning of the

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task recommending the use of the most compatible browser, Google Chrome. This also highlights the third challenge we experienced, limited control over experiment implementation. During in-person research, an experiment can be tested on the computer that will be used for data collection, reducing the chances of technical errors. However, when collecting data online, computer configuration, screen sizes, and availability of a keyboard number pad are outside the experimenter's control. Moreover, in a lab, it is possible to oversee experiment implementation and thus prevent or quickly diagnose and troubleshoot issues such as participants accidentally exiting the experiment or experiment crashes. However, this control was diminished with our online data collection as participants may have encountered errors in the task but not reported them or simply attempted to restart the experiment. To address these issues, we asked participants to report any issues at the end of the experiment.

While solving the outlined challenges to experiment implementation, we found it beneficial to learn new skills in the form of JavaScript programming, HTML, and CSS that can be applicable in different situations. For example, taking the time to learn the basics through tutorials and practice with examples and instructional videos resulted in improved knowledge of Python, JavaScript, and HTML. We were also able to improve our code to capture the essential aspects of the experiment and allow the experiments to run smoothly without experimenter oversight during data collection. While the second and third challenges had different approaches to the resolutions, we developed essential skills including problem-solving in a time-limited context, for example, implementing a solution before more participants encounter the same error. We also learned to adapt to new challenges such as including disclaimers or questionnaires where necessary. Finally, we learned critical time management skills, that is, scheduling enough time to learn a new programming language while maintaining research progress. In sum, we faced several challenges during our experiment implementation when shifting to online research, including managing different software and browser compatibility while maintaining control over the experiment during data collection. However, finding solutions to these difficulties led to vital learning opportunities and skill development as researchers.

Participant Recruitment

Participant recruitment for in-person studies can include convenience sampling, flyer advertising, and local online platforms. Recruitment involves scheduling, ensuring potential participants meet the inclusion and exclusion criteria, preventing repeated participation in the same study, and ensuring ethical guidelines are followed to protect anonymity during the research process. When moving to online data collection, some of these considerations remained in place, but we also needed to make some adaptations for our experiments. The challenges we experienced included screening eligibility and participant engagement. However, advantages to recruiting online rather than in-person included (1) rapid data collection, (2) large sample availability and diversity, and (3) reduced scheduling requirements.

Online platforms available for recruiting participants include the psychology research participant pool that many universities have, where undergraduates participate in experiments to receive credits, and recruitment websites where individuals can participate and receive monetary payment (Palan & Schitter, 2018; Sauter et al., 2020). In two of our studies, we used Prolific to recruit participants and initially found it challenging

to manage screening eligibility. Briefly, Prolific (https://prolific.co) is an online platform for recruiting research participants when conducting behavioral, user, or market research. We prescreened potential participants using Prolific filters with demographic (e.g., age), geographic (e.g., current country of residence), and language fluency (e.g., English as a first or fluent language) criteria. However, these filters are based on self-reports from participants and can be falsified to maximize study participation opportunities. To reduce this possibility, we included questions *within the experiment* that matched the phrasing of the Prolific filter questions to verify consistency. When doing so, we found some discrepancies between the Prolific demographic output data and the responses in our questionnaires, leading us to question whether we were recruiting our intended sample. To resolve this issue, we contacted participants via the Prolific messaging system to confirm the correct information, but this required increased time and effort because the responses sometimes meant that their participation was invalid, and thus the slot had to be reopened.

Another challenge of online recruitment is that some participants engage with research studies as a form of work with the intention to maximize monetary compensation and thus regularly participate in multiple research studies throughout the day. This may not only result in fatigue but also in non-naivety, where participants are familiar with research methodology and maybe "vulnerable to demand characteristics by providing untrue responses based on their perceptions of researchers' expectations" (Newman et al., 2021, p. 1385). In our previous experiments, we found participants trying to maximize monetary compensation by randomly clicking answers or providing incoherent responses, as this would allow them to complete the study and get paid more quickly. To address this, we subsequently included attention checks and open-ended questions to filter out unengaged participants. Moreover, dedicated research platforms such as Prolific attempt to prevent these instances and provide information about participant engagement. This information can be used to identify "super workers," for example, if their number of completed or rejected studies is unusually high in comparison to the other participants. This was an important consideration for us when deciding where to recruit participants for our studies—though the cost is higher when using such platforms, as opposed to distributing the link to a study through social media, these mechanisms in place can improve data quality.

