EXPLORING THE ROLE OF LATE-OCCURRING NONSPECIFIC RETROACTIVE INTERFERENCE AND INTEREST ON RECALL

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ABSTRACT

Any form of post-encoding distraction, known as Nonspecific Retroactive Interference (NRI), may cause forgetting (Keppel, 1968; Wixted, 2004). However, recent experiments have not always found evidence for NRI and its effect may be very mild. NRI was tested across five experiments which aimed to take the epistemological approach of cognitive memory and forgetting research, and to incorporate the educational psychology domain of motivated learning through interest development. This enabled the exploration of factors which may affect NRI based forgetting, including wakeful rest, mind wandering (MW), and various forms of interest. Verbal memory was tested within a short-term (five-minute retention intervals) learning and recall setting by comparing conditions where NRI (usually elicited by spot-the-difference tasks) was present or absent. This project carefully manipulated the role of prior-tasks, measurements of interest and MW (depending on conceptualisation), and the NRI task. As a result, the thesis was able to explore the role of fatigue vs. cumulative similarity interference, the reliability of NRI effects, and provide a cognitive explanation of interest-based learning. The results demonstrated that (1) overall effects of NRI were more reliable than first hypothesised. (2) Interest is separate from NRI within this paradigm as it increases recall during the encoding phase, with interesting facts being retained more, but experiencing a similar susceptibility to interference as less interesting facts. (3) Subjective interest increases recall, with dispositional individual interest modulating the amount of situational interest evoked by the stimuli. (4) MW decreases recall but any interaction with interest requires further exploration. (5) Recall was consistently worse if the NRI condition was late-occurring, and there was limited evidence for a fatigue explanation. It is put forward that NRI is a low-level form of diversion interference which can accumulate with similarity-based PI, and potentially cognitive load.

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I would like to dedicate this thesis to one of my childhood idols; my grandad, Harry Hibberd who is suffering through one of the most heart-breaking types of forgetting dementia. Thank you all.

ABBREVIATIONS

CI	Control- Interference (condition order)
IC	Interference-Control (condition order)
IIQ	Individual Interest Questionnaire
MW	Mind Wandering
NRI	Nonspecific Retroactive Interference
PI	Proactive Interference
RI	Retroactive Interference
S-T-D	Spot-the-difference
TBRS	Time-Based Resource-Sharing
TOT	Time On Task
TSI	Triggered Situational Interest
TUT	Task Unrelated Thought
SIMPLE	Scale Independent Memory Perception and LEarning
SWS	Slow Wave Sleep
VWM	Visual Working Memory
WM	Working Memory

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CHAPTER 1

Our memories are fragile once initially formed, making them prone to interference-based forgetting. Retroactive interference (RI) occurs when newly learned information hinders the recall of previously learned information thus increasing forgetting and hindering learning and recall. Imagine boiling a kettle then having a conversation while it boils. The conversation may distract you from the task even though it is not related to the task, causing you to forget the initial action. This is known as nonspecific retroactive interference (NRI). It is nonspecific as the distracting and therefore interfering information is different and unrelated to the previous learned event. This NRI is purported to be the primary cause of everyday forgetting (Keppel, 1968; Wixted, 2004b) as it is common to switch attention between unrelated tasks throughout the day (did you remember to lock the door on your way to work this morning?). However, interference itself can be prevented, or at least minimised. It has been found that the later the onset of the interfering task post encoding (the initial acquisition phase of the memory), the greater the recall performance (having the conversation shortly after boiling the kettle will increase the influence of interference, whilst delaying the conversation would provide a form of ‘wakeful rest’ that increases the consolidation potential of the memory (Dewar, Alber, Butler, et al., 2012; Ecker, Tay, & Brown, 2015; Mercer, 2015).

The introduction will begin by defining forgetting and broadly exploring the historical background literature of the two main theories of forgetting: Decay vs. Interference (similarity vs. nonspecific). The second section will explore the literature surrounding NRI including prevalence, salience, and underlying mechanisms. Following from the understanding of the mechanisms of NRI the final section will explore an educational psychology factor of learning that may reduce it: Interest development.

Defining Forgetting

Forgetting is often seen as a nuisance, an annoying phenomenon which plagues individuals through different aspects of life. It is commonly accepted that learning is a by-product of the processes involved in memory, whilst forgetting is a failure to learn, a failure of memory, and the result of a defective memory – resulting in the inability to retrieve previously stored information (Cubelli, 2010). Nairne and Pandeirada (2008, p. 179) stated that "forgetting is a scourge, [] nuisance [and] breakdown in an otherwise efficient mental capacity". However, rather than simply a failure of memory, mechanisms of forgetting have formed over time to have an adaptive purpose, with the forgetting of irrelevant memories allowing for more adaptive and flexible behaviour (Bekinschtein, et al., 2018). For example, we may forget or 'inhibit' competing items in memory to make other similar items more readily available (MacLeod, 2002). Imagine, for instance, trying to find where the car is parked today on a multistorey carpark where it had been parked numerous times previously. All the previous instances would provide irrelevant competing information to sort through, hindering recall efficacy (Anderson & Neely, 1996). In this way both memory and forgetting processes are complimentary to the learning process, involved in the construction and maintenance of useful memory representations (Markovitch & Scott, 1988).

Despite the positive and adaptive value of forgetting, a failure to accurately recall information can be problematic. Similar to the concept of the 'seven deadly sins' in Christianity, Schacter (1999) argued that there are seven basic 'sins' of memory. The first three sins are the most relevant to this thesis and will be looked at in more detail as they are forms of forgetting: transience, absent-mindedness, and blocking. Following this there are three sins which cover types of distortions: misattribution, suggestibility, and bias. The final sin, aptly named *persistence*, relates to intrusive or hard to forget memories. Returning to forgetting, t*ransience* refers to the temporal element of forgetting – first explored by Ebbinghaus' (1885) forgetting curve – whereby the recall of a memory trace becomes more difficult over time. It is seen that forgetting in this way is a power function of time. This means that forgetting is initially very rapid and whilst the total amount of forgetting continues to increase over time when experienced without maintenance or rehearsal of the memory trace, the rate of forgetting decreases or plateaus over time. Simply put, forgetting rapidly occurs within seconds of the initial memory trace and while forgetting continues to happen, the speed of forgetting slows down over time creating the forgetting curve. *Absent-mindedness* is the form of forgetting which occurs when a memory is insufficiently attended to during the initial encoding phase (the phase where a memory [trace] is first formed). An example of this is the misplacement of items (keys, wallet, phone etc.) while multitasking as the lesser attended to task/stimuli receives poorer, shallower and superficial processing. This leads to a poorly encoded and weak memory trace, exemplifying the traditional conceptualisation of forgetting as memory failure and a prevalent everyday nuisance. The third form of forgetting is *blocking*. Schacter mentions that one of the most prominent examples of blocking is the "tip of the tongue" state, whereby the memory trace exists but the retrieval is hindered, partial (similar phonological sounds, or semantic information) or delayed (but potentially fully retrievable). This fits within the cue-overload paradigm (see page 13).

Misattribution, bias, and suggestibility — sins of distortion — are attributes which influence the memory understanding and quality. Misattribution refers to a distortion of the engram affecting the accuracy of specific details around a memory, i.e., remembering an instance but confusing the time (see retrieval induced failure and temporal distinctiveness theories below). Similarly, suggestibility shows how the recollection of specific details of an event may be warped by the phrasing of the questions i.e., in eyewitness testimony. Personal beliefs and prior knowledge have also been found to bias the type of information recalled (that which conforms to your beliefs may be easier to remember) as well as your emotional state – a negative emotional state leads to more negative recollection of instances.