Across our research projects, we also experienced considerable benefits of using online recruitment platforms. First, data collection was completed within 2 weeks with multiple recruitment postings in a day, whereas in-person data collection for a prior study required months of booking shared lab space. Moreover, the sample availability was much larger and more diverse compared to in-person recruitment, which mostly included university students. This was particularly beneficial for our aging research, as recruiting older adults in person would require travel to participate, limiting engagement. In addition, with a more diverse sample of online participants, study findings can be more generalizable to wider populations. Finally, we experienced a substantial reduction in scheduling requirements; where our prior in-person studies required multiple emails, booking the lab space, and a limited timeframe based on researcher availability, online recruitment allowed for improved scheduling as we were able to publish our studies and allow participants to participate at their convenience. In sum, screening eligibility was relatively challenging compared to in-person recruitment for our projects, but we determined that selecting a recruitment platform that provides reliable participants is crucial. Moreover, online recruitment has considerable benefits, including faster data collection, a wider sample, and

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reduced scheduling requirements.

Procedure Compliance

In-person testing does not typically require the experimenter to include "attention checks," as participants normally have minimal distractions in the lab and can ask for further clarification if necessary. The experimenter's presence in the room can facilitate procedural compliance, and instructions can be given through a combination of verbal communication, body language, and demonstrations. However, online testing does not allow for this ready interaction with the experimenter, thus requiring additional steps to ensure instruction comprehension and adherence. In our studies, we found it challenging to have limited opportunities to provide instructions and improve participants' comprehension where needed or prevent the use of external memory aids such as notepads during the memory tasks. Nevertheless, with careful consideration, appropriate checks were implemented remotely, significantly saving us time and resources.

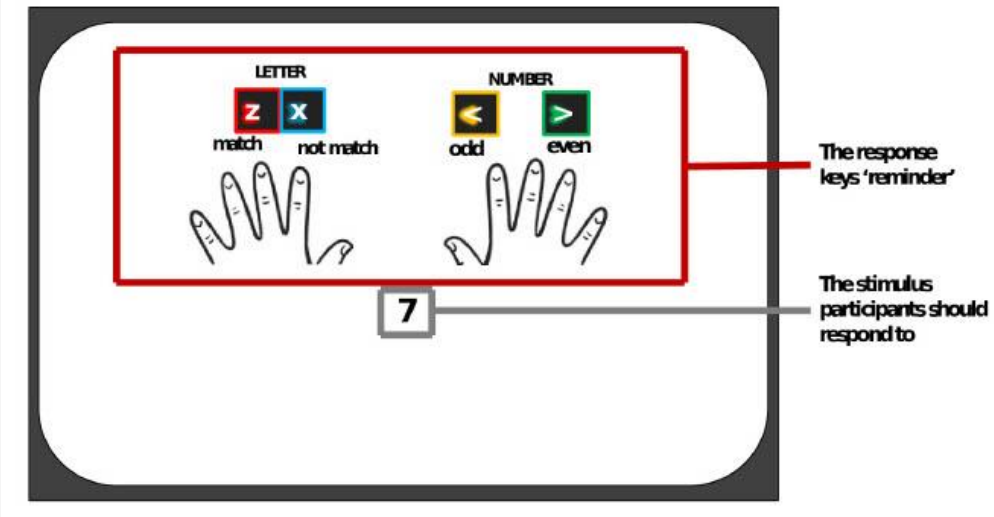
Our first challenge with procedural compliance was whether online participants had sufficient and accurate comprehension of instructions without interacting with the experimenter. This was important because our experiments involved multiple steps of stimuli exposure and responses. For example, our face-name association study required participants to understand and apply the strategy, while the task load study required participants to make multiple types of responses during the task while remembering the word lists. The issue of procedure compliance in online tasks is commonly addressed with attention-check questions or additional instructions throughout the task (Gummer et al., 2021; Shamon & Berning, 2020). These may include questions that are phrased in an irregular way, likely out of context with the rest of the survey or task. An example of an attention-check question in a survey assessing memory strategies used in daily life, participants could be asked: "Have you ever had a fatal heart attack while watching TV?" However, we were particularly concerned that asking participants in a memory study if they have understood and followed the instructions may not necessarily elicit honest responses—unlike survey questionnaires which may not have a "correct," but only the "best" answer, our task load task was characterized by a dichotomous, "right-or-wrong" response. Thus, participants who consider their performance as an aptitude index may be motivated to achieve correct responses. Conversely, due to being unmonitored, those who only participate to get monetary rewards may haste through the instructions without full comprehension, especially when the instructions are complex. To improve instruction comprehension, we included a practice task at the beginning of our experiments; yet, this prolonged the tasks and could not guarantee comprehension or adherence to instructions throughout the experiment. To check instruction comprehension, we asked participants questions about the instructions they were given before the task. Multiple incorrect responses indicated that participants did not understand or were not engaged. However, even if participants answered these questions correctly, conceptual understanding does not necessarily translate to the acquisition of the psychomotor responses, especially when participants were asked to respond with predefined keys, as with our task load study.

When testing in person, participants learned the instructions from our demonstration, completed several practice trials under monitoring, and received real-time feedback from us if they made an incorrect response. For the task load study, we also placed stickers on the keyboard to indicate the mapped response keys,

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providing tactile feedback to facilitate rapid psychomotor learning. In contrast, during online testing, participants may read the instructions, learn to associate pressing the left or right arrow key in response to an odd or even number, yet still need additional practice. To address this issue, we added a visual instruction to remind participants of the response keys throughout the task (Figure 1), but this resulted in limited control over the actual mapping of participants' own keyboards. For example, the mapping would differ if participants had a full keyboard with the number keypad or a laptop keyboard (without a number keypad). Without tailoring to individual devices, a standardized instruction page can be misleading, and some participants also found the reminder instruction distracting. These issues raise questions about the benefits of having additional instructions on the same screen as the task. Additionally, having both instructions check questions and practice trials can be time-consuming and without fully understanding the instructions, participants may still score above chance level in a choice reaction time task like ours. This further complicates data analysis, where we must decide on the performance criteria for participant exclusion. Therefore, having questions and practice trials prior to commencing the experiment proper like online survey questionnaires may not reliably prevent instruction misconception in memory studies with behavioral tasks.

Figure 1. A schematic of a trial stimulus and response key reminder.



Note. The two hands and mapped response keys (red box) is the reminder, shown on top of the screen. The number "7" (gray box) is the stimulus participants respond to. In this example, the correct response key is the left arrow key, corresponding to the right index finger. These images are not scaled to size to improve visibility.

This leads to the second challenge we encountered with procedural compliance: in memory studies, participants' motivation to achieve high performance, the absence of an experimenter, and the lack of real-

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time feedback may have driven incompliance. Specifically, our concern is participants' use of external aids to help them remember. Across our studies, there was a memory component that required participants to learn and recall information, making the tasks especially challenging. Without the presence of the experimenter engendering a sense of being monitored, online participants may use unwanted external aids for memory offloading, such as writing down to-be-remembered information or cues on a notepad. Here, having an additional instruction asking participants to *not* use external aids creates a dilemma: first, the extent to which participants follow this instruction cannot be verified. For instance, if a recall ceiling effect is observed, we cannot differentiate genuine recall from participants who have exceptional memory and those who use external aids. Second, the additional instruction may inadvertently cue participants who did not previously consider using external aids to do so. Specifically, participants who consider their performance as an aptitude index, being performance-driven, or incentivized by the monetary compensation may be more mindful about their data quality, therefore inclined to use these methods. Hence, the validity and reliability of using additional instructions to improve procedural compliance remain questionable. One potential solution to this issue is to ask participants at the end of the experiment whether they used any aid to improve their memory during the task while emphasizing that they would retain their compensation to encourage truthful responses. In summary, challenges to online procedure compliance include limited oversight by the researcher to improve instruction comprehension and prevent the use of external memory aids, but these challenges can be subverted by implementing checks that are carried out remotely, greatly reducing time constraints for the researcher.