The final sin involves intrusive memories that cannot be forgotten and – as with bias – is linked to emotional valence, i.e., strongly negative memories being recalled outside of the individual's deliberate control. Similarly, a positive emotional state, such as evoked 'interest', may increase the strength of a memory trace to increase learning and this learning will be the secondary focus of the current thesis, with the main focus being cognitive forgetting.

The early study of memory and forgetting such as decay theory (see below) viewed forgetting as a loss of information over time, potentially leading to permanent loss. However, while this complete loss of storage remains a theoretical possibility, Davis (2008) argued that it is currently impossible to scientifically test this on humans as the complex neural circuitry would need to be fully mapped out. Davis (2008) argues that the only true evidence of this strong form of forgetting can be provided once all cellular and molecular events resulting from a memory's formation return to the original state (Roediger, Weinstein, & Agarwal, 2010). This strongly links to the evidence of neuroplasticity (the process within which new connections are made and changed by neurons and synapses in the brain to make associations, adapt, and learn) being crucial to the learning process (Gulyaeva, 2017). Bjork (2014) defines forgetting as a decrease in retrieval strength at a given point of time, within the presence of retrieval cues. Modifying this definition for the purpose of this thesis, forgetting results from an inadequate process of retrieval of previously learned information, resulting in weakened accessibility or a potentially inaccessible memory trace. This definition befits learning scenarios such as written exams where retrieval cues are not present.

Explaining forgetting: decay or interference?

How can the above types of forgetting be explained? The two major theories of forgetting are decay and interference.

Trace Decay

As with Schacter's (1999) sin of transience, 'Trace decay' theory argues that a memory may decay and atrophy (like a muscle) over time, *potentially* resulting in the permanent loss and erasure of a memory (Thorndike, 1913). This was developed to explain the forgetting curves produced by Ebbinghaus (1885) from one of the first known studies of memory. Ebbinghaus found that forgetting occurred rapidly immediately after the learned period, with the rate of forgetting plateauing over time. Peterson and Peterson (1959) found that increasing the length of time of the retention interval before recall led to a decrease in recall scores within a relatively short period of time, with recall performance matching the pattern of the early forgetting curve within the time frame of just 0-18 seconds. Whilst there may be a biological premise to decay theory, a behavioural explanation is trickier as not all memories are lost over time. As decay theory uses the absolute passage of time to explain forgetting, the theory has received numerous criticisms for its over-simplistic nature which fails to explain *why* forgetting happens, and for uncertainty over the mechanisms that are involved. It is also unable to explain instances where memories last overtime, such as consolidation (linked with sleep benefits), serial positioning (the primacy and recency effect), reminiscence, and hypermnesia (Brown, 1923; Brown &

Lewandowksy, 2010; Erdelyi & Kleinbard, 1978; Healy, et al., 2000; Jenkins & Dallenbach, 1924; McGeoch, 1932; Roediger, WeinStein, & Agarwal, 2010; Talamini et al., 2008).

The strongest source of support for a time-based decaying theory of memory within the modern literature is provided by the study of rapid forgetting (within seconds) and adopted by the Time-Based Resource Sharing (TBRS) model proposed by (Barrouillet et al., 2004).

The TBRS model states that "recall performance is an inverse function of time during which attention is engaged in processing, impeding the refreshing of memory traces." (Portrat et al., 2008, pp. 9-10). Through this theory forgetting results from a lack of memory maintenance caused by the 'trade off' between the processing of information and the storage of information within the Working Memory (WM) system: "WM is the system enabling online maintenance of representations for ongoing cognition" (Souza & Oberauer, 2016, p.1). Memory traces decay rapidly within the WM and executive attention is required to rapidly switch between the refreshing and maintenance of the memory traces, and the processing of cognitive tasks/newer information (Glavan & Houpt, 2019). The longer the time attending to other tasks the less time or attentional resources available to prevent forgetting. This is moderated as a function of cognitive load (how difficult or mentally taxing an activity is) with the higher cognitive load tasks experiencing worse processing trade-offs leading to trace decay (Barrouillet, 2015).

To test the temporal decay hypothesis Barrouillet et al. (2012) utilised complex span tasks and manipulated the cognitive load of attention processing to measure rapid forgetting. Participants were asked to remember a sequential list of 16 (eight per condition) memory items (either letters or spatial locations) for 1000ms while verifying the accuracy of multiplications with a keyboard response. Attentional processing was manipulated via presentation i.e., 6 x 7 = 42; six x seven = forty-two, with the latter condition taking longer to process. Both conditions contained the same period of time for remembering stimuli and differed only in the processing manipulation. On average participants took longer to respond to the digit problems (504ms longer for the letter list, 371ms for the spatial locations) and this processing vs. storage processing ‘trade off’ led to significantly decreased recall scores in the letter condition. This is consistent with the rapid decay theory (occurring during 1 second and 1.5 seconds) and the TBRS model, with the additional attentional processing being argued to hinder the refreshing of the memory traces in the WM capacity necessary to prevent decay. However, the TBRS model is often criticised by alternative interference-based/ event-based theories (discussed in-depth below).

Interference Theory

As noted above, the major alternative to decay is interference theory, which is a theory of forgetting where interfering events disrupts the process of learning, as associative information compete for a “place” in the retention of memory. An early example was reported by Bergstrom (1893), who found that when placing cards (with an associated word attached) into place, participants appeared more confused and placed cards more frequently into positions they had placed them in previous rounds. This experiment discovered the interference of associations. There are two main forms of interference within the learning theory: **Retro**active interference (RI) and **Pro**active interference (PI). PI occurs when previously learned information interferes with the retention of new stimuli/information (Underwood, 1957). Retro (meaning previous) active interference occurs when newly learned information interferes with previously learned information, increasing forgetting (Nairne & Pandeirada, 2008).

Proactive Interference

In the early literature, the emergence of PI led to a temporary loss of confidence in RI theory (Dewar et al., 2007; Wixted, 2004b; 2005) and decay theory as a way of explaining time-based forgetting (McGoech, 1932; Underwood, 1957). PI is particularly evident if the stimuli are similar in nature. In fact, one of the main early theories of PI, termed 'cue-overload theory' (Wixted, 2005), will be explored as a mechanism of PI and discussed in the similarity interference section below due to PI's strong prevalence as a form of associative forgetting.

Bower (2000) provides a great everyday example: If you have trouble remembering the name of someone's second husband because the name of their first husband keeps coming to mind, this is an example of PI (and an awkward conversation!) Keppel and Underwood (1962) retested the rapid forgetting experiment by Peterson and Peterson (1959) with the aim of testing PI. The hypothesis was that forgetting occurred not from decay over time, but from increasing PI from the prior trial. By testing the initial trial for each interval (trials without PI), the same rate of decline was not found, supporting PI. However, this finding was not consistent when re-tested with a more difficult verbal list (Baddeley & Scott, 1971). Instead, one of the best ways of testing the prevalence of PI is to measure how long it takes for participants to respond accurately and correctly. As PI results from previous representations, participants may not forget these items but instead may experience a greater confusion of items and have to 'sort' through associated memory traces. This is found in numerous experiments utilising the 'recent probes' task (e.g., Berman, Jonides, & Lewis, 2009; Jonides et al., 2000; Nee et al., 2007) and has been found not just to decrease response certainty but to induce time-based forgetting effects. Mercer and Duffy (2015) used similar but unfamiliar (abstract) visual items using the recent probes task. Participants were asked whether a target image matched the previous exemplar and responded 'match' or 'no match' within a trial. The interval lengths between each trial were manipulated between 0.3-8.3s. Whilst participants believed that their recognition accuracy (correct 'yes' responses) were measured, with the recent probes task the experimenters are interested in the unmatched 'no' responses, as this is where PI is manifested. The results showed that response accuracy was much lower if the target image was shown in a previous memory trial (recent negative) than if the target image was novel (not a recent negative—the 'control') and that this also occurs as a function of time, with the worst accuracy occurring at 0.3s and increasing to the control accuracy at 8.3s. This indicates that PI may also function within the rapid-forgetting timeframe found by Peterson and Peterson (1959), and is parsimonious with Campoy's (2012) time-based finding that information may be lost over the short-term but also found that PIs influence may decrease in prevalence over time.

Retroactive Interference (RI)

As noted above, the major alternative to PI is RI. Müller and Pilzecker (1900) pioneered research into RI, which was first called retroactive inhibition, by discovering its effects on memory consolidation during their research. In their first experiment (demonstrated in Figure 1.1 below), participants were provided with six paired syllables from List A, followed by a rest interval of 32 seconds and then eight syllables of List X (the interfering list). Cues were then provided testing for a mixture of A and X responses, of which only the retention of A was recorded (condition 1). To see if List X interfered with memory for List A, a control condition was added without interference. The participants learned the paired syllables but only experienced a retention interval and no interference list. In condition 1, participant's correct recall percentage was 23% compared to 48% for the control List B. Therefore, this was one of the first studies to uncover the effects of RI, as the correct responses from participants were more than halved by the stimuli from List X. As List X was similar in nature to the stimuli of List A, this provides support for Bergstom's (1893) study, as List X facilitated RI and impaired overall memory retention in comparison to the control list (Lechner, Squire, & Byrne, 1999).

Figure redacted for online publication to prevent copyright

Figure 1.1. Reprinted from Lechner, H. A., Squire, L. R., & Byrne, J. H. (1999). 100 years of consolidation—remembering Müller and Pilzecker. Learning & Memory, 6(2), p.80. The figure shows the method of Muller and Pilzecker's first experiment.

A second experiment by Muller and Pilzecker (1900) aimed to test whether RI was present for unrelated material as well. The second experiment was set up similar to the first, with the distractor task of List X being replaced with visual stimuli: three landscape pictures which participants were to describe before recalling List A (a control List B was again included). As with the previous experiment, the retention of List A was lower than the retention of control List B (24% vs. 56%), as the distractor task, although unrelated to the stimuli of List A, facilitated RI and impaired recall. Muller and Pilzecker argued that RI reduced the ability of participants to achieve a ‘preservation tendency’ (unprompted repetition in thought) that otherwise would have induced greater potential for consolidation. However, it is also argued that the RI impairment may not be specifically due to the preservation tendency, as much as how mentally effortful the interference task is. i.e., The greater mental effort needed to perform the task, the lesser the potential for consolidation. This is congruent with the TBRS model and resource depletion (the concept that there are limited cognitive resources for attention and memory; [Chen et al, 2017]).

An adaptive value of RI has been demonstrated by Hensley et al. (2019), who found that negatively emotional memories can be subjected to RI. When negative picture lists were followed by interfering picture lists, there was a reduction in the ability to recall the previous negative list, reducing the amount of negative memory items accessible during free recall which is an experimental recall condition where individuals attempt to recall stimuli in any order, without retrieval cues/prompts. Furthermore, an adaptive and experimental value of RI as an explanation of time-based forgetting is provided by Georgiou et al.’s (2019) ‘Retroactive Interference Model of Power-Law Forgetting’. Here, the power of the memory trace is assumed as a function of its importance, with the primary assumption of the model being that the maintenance of the memory system involves replacing less important information within the memory system with newer, more important information (items with greater valence/power). Older items may be retained if the newer items have a lower valence power. Utilising a recognition task intermittently amongst a sequence of 500 words and including data from participants who achieved perfect 2 n-back results (recognition of words shown two sequences prior), Georgiou et al. found that RI with the multidimensional valence of importance component within the model was sufficient to explain the results without the need for PI or consolidation interpretations, and was consistent with the historical forgetting/retention curves. RI, therefore, is an important component of the forgetting process which will be explored further throughout this thesis.

Evidence for congruence between Decay and Interference

Portrat et al. (2008) conclude that it is possible for the two forgetting mechanisms (decay and interference) to be related. Support for this idea can be seen in an experiment by Pertzov at al. (2017) on visual WM (VWM), where participants had to use their memory to revert a coloured item back to its originally experienced orientation. Pertzov et al. found that memory errors increased as a function of both the number of items (different coloured shapes) and the passage of time (1-3 seconds), indicating that both the previous memory representations (interference) and the temporal element of rapid forgetting were connected as a function of accurate recall. Campoy (2012) concluded that rapid loss of a memory trace from the WM system from the TBRS account occurs over a matter of seconds, then the interference of representations takes over. However, most of this evidence is based on VWM and as stated by Mercer and McKeown (2014), who also found decay in short-term nonverbal memory, the case for verbal memory is still open. While decay theory has received a lot of criticism as a behavioural explanation of time-based forgetting - interference theory remains a prominent experimental focus in the empirical literature.

Types of Interference

Similarity-Based Interference

The previously mentioned research, theories, and examples of interference of memory representations predominately centre around the findings that memories hinder the recall of other competing similar and associative memories/stimuli. The prior studies of PI above are prime examples of this, along with the previously discussed research on RI, as the primary method of measuring interference was conducted using the associative memory procedure the A-B A-C paradigm or associative stimuli lists. Within the A-B A-C paradigm, participants learn a list of paired words (A-B) such as dog (A) with door (B), and a second list (A-C) with the same A cue and different C cue i.e. dog (A) with car (C). When provided with prompt A (dog), participants attempt to recall cue C (car) from the later list when testing PI, and prompt B (door) from the preceding list when testing RI. Delays in reaction times, inaccurate responses, or decreased recall therefore indicate an interference of associations or 'cue-overload' (for more examples of the A-B A-C paradigm, see Weaver et al., 1971, and Birnbaum, 1965).

Cue-overload Theory

Cue-overload theory is focused on context-specific memory during the process of retrieval, whereby continued retrieval of similar item/events subsumed under a specific cue leads to overload, reducing the accessibility of other similar items for retrieval (Earhard, 1967; Watkins

& Watkins, 1975). This is most prevalent when the information is associative and processed semantically (highlighting an influence of higher levels of processing [Parkin, 1980]).

The concept supports similarity interference theory, with previous associative cues interfering with retrieval of other interpolated stimuli as a major factor of PI (Roediger et al., 2010; Watkins & Watkins, 1976), and similarity RI (Dewar et al., 2007). However, the testing of this phenomena had been conducted primarily via the A-B, A-C paradigm mentioned above (Roediger, 1973; Roediger et al., 2010, Watkins & Watkins, 1976). The theory therefore received criticism from Wixted (2005) for its lack of ability to explain forgetting caused by interference induced within everyday life or a natural learning environment. For Wixted, forgetting is better explained by NRI interfering with a fragile memory trace before it has a chance to consolidate. Due to the nonspecific nature of the interference cue-overload cannot explain NRI and is best contextualised within a similarity-based interference paradigm.

Therefore, whilst the findings of similarity-based interference are well documented they are largely experimental and may not fully translate onto everyday forgetting, as individuals continually switch between different types of task during everyday activities. As noted by Skaggs (1933) and Dewar et al. (2007), both PI and similarity-based RI appear to affect a memory in the same way, during the retrieval phase (rather than encoding or, as might be expected, retention/storage). This may be due to the similarity and confusability of the stimuli/memory items, which occurs mostly in experimental environments. With Wixted (2004b) critiquing PI for its inability to explain everyday forgetting, and Skaggs, and Dewar et al. arguing that similarity-based RI is akin to PI, then in order to explain everyday forgetting within the interference literature, evidence of forgetting from dissimilar, un-associated interference must be considered. This type of forgetting is referred to by Dewar et al. as ‘diversion RI’, as it diverts attention away from maintenance, differing not only in the type of stimuli/memories affected but *where* the recall hinderance occurs during the retention/storage phase.

Despite the early findings of Muller and Pilzecker in discovering RI of associated stimuli, the findings of un-associated material causing RI were critiqued by Dewar et al. (2007) on the grounds of insufficient evidence. They argued that although an un-associated experiment was attempted, the pictures were verbalised and therefore contained the potential for association. Thus, evidence for similarity-based RI was more robust than that of the dissimilar, or *nonspecific*, RI effects. This critique is supported by Skaggs (1933), who asserts that the interpolated stimuli should be as different from the original stimuli as possible, short in duration in order to control the mind-set of the individual (to reduce mind wandering) and presented shortly after the original stimuli. Skaggs asserts that research following these parameters indicate the importance of the temporal positioning of the interpolated material. This follows the Temporal Gradient of RI described by Muller and Pilzecker (1900) and reviewed by Wixted (2010).

Other factors of interference are discussed further in the sections below, as the hindering effect of the RI phenomena itself can be evidenced and fit differently within multiple paradigms, from interference of similar stimuli causing an overwriting effect on VWM representations, to distorting a memory trace before it can solidify through consolidation, or distortions caused by reducing the retrieval potential of temporally cluttered information by reducing the distinctiveness of the memory trace. Distinctiveness demonstrates that the more similar the interfering stimulus, the more strongly interference appears to occur. However, following from the criticisms of Dewar et al. (2007) and Wixted (2004b) regarding the experimental nature of similarity interference failing to account for everyday forgetting the next section will focus on interference of a non-specific nature—the diversion interference of the retention phase.

Non-specific Interference

Whilst it has already been discussed that both associative and interpolated interfering stimuli of associative memory tasks disrupt recall, interference is not just a function of associative stimuli competition. Increased forgetting has also been found to result from information within a non-specific, non-associative task. This is known as non-specific interference. Succinctly, nonspecific interference is a form of forgetting which occurs when non-associative information gained from a dissimilar task interferes with recall. Following on from Muller and Pilzecker's (1900) early work into RI (which discovered nonspecific interference effects), Dewar et al. (2007) conducted a study that supported the theory that RI causes forgetting along with unrelated material (the before mentioned diversion RI). Within the study six groups of participants attempted to recall a list of 15 nouns after an interval containing a task specific to each group: control (unfilled rest period), audio (listening to a radio show), serial (visual) recall, (visual) recognition, maths tasks, and audio tone detection. It was found that any task or stimuli that causes a distraction increases forgetting, regardless of whether the stimuli are relevant to the experiment or not, with no meaningful difference between the recall of the distracting tasks which all had lower recall than the control. Another argued conclusion of the study was that RI has two forms: Diversion and similarity. Diversion RI hinders learning on the consolidation level, whilst similarity RI hinders the processes of retrieval of memory. This distinguishes the importance of the types of stimuli used for the 'to be remembered' and interference stimuli retrospectively.

This reinforces the concept that interference is not just a function of associative stimuli competition. Another important aspect of non-specific interference is that it is akin to natural every day forgetting, as even autobiographical internal thoughts which occur naturally have been shown to interfere with recall (Craig et al., 2014). Across four experiments Craig et al. (2014) demonstrated that both a visual (picture search) task, and internal autobiographical thinking induce significant NRI effects. Using three word lists and three counterbalanced condition-orders, the experiment contained three conditions. Participants immediately recalled each word list post-presentation to establish baseline equivalence, followed by the nine-minute manipulation: wakeful rest, picture search, and autobiographical thinking. This was followed by the next list until all conditions had been completed. In the thinking condition participants heard a sound and were required to recall past (or imagine future) scenarios. The results showed that both the picture tasks, thinking tasks, and external sound induced thinking tasks resulted in hindered recall. This suggested that NRI hinders consolidation both externally and internally. In amnesic patients the NRI condition of listening to piano notes significantly impaired recall of prose stimuli compared with a controlled delay condition (Dewar et al. 2010). Dewar et al. (2010) used this to demonstrate that interference can occur not just within a context that is item-specific such as during retrieval, but by distractions that are not item-specific, thus nonspecific, which hinders memory consolidation. This is a key example of the similarity vs. diversion interference/ item similarity vs. mental effort argument (Dewar et al., 2007).

To conclude, the final study example is that of Brokaw et al. (2016) who compared 15 minutes of wakeful rest (with eyes closed) with the NRI task of playing the video game ‘snood’. Snood is a simple video game in which you match coloured balls to make them disappear. Wakeful rest significantly improved delayed recall of story details (provided auditorily) whilst the video game condition hindered accurate recall and increased false recall (recall of incorrect details). This is an example of how a simple and non-demanding activity can significantly reduce recall in a real-life scenario. i.e., someone who ops to ‘wind down’ after studying by playing a simple mobile game may unwittingly hinder their learning potential.

So far it has been demonstrated how NRI can occur through any form of mental distraction. The next section will focus on the reliability and replicability of this effect within the literature.

How consistent are the effects of non-specific RI?

The concept that forgetting is induced by new information or a subsequent task of a nonspecific nature displacing or *diverting* attention away from the maintenance of a memory trace (for example rehearsal) is intuitive, particularly as an explanation of everyday forgetting over time. Craig et al. (2014) found NRI effects from internal thoughts and a visual searching task, and Dewar et al. (2012) from spot-the-difference tasks (S-T-D). Both are distractors which require attention but are not cognitively demanding, indicating NRI prevalence. However, within the recent literature, studies of NRI from low-demand cognitively distracting tasks have not always supported this assertion.

Two experiments by Fatania and Mercer (2017) explored whether verbal memory performance was hindered by subsequent nonspecific S-T-D tasks for children (aged six and seven) and adults. A list of 20 words were used followed by a five-minute interval, which included visual S-T-D tasks in the interference condition, or an equivalent wait period for the control (condition orders were reversed for counterbalancing). Results from the first experiment found decreased recall scores were caused by the distractor for the children but not the adults. This indicated that the adults may have been able to resist this form of NRI whilst the children could not. The second experiment repeated the methods of the first with another sample of children but extended the length of time available to participants during the encoding (word presentation) and retrieval (free recall) phases. When the time constraints were relaxed the children were able to resist the effects of NRI, leading to recall scores non-significantly different from the control. Although there was some evidence of NRI caused by the S-T-D tasks, the ability for adults to resist these effects, and for children to resist under more relaxed conditions, raises questions for the strength and prevalence of this form of forgetting.

Similarly, a study conducted by Martini et al. (2017) used immediate recall followed by the condition manipulation. Another S-T-D based distractor was used with the main aim of measuring the effects of an eight-minute wakeful rest (vs. a NRI distractor) on long term memory retention following a seven-day delay. The results found that an eight-minute wakeful rest period and the NRI distractor produced no difference between recall scores after seven days. The converse was found in a later study where an additional recall phase occurred shortly after, with an interference effect – caused by a visual problem-solving task – lasting over seven days (Martini et al. 2018). Similar results were shown using a visual film task for children aged 10-13 (Martini, Martini, & Sasche, 2019).

Varma et al. (2017) used a similar procedure measuring immediate recall vs. subsequent recall after the manipulation. They aimed to test wakeful rest and NRI throughout six experiments whereby the encoding of stimuli was followed by either a wakeful rest period or a low-demand n-back task (2-back, followed by 3-back). It was found that consolidation was not hindered by interference from the n-back tasks as the tasks include minimal semantic involvement and episodic memory processing. This indicates that a passive wakeful rest period is unnecessary for continued consolidation processing. However, the participant accuracy of >90% during the n-back tasks may indicate a lower cognitive load incapable of creating interference greater than the interference caused by autobiographical memory reactivation (Craig et al., 2014) during wakeful rest periods. Within this scenario the n-back task would provide a form of active rest, whereby consolidation processes are maintained in spite of the resource demand, due to reduced interference in comparison to the autobiographical thinking interference in a passive wakeful rest state and providing a balance/trade off (Ecker, Tay, & Brown, 2015).

These results present a view of NRI as a less potent form of forgetting which may be resisted or negated, so the question arises: In what circumstance does NRI result in recall hindrance?

If a nonspecific distractor task does not induce greater NRI than that of natural mind wandering (MW) or everyday autobiographical thinking, this could mean that NRI is potentially an always present but low form of forgetting which may be exacerbated or elevated under certain conditions. This may include the level of cognitive load, the amount of encoding and retrieval time, and the point at which NRI is experienced. Within this contextualization, the later conditions of NRI which were counterbalanced by the research above may experience repeatedly worse RI effects that are masked beneath global overall effects. This indicates not that NRI does not occur, but that it may be a lower form of interference with an ever-present cumulative effect. This is one of the key manipulations that will be explored within this project.

Furthermore, the experiments by Varma et al. do not consistently represent verbal memory, as firstly, the experiment aimed at verbal memory contained 20 words which may be too simplistic to measure forgetting. Secondly, the distractor used was a low-level cognitive demand task (2-back). It is plausible that the 2-back task which has the lowest form of load in some cognitive load studies (Reed et al., 2017) did not decrease learning sufficient to cause overall interference effects. Varma et al. acknowledge that both of these factors could prevent the interference effect. This led to an experiment with a greater encoding and demand task but on a different memory system (facial recognition). Instead, it is put forward that a more demanding free recall test would better indicate intentional learning and more differences alongside the more demanding interference task. Thirdly, due to immediate recall the delayed interval is not a retention interval consistent with everyday life with participants immediately attempting to recall the list post encoding. This creates an additional novel recall event. This means participants may benefit from attempting to re-recall the words they remembered previously (providing a testing effect) AND the memory of the initial encoding phase, allowing the simplistic re-remembered/rehearsed stimuli to become more consolidated against interference post-retrieval. Within the contextualisation provided, following immediate recall a more demanding visual NRI task would be necessary to elicit interference effects and not produce an active-rest effect due to the strengthened recall potential.

Reducing RI

With RI being such an established factor of forgetting, understanding how to reduce RI effects induced by newer information would be advantageous to the learning process.

A study by Koen and Rugg (2016) found that if memory reactivation occurs or is elicited during the interference task then RI is reduced, increasing recall scores, though the recollection (“reactivation”) of the memory during the interference task returns it to a state in which it may be influenced again by RI. This indicates that retrieving a memory can strengthen the recall-ability of the memory trace, but potentially leave it open to further interference/distortion upon reactivation and can be elicited from something as subtle as the way a retrieval question is phrased. This was found by Loftus and Palmer (1974) during two experiments which aimed to test the reliability of eye-witness testimony. Participants were placed into groups differing only in the phrasing of the post-event interview questions. Participants viewed a video of a car crash incident and were subsequently asked questions about the event. Participants in the group that were asked how fast the cars were going when they *Smashed* into each other provided higher estimates of speed than the groups where the questions were phrased "how fast were the cars going when they 'hit' or 'bumped' each other?" When interviewed a week later, participants in the group who heard the phrase "smashed" were more likely to answer 'yes' to whether they saw broken glass on the floor of the incident. This highlights the influence of inaccurate/false recollection of certain features of the memory. In this way, understanding the role and impact of RI has a strong applied value for the evaluation of the reliability and validity of eye-witness testimony.

Whilst reactivation has been shown to increase the strength of a memory trace against RI to some extent, there are other factors seen to bolster a memory trace's resistance. One such factor is known as priming. Priming occurs when a prior learned memory representation or response positively influences the response anticipation, certainty, and/or accuracy of newer actions. For example, if you are to respond 'match' or 'no match' to colours in a Stroop test, if the font colour of prior trials remained the same then participants would be primed to anticipate and respond quicker to another colour congruent trial than to a newer incongruent trial. This would be an example of colour priming (Kristjánsson & Campana, 2010). In relation to RI, Bower et al. (1994) found that when the category of the stimulus word predicted the response word category, and the response was unique within that category, then learning was rapid and the influence of RI was negligible. Conversely, when the cues and response stimuli were unrelated the recall scores were significantly reduced. This reduction in recall performance was highly attributed to RI.

One memory process triggering another is an example of an implicit memory process (Kristjánsson & Campana, 2010). This differs from declarative and deliberate memory processes necessary for free recall, i.e., being explicitly asked to retrieve a list of items, such as naming as many states in the U.S. as possible within a short period of time. Therefore, whilst priming may reduce the influence of RI through the implicit memory system, it cannot be fully applied to declarative memory processes indicative of traditional learning and retrieval. This is because explicit learning is typically intentional (Diekelmann et al., 2009), i.e., exams where an individual learns material and must deliberately recall them at a later date explicitly and without retrieval cues.

As previously highlighted, Dewar et al. (2012) found that delaying the onset of interference increases recall potential and that this consolidation effect has long term benefits. Although, (as highlighted above) this was conducted using S-T-D tasks which may be a form of diversion RI itself, the effectiveness of wakeful rest as a technique to reduce both PI and RI and therefore boost memory is gaining precedence in the recent literature (Dewar et al., 2012; Ecker, Tay, & Brown, 2015; Mercer, 2015). With empirical research into RI showing its hindrance of retention and consolidation it is important to understand potential factors that may facilitate an individual's susceptibility to RI. Whilst some research is emerging on factors that reduce RI, more is needed as accounting for these factors would reduce the degree of forgetting, increasing total learning potential.

Mechanisms of NRI

In order to explore factors that may reduce the hinderance of NRI on recall it is important to first understand how and why RI occurs, and whilst RI as a form forgetting has been researched and demonstrated since the 1900s there has been some debate regarding the mechanisms of RI, particularly as an explanation of time-based forgetting/*transience*.

Consolidation

One explanation for RI hindrance is provided by consolidation theory. Consolidation refers to the processes involved in memory which seek to stabilize the memory trace post-acquisition (Dudai, 2004). The primary assumption of this theory is that a memory trace/engram, once encoded, is fragile before consolidation processes take place (Maquet, 2001). After consolidating and storing the memory, it is then protected from interference, disruption, or decay. The early work of Muller and Pilzecker (1900) (discussed on page 9) highlighted the effect of consolidation after discovering that accurately recalled verbal information required a few minutes post-training to fixate before new stimuli is presented, disrupting the process and hindering memory (Dudai, 2004; Lechner, et al., 1999; Muller & Pilzecker, 1900) (see retroactive interference, page 9).

As an explanation of a strengthened memory trace over time, consolidation theory complies with Jost's Second Law of forgetting. The law states that two equivalent memory traces or associated cues, separated by time, experience different retrieval strengths, with the older memory being stronger than the other, as the younger memory trace will be lost at a faster rate (Britt, 1934, 1935; Jost, 1897; Wixted, 2004a). Though the claim is that this results from a 'strengthening' or consolidation of a memory trace has been challenged by Brown and Lewandowsky (2010) (see temporal distinctiveness, page 28).

Despite an early conception, consolidation theory still has a place within the modern literature, buttressed by modern sleep studies which theorise that consolidation processes are strengthened through sleep, particularly for procedural learning (non-declarative memory) (Stickgold, 2005) and episodic memory performance (Grieder et al., 2017) through slow-wave sleep (SWS); Mander et al., 2013). However, the evidence for consolidation for semantic declarative memory (the storing of facts) is weaker, as the increased recall could be better explained via a lack of interference provided by sleep (Stickgold, 2005). Yet the Non-Rapid Eye Movement (NREM) stage of sleep with SWS brought through small periods of sleep (1-2hrs) has been linked to increased declarative memory consolidation of associated word lists similar to the A-B, A-C interference paradigm (Diekelmann et al., 2009; Grieder et al., 2017). This provided evidence not only for consolidation, but for similarity-based RI as well. As Wixted (2004b) pointed out, the theory of PI failed to account for greater memory consolidation provided by sleep, which reduces RI (Jenkins & Dallenbach, 1924), even within a condition where PI is present (Ekstrand, 1967). This is further supported by Lechner, Squire, and Byrne's (1999) review of 100 years of consolidation and the research of Muller and Pilzecker (1900) when they first uncovered the effects of RI. Muller and Pilzecker (1900) found that a longer rest period after the initial learning phase, before the interference task (six minutes rather than 17 seconds), increased the strength of recall for learned syllable lists in comparison to shorter periods. This was one of the first studies to provide supporting evidence for consolidation theory, in which consolidation reduces the influence of RI.

Furthermore, Dewar et al. (2012) found that a period of wakeful rest immediately after post-learning caused significantly greater recall than a filled spot-the-difference task and this significant difference was maintained when participants were asked to recall after seven days. This shows that an immediate short-term rest can increase the retention of memories into the long term, potentially resulting from the stabilising of the memory traces through consolidation before interference can occur. In keeping with this was the findings of a recent study by Sosic-Vasic et al. (2018), which indicates that faster learners may experience a greater RI hinderance to recall than slower learners during a 12-minute consolidation period (the faster you intake information, the greater the interference potential from newer information). However, Dewar et al. did not take into account the potential interference caused by the spot-the-difference tasks as they were unrelated to the memory stimuli (participants were asked to recall features of a story).

Due to the strength of support provided by modern sleep studies, consolidation is an important component of learning and, therefore, the forgetting process, particularly for a neuroscientific or biological account of memory. However, within the cognitive theoretical framework of forgetting consolidation has received opposition, with the forgetting function of a memory trace strengthening over time being conceptualised within a different theoretical paradigm of distinctiveness (Brown & Lewandowsky, 2010; Lewandowsky et al., 2012). The findings of Dewar et al. (2012) will therefore be evaluated further in the next section on Temporal Distinctiveness.

NRI within consolidation.

An explanation of NRI within the consolidation theory framework is provided by Varma et al. (2017). According to Varma et al. the primary cause of this form of forgetting is the reallocation of brain resources from memory consolidation processes to other resource demanding tasks (such as language, encoding and retrieval of task irrelevant information, sensory processing and language, etc.). This causes memory consolidation processes such as maintenance and memory trace reactivation to be 'put on hold' or suspended during demanding cognitive processing tasks (such as the S-T-D tasks found within this thesis), though Varma et al. argues that wakeful rest may not be necessary to prevent NRI (see page 19). As a wakeful rest period may not fully reduce the interference of consolidation processes with autographical thinking occurring during wakeful rests, and the concept that *demanding* tasks create the NRI hinderance, a low demand task may be beneficial. This was explored by Ecker, Tay, and Brown (2015) who induced a form of *active* wakeful rest by filling the rest period with a low cognitive demand tone detection task. The results found that both prestudy and poststudy (to a lesser extent) rest provided by the wakeful low demand task had a beneficial effect on free recall. This study provides support for interference-based forgetting over memory consolidation processes, as consolidation theory would not expect a greater effect of prestudy rest, than poststudy rest. Rather, a better explanation is provided by Temporal Distinctiveness theory, in which the recall of individual items is an exponential power function of the memory traces' temporal isolation. Studies testing this theory through temporal isolation (Brown et al., 2006; Ecker, Tay, & Brown, 2015; Morin et al., 2010; Rönnberg, 1980) found that the greater the temporal isolation of the memorandum from competing or distracting information, the more 'distinct' the memory trace, thus leading to greater recall potential.

Temporal Distinctiveness

The temporal distinctiveness model attempts to explain time-based forgetting within a paradigm where consolidation failure is an inefficient interpretation of the temporal effects of forgetting. The positive effects of rest periods noted above are subsumed within the temporal distinctiveness model to be a function of time rather than consolidation specifically. Temporal distinctiveness falls within an interference framework, whereby forgetting is caused by a disruption or displacement of a memory trace resulting from its temporal positioning. The main model of temporal distinctiveness is known as SIMPLE (scale-independent memory, perception, and learning; Brown et al., 2007).

SIMPLE contains four main assumptions; (i) memory items can be seen as independent items across the temporal dimension; (ii) The retrievability of a specific memory item is a function of its discriminability from other temporally local memory traces; (iii) This discriminability is in ratio to the temporal distances from the time of retrieval; (iv) Finally, discriminability of a memory trace is inversely proportional to its confusability from other memory traces resulting from the relative distance between the items in ratio with time of retrieval.

This means that within this model recent items are less confusable and therefore more memorable than older items (at the time of retrieval), whilst items which were temporally cluttered (presented with little to no time-gap between) are significantly more difficult to recall as the memory trace is less distinctive from other associative cues within that time phase/period. Similarly, through the passage of time the spaces between memory items decrease relatively as they recede into the past thus becoming more cluttered relative to each other and less discriminable over time. Conversely, more recent memory retrieval cues which are spaced out temporally are less confusable (*receiving less interference*), and therefore are more distinctive and easier to recall during the process of free recall. According to Brown and Lewandowsky (2010) temporal distinctiveness removes the theoretical value of decay as a time-based forgetting interpretation by explaining temporal effects relatively (relative to other memory traces/events). Temporal distinctiveness also uses primacy and recency effects to explain consolidation effects, with earlier items in the list (primacy) being recalled more due to a reduction in PI, and newer items (recency) receiving less RI. Through this theory the temporal isolation of a to-be-remembered item would greatly boost its distinctiveness resulting in greater recall (Brown, Morin, & Lewandowsky, 2006; Ecker, Brown, & Lewandowski, 2015; Lewandowsky et al., 2012).

Within this model the increased recall resulting from immediate rest found by Dewar et al. (2012) results not from consolidation but from the immediate reduction of RI leading to a greater degree of temporal isolation and therefore distinctiveness. However, as Dewar et al. states, temporally the difference between the S-T-D task groups and the wakeful rest groups would be less distinct over time. This would likely lead to a decrease in the differences in recall scores between conditions at the seven-day interval than the short-term interval (15-30 minutes), as over time they become less temporally distinct relative to each other. This was not found, causing Dewar et al. to conclude that consolidation was the primary cause of the *maintained* increased recall over the long-term. Finally, the positive effects of temporal isolation have not always been replicated in memory studies, such as probing or serial recall (Lewandowsky et al., 2006). The concept that temporally isolated items may benefit from greater recall than cluttered items for free recall is explored throughout this thesis.

NRI and attention

With one of the primary mechanisms of NRI involving the distraction from maintenance of the memory trace, factors which induce or reduce distractions can influence recall. The following sections will cover attention and cognitive arousal, MW, and various forms of interest/interestingness to evaluate their role in learning and assess whether these factors influence whether NRI is found.

There are numerous articles which evaluate the different forms of attention and focus and the role in which it plays in the encoding of memories, along with its importance within WM functions. Attention is the cognitive ability to selectively process information to enable information to be retained within an accessible state of WM (Fougnie, 2008). Conway et al. (2001) explain that individuals with a smaller WM capacity lack the ability to focus on the task and therefore struggle to ignore distractions highlighting the strong relationship between attention processes within the WM system, which may link to an individual's susceptibility to NRI.

Attention as a selective process can be directed to – and by – perceptual information (such as the visual focusing on an object) and to/ by information within the WM system, as a form of internal focus of attention (Souza & Oberauer, 2016). Evidence towards the internal focus of attention within WM is provided by the Retro-Cue paradigm which is reviewed by Souza and Oberauer. The Retro-Cue consists of a spatial cue which is used to indicate a higher importance/relevance of a targeted stimuli known as cue reliability, this effect increases the performance of the cued item, whilst hindering the recall of non-cued items (Griffin & Nobre, 2003; Landman et al., 2003). This highlights the importance of selective focus provided by the retro-cue, and potential directed forgetting of non-cued items through decreased attention (MacLeod, 2012) with non-cued items having attention ‘diverted’ away from maintenance, which is one of the primary explanations of NRI.

Therefore, the role of attention is crucial to the memory process, with attention used to deliberately inhibit recall of irrelevant/unwanted information which are not maintained (Conway et al., 2000; MacLeod, 2012; Wilson & Kipp, 1998; Zacks et al., 1996). Conversely, attention when focused facilitates learning with increased recall. A study by Pertzov et al. (2013) used the Retro-Cue after the presentation of the to-be-remembered stimuli and the results showed that attentional processes during maintenance of the engram increased accuracy and recall which was present even if elicited by the cue retrospectively.

As mentioned previously, Souza and Oberauer (2016) highlighted that the role of attention within WM is crucial for avoiding disruption of the memory trace. In fact, the primary form of forgetting assessed within this thesis is NRI, which disrupts and weakens a memory trace after initial encoding. Therefore, focused attention could be crucial in providing resistance against this form of forgetting.

This was explored using three potential mechanisms to explain the effect: item retrieval prioritisation, decreased interference of subsequent stimuli, or reduced temporal decay. For decreased interference of subsequent stimuli, a study by Landman et al. (2003) found that the average person is typically bad at noticing small visual changes, with a small amount of visual items being represented in the brain at a time (these are the items the individual is currently focusing on). Landman et al.’s study found evidence that indicate that a large portion of the participants’ memory representations became overwritten by post-change displays, showing that the memory representations had been interfered with after encoding, as long as attention has not already focused upon one of the item representations (such as the focus provided by the retro-cue). This was used to explain ‘change blindness’ using a change detection task, which indicated that participants had a large capacity for visual representations for cued items (>4) which remained for 1500ms after the stimuli had disappeared, two stimuli representations within this period allowed the correct change detection, while the non-cued items at 1500ms period capacity remained at just four. This finding was consistent with Becker et al.'s (2000) study where an attentional cue was used to indicate the location of the stimuli change. Again, the results showed that without the attentional cue, the second occurring stimulus overwrites the visual representation of the first stimulus, and Becker et al. argue that this is due to the inability to hold two representations at the same time.

Makovski et al. (2008) provides evidence towards a resistance of interference, however they explain that the retro-cue effect itself cannot be explained by decay or the reduction of interference itself, but by the change in the orientation of focused attention upon a memory item creating a robustness for resisting the effects of interference in VWM. Makovski and Jiang (2007) found evidence that VWM is weak and prone to interference caused by subsequent information when attention was spread-out across multiple memory items, but when attention is focused on a particular memory it solidifies and becomes robust against interference of subsequent information. The Pertzov et al. (2017) study also found that multiple memory items stored simultaneously were more prone to forgetting/interference than single memory items, consistent with the Temporal Distinctiveness model (see page 28).

Cognitive arousal: Alertness. A link between attention and a reduction in interference has been established, but what mechanism is behind it? A high level of alertness is one of the main components of attention (Posner & Boies, 1971). Therefore, if an individual was cognitively aroused by the task it may modulate selectivity of attentive focus towards task-relevant information and towards arousing stimuli (the opposite of an NRI/diversion distractor), which would make the process of retrieval of the stimuli from WM easier, through the cognitive processes involved in encoding, maintenance and updating of the information whilst being attentive (Fougnie, 2008; Sharot & Phelps, 2004; Souza & Oberauer, 2016). The tendency to focus attention towards more cognitively arousing stimuli items causes similar effects to the Retro-Cue, with less arousing stimuli experiencing a hindered recall by a narrowing of attention towards arousing stimuli, and away from the lesser arousing stimuli (Easterbrook, 1959; Sharot & Phelps, 2004). This indicates that alertness and attention are related constructs, with cognitive arousal mediating attention and alertness towards task-relevant goals. This is how focusing on task-relevant information aids in learning and recall. An understanding of this role may help to further reduce the effects of interference.

A case has been made for the positive effects of attention, alertness and focus in reducing NRI, but what if the attention to task-relevant information is low? One such occurrence is known as mind wandering (MW).

Mind Wandering

MW is usually defined as self-generated task-unrelated thought (Smallwood & Schooler, 2015), and MW whilst encoding new memories is costly (Risko et al., 2012). MW during encoding may also exacerbate the effects of RI, as the recall hinderance caused by MW may result from the same processes as NRI (through hindered rehearsal and maintenance). However, this has not been properly tested in prior research and MW can occur during encoding, whilst NRI is operationalised during the retention/storage phase.

External distraction and MW are considered within the recent literature of attention as two distinct constructs with overlapping and correlating variance, therefore incorporating the two constructs within attention fuels understanding of cognitive abilities such as WM capacity and fluid intelligence (e.g., problem solving or identifying patterns [Unsworth & McMillan, 2014]). As Unsworth and McMillan mention, the ability to focus attention on goal-related information and sustain this attention against distractors is one of the key hallmarks of cognitive ability, as it is needed to prevent undesired and unsolicited lapses of attention which may result in detrimental performance. Both MW and external distractions can invoke task unrelated thoughts (TUT). External distractions are distractions away from task-related attention caused by the external environment (such as noise pollution from an open window or visual information from video billboards whilst driving). The influence of this form of distraction is reduced/controlled for within the experiments in this thesis due to exam conditions within quiet rooms.

MW is considered to be part of a meta-cognitive process known as 'meta-awareness' whereby individuals do not realise that they are engaging in TUTs and must become aware before re-directing attention back to the task (Smallwood et al., 2007). Smallwood et al. argue that when an individual engages in MW the awareness of the external environment ceases to be of impact, with a focus now towards a natural process of inner thought processing. MW represents a 'baseline' of thought processes which discontinue during the focus of a task, but the mind naturally reverts back to following a lack of external engagement (Mason et al., 2007; Schooler, 2004). This is further supported by a study conducted by Mason et al. (2007) which found that MW is associated with default brain regions which activate when the brain is at rest, with periods of reduced executive command producing increased incidences of MW. Therefore, a mentally engaging task *may* reduce the frequency of MW occurrences.

Finally, MW can be described as an internal factor which can be influenced by the external environment (befitting the findings of Craig et al., 2014), and MW whilst encoding new memories is costly (Risko et al., 2012). A notable feature is that recognising and attempting to correct MW (in an attempt to increase attention) is a meta-cognitive function whereby some individuals may struggle and therefore become more susceptible to MW, thereby suffering the negative impairing effects upon learning potential cause by internally, nonspecific interfering thoughts.

Flow

The antithesis of MW is the 'flow state' whereby individuals are 'in the zone' thereby effortlessly present and strongly focused on the task at hand to the extent that a suppression of self-consciousness occurs (Csikszentmihalyi, 1990). It is a positive experimental state that is linked to motivation and occurs when the skill of the individual equals the challenge of the task (Csikszentmihalyi, 1990; Jackson & Marsh, 1996). One of the preconditions of entering flow is the development of interest in a challenging activity where the individual has skills to achieve clearly defined goals. In this way flow is argued to be "a force for expansion in relation to the individual's goal and interest structure, as well as for growth of skills in relation to an existing interest." (Nakamura, & Csikszentmihalyi, 2014, p. 92).

To construct an a priori position on factors that may reduce NRI and MW resulting from task irrelevant information and thought, it is logical to explore motivational factors of learning and attention— such as interest development— that induce the opposing state of MW: Attention and flow.

Learning and Interest

When aiming to explore factors which may reduce the hindering effects of NRI on recall, investigating factors which increase learning (the antithesis of forgetting) and attention may be useful. The motivational factor of 'interest' will be explored to see if the positive effects of interest on learning may, in part, result from the potential to mediate MW and NRI effects.

Contextualising Interest

The current interest literature has two main points of focus: (i) individual interest in content or preferences for particular object domains; (ii) interestingness as a modulator and trigger of situational interest (interest in the environmental factors such as the experimental task or the interestingness of text). Krapp, Hidi, and Renniger (1992; 2014) separate topic and situational interest as psychological constructs linked with increased knowledge and positive emotions along with an increased reference value (similar pattern of results enabling accurate predictions). Situational interest is considered to be evoked suddenly from the environment and therefore is typically short-term and can be shared by individuals within the same environment, following certain themes. For example, something shocking and dangerous happening in a talent show creates novelty and therefore evokes situational interest amongst a large number of audience members within potentially similarly shared themes and could therefore potentially lead to a long-term basis of individual interest (i.e. a new individual proclivity for going to talent shows or magic acts). In such a way, situational interest evokes a positive emotional state that brings individuals to be more present and focused in a similar way to the other person-activity affect state of 'flow' (Chen et al.., 2001).

Figure redacted for online publication to prevent copyright

Figure 1.2. Figure reprinted from Krapp, A., Hidi, S., Renninger, K. A. (1992). Interest, Learning, and Development. In K. A. Renniger, S. Hidi, A. Krapp (Eds). *The Role of Interest in Learning and Development*, (p. 10). Elbraum Associates. The figure shows the separation and link between types of interest.

Within the context of this thesis, interest has been contextualised using Renninger et al. (2014) as a guide (see Figure 1.2). Topic interest is contextualised as actualized interest. Actualized interest is content specific with an intrinsic motivational orientation, which means that an individual with personal interest in the topic will be more motivated to continue learning within it. Within this thesis, actualized interest can also take the form of subjective interest (McGillivray, 2013) through dispositional individual interest factors modulating the experience of interestingness (Rotgans & Schmitt, 2018) experiences relating to interestingness of the stimuli formed by personal pre-existing individual interest dispositions (Rotgans & Schmidt, 2018). Situational interest is best conceptualized as a measure of 'interestingness' i.e., of the learning environment and therefore, shared interestingness of the text or experimental task itself. It has been shown that the experience of interest results in intrinsic motivation (Ryan & Deci, 2000). Topic interest (TI) is a form of actualised interest, which is content specific. The interest generated is personal and seen as motivational, leading to continued effort in the face of setbacks which may increase performance (Schiefele, 1991; Schraw & Lehman, 2001).

Due to the lack of a lead cohesive contextualisation of both topic interest and situational interest among researchers, the study literature rarely compares/measured topic interest and situational interest together in the way this thesis intends (actualized interest vs. interestingness vs. individual experience of interestingness). Therefore, for the purpose of exploring interest within this thesis, the above contextualisation of topic interest as actualized interest (and interestingness as a form of situational interest) is adopted and will be developed throughout.

Evidence for a link between interest and learning can be seen in studies of text-based interest (Schiefele & Krapp, 1996). The previous literature between text and interest show a positive connection between the two, within a learning context (Garner & Gillingham 1991; Hidi & McLaren 1988; Schiefele, 1996, Shirey & Reynolds, 1988). This text-based interest is formed as a result of the emotional state being aroused by certain features/characteristics of the text. In this way, text-based interest is seen to measure the 'interestingness' of the different aspects of the text. Therefore, the text-based research may be linked as a form of situational interest.

It is useful to look at text-based interest within its own domain and the aspects within it. When researched separately from situational interest, text-based interest provides the researcher with themes and characteristics of interestingness within a text. The importance of these themes/characteristics was first highlighted by a study conducted by Bernstein (1955). This study indicated that there were two components towards a text's interestingness: (i) the characteristics, and (ii) personal aspects of the reader (Bernstein, 1955).

These themes were further supported by Krapp, Hidi, Renniger, et al. (1992) on novelty, character identification, life themes, intensity of actions, and the imagery value (Anderson et al., 1987; Hidi & Baird, 1988). The influence of the personal characteristics to the reader (within the text) was first found by Hid and Baird's (1988) content analysis that 'interestingness' of the text increased the understanding of concrete, specific and personally involving information. However, no significant differences were found for the acquisition of abstract and scientific information.

Craik and Tulving (1975) argued that the deeper the level of cognitive processing during the encoding phase, the easier it is to activate the episodic memory trace during retrieval, leading to a greater potential for recall, consolidation and a greater degree of understanding of the stimuli/material. Related to this point, Marton and Säljö (1984) found that students who were less interested in the materials were less motivated to perform during the task and less likely to display a great level of understanding of the stimuli in comparison to those who were more interested. More interested individuals attempted to find a deeper level of understanding of the text, leading to greater semantic processing.

A later study by Schiefele and Krapp (1996) supported the link between interest and semantic processing with regards to greater performance and understanding, as the complex and deep comprehension questions presented as text stimuli were found to be highly significant predictors of recall when combined with highly interested participants. Combined, these studies show that interest and semantic thought are interlinking factors to be considered when conducting an experiment into RI susceptibility. When choosing the to be remembered stimuli, the intrinsic meaningfulness potential of that stimuli should be considered to increase the elicitation of semantic thought processes, whilst the participant's individualistic and extrinsic interest levels should be measured to observe the overall impact of semantic processing.

Both topic and situational interest have been shown to increase memory retention in participants (Hidi, 1990) as interest causes a facilitative effect on text-based learning (Hidi, 1990). Hidi found that higher levels of situational interest induce greater text recall, creating a positive effect on learning. As such, greater interest in memorised material may help decrease RI.

A meta-analysis of psychological research spanning 60 years with 60 studies of interest (involving 568 correlations) was reviewed by Nye et al. (2012). The correlations were analysed using a regression-based approach (the mean score as a total was taken from each study for multiple factors), examining the extent to which interest influences performance. Nye et al. found a positive correlation between high interest levels and a high level of performance within the learning context, providing a large evidence base for the assumption that interest is an important motivational factor. It is reasonable to conclude that a larger degree of semantic processing (greater thought about the nature of the stimuli) may be elicited due to interest and therefore the encoding and retrieval of the information to and from the long-term memory store is made easier, creating a better condition for learning.

Another explanation for the increase in recall resulting from interest is that of the potential link between interest and the flow state. It has been shown that both are factors of motivation that leads to a positive experiential experience of increase in attention resulting in improved performance. In contrast, a lack of interest in the subject material may lead to a disengagement from it, and MW (Smallwood & Schooler, 