Conference Presentations

Attending and presenting at academic conferences is an integral aspect of being a researcher and an essential skill to be developed, especially for junior researchers. For many years, conferences have discussed shifting to online to improve inclusivity and decrease contributions to climate change (Aron et al., 2020; Gichora et al., 2010). As research is increasingly adjusting to be online, the numbers of virtual or hybrid conferences have also been soaring since last year. While this has created unprecedented opportunities and encouraged equality, diversity, and inclusivity on a large scale, we highlight several challenges we experienced, including (1) reduced professional networking opportunities, (2) limited audience–presenter interaction and learning from feedback, and (3) conference platform-dependent user experiences. These challenges underline the need for academics and conference organizers to leverage the benefits of virtual and hybrid conferences while generating creative solutions for the betterment of future conferences.

On the macro level, virtual conferences can save the rigmarole of traveling across country borders or time zones, encouraging the participation of disadvantaged researchers. The reduced amount of travel can also significantly decrease carbon emissions and help fight against climate change (van Ewijk & Hoekman, 2021). However, compared to in-person conferences, there are fewer networking opportunities through casual interactions, for example, "water cooler" conversations. Although virtual conferences often dedicate time slots or virtual chat rooms for networking, these discussions lack spontaneity compared to in-person encounters, especially given the transparency of attendees' names. In contemporary Western culture, employees who

spend more time in the office are generally perceived as more committed to their jobs regardless of actual productivity levels (Nakrošienė et al., 2019). Similarly, in hybrid conferences, in-person attendees may be seen more favorably compared to virtual attendees and are exposed to more networking opportunities during conference break times.

On the microlevel, attending virtual conferences may require researchers to prerecord their presentations. This practice is beneficial for (1) creating digital archives that facilitate open access and open science practices, (2) freeing attendees from "fear-of-missing-out" as they can view talks that they might have otherwise missed due to scheduling conflicts, and (3) permitting errorless learning for inexperienced presenters, as they can use notes to refine their presentation without being exposed to a large audience. However, these practices also limit engagement and reciprocal interactions between researchers and audiences. For instance, a principal investigator may simply prerecord the presentation and delegate the question-and-answer sessions to a junior lab member during the conference. Furthermore, virtual conference platforms such as Zoom and Teams allow the audience to switch off their cameras and microphones. During presentations of the outlined projects, this limited our opportunities as presenters to receive real-time feedback through body language cues and adjust our presentations accordingly, creating an "errorless, but no learning" scenario.

During a virtual poster presentation in the Gather.town platform, we experienced the faux pas of immediately asking if an attendee wanted to hear about our study, while they were still listening to the prerecorded video. These situations occurred due to the lack of social cues we normally experience in face-to-face communications. Finally, in virtual or hybrid conferences, the experience largely depends on the platform user interface and internet stability. While some platforms provide easy-to-navigate interfaces, others focus on embedding excessive functions and links which can be confusing and overwhelming. We have also experienced website crashes due to high traffic or disruption of the prerecorded video due to compatibility issues. Taken together, virtual or hybrid conferences improve general inclusivity, but those who do not have a stable internet connection and, thus, access to the required conference software may be at a disadvantage in virtual or hybrid conferences—an important issue that should be considered by academics and conference organizers. One option would be to allow text comments to be left at the presentation by conference attendees, allowing for the presenter to later leave a response comment as well. This asynchronous communication can allow for presenters to get more feedback from attendees that may have otherwise been unable to view the work at the scheduled time due to other responsibilities or time-zone differences.

Section Summary

- Programming an online experiment required managing different software and programming languages, browser compatibility, and experiment control. Solving these challenges presented critical learning and skill development opportunities.
- Online recruitment and data quality can be challenged by participants' motivation for participation. After screening tools and check questions were implemented to verify demographic data

consistency, online recruitment had clear advantages—including rapid data collection, diverse samples, and reduced scheduling requirements.

- Challenges to online procedure compliance included limited oversight by the researchers and preventing the use of unintended external memory aids. However, it is possible to maximize procedure compliance by implementing attention and comprehension checks, as well as performance data quality checks.
- The rise of virtual or hybrid conferences has greatly improved inclusive participation. However, these types of conferences may also result in reduced networking opportunities and presenter–audience interactions.

Practical Lessons Learned

- *Take the time to learn.* To move our research projects from in-person to online, we needed to change our experiment programs from Python to JavaScript. While initially relying on the automatic translation feature for its convenience, we soon realized its insufficiency, causing us to revert to the beginning phase of programming language learning. Our first takeaway from this experience is that the best approach is to take a step back and learn the basics. The second takeaway is the importance of testing the experiment on multiple browsers and operating systems to check compatibility. Finally, we found that although control over the actual experiment implementation is limited, it is possible to capture relevant experiment information such as screen size, operating system, browser, and whether participants encountered any issues during the experiment which can then be examined to improve consistency during online testing.
- *Online recruitment can provide quick data but is it reliable?* While online recruitment is appealing because of rapid data collection, it is important to consider unspoken aspects of data quality. Although online platforms may have prescreening options which can improve sample quality, these are often self-reported and should be cross-checked within the experiment. It is also necessary to consider the type of recruitment platform and if participants engage with the platform as a major source of income as this may influence the data quality. Finally, online data collection can be instantaneous, saving tremendous time from haphazard scheduling, sharing a limited lab space, and allowing participants to participate at their own time of convenience. We acknowledge these myriad benefits, and as more data are collected online, we expect better methods to improve data quality.
- *Approach the task and instructions from the participants' perspective.* Despite the emerging use of online testing for behavioral tasks, we faced extra challenges in our memory and aging studies. First, participants' comprehension of instructions should be evaluated when the task involves complex response contingencies. Although it is possible to check instruction comprehension by asking questions about the instructions, correct answers may not equate to real comprehension or adherence. Online testing for learning and memory experiments can be further complicated by whether performance is truthful and reflects participants' real memory capacity, that is, without the use of unintended external memory aids. As experimenters, it is important to approach the task

and instructions from participants' perspective, being clear, yet simplifying task instructions, and implementing checks before, within, or after the task to encourage procedural compliance.

- *Focus on learning when attending virtual/hybrid conferences*. While presenting the outlined projects at hybrid conferences, we not only benefitted from fewer travel requirements and the convenience of prerecording our presentations but also experienced the challenge of presenting to an audience with limited social cues. Additionally, we have remaining queries on professional networking opportunities because of the "unnatural" flow of virtual or hybrid conferences and inclusivity being dependent on internet or platform accessibility. Altogether, virtual and hybrid conferences can be beneficial if we focus on the available learning opportunities.

Section Summary

- When designing an online experiment, it is important to take time to learn the new software, test the experiment thoroughly, and identify components that can vary across devices.
- Online recruitment is appealing due to rapid data collection, but it is essential to evaluate the available platforms and confirm prescreened measures by embedding questions in the experiment.
- It is important to consider participant perspectives when designing an online task and check comprehension and adherence to the instructions as the experimenter is not readily available as in the lab to provide support.
- Virtual and hybrid conferences immensely improve inclusivity, but it is equally important to actively seek out networking opportunities and audience feedback to adapt to the virtual presentation format.

Conclusion

When moving from in-person to online research during our studies, we found several challenges in the experiment implementation, participant recruitment, procedure compliance, and conference presentations. We approached these challenges by taking the time to learn a new programming language to efficiently code an online experiment, carefully designing questionnaires to screen participants, implementing comprehension checks to make sure our instructions were being understood, and using the tools provided by conferences to improve our opportunities to disseminate our research. These challenges served as an important feature of our shift from in-person to online research as they have led us to be adaptive to the changing aspects of research and required us to critically assess our research methods.

We also experienced notable advantages to conducting research online as opposed to in-person. These included the opportunity to develop new programming skills as a researcher that will aid in preparation for future opportunities, rapid data collection through online platforms that provide features to improve data quality, the ability to implement procedure compliance checks remotely to reduce time commitments, and the opportunity to attend more inclusive conferences to disseminate our research to the wider community. We suggest that researchers who are embarking on a similar approach of shifting to online research consider the challenges and benefits in experiment implementation, data collection, and dissemination aspects of research

outlined here.

Classroom Discussion Questions

1. What are some considerations that are unique to designing an experiment that will be run online?
2. What are some differences between recruiting participants online versus in-person?
3. For an experiment related to a different domain of cognitive psychology, what are some additional measures that might be necessary for ensuring that online participants comply with task instructions?
4. Some conferences have organized international multisite events, where groups meet in their local city with presentations live-streamed to all sites around the world. How do you think this model will be used in the coming years, as an alternative to in-person or hybrid conferences?
5. How does the relatively new possibility of online presentations change our ability as researchers to engage in science outreach with the broader community?

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Web Resources

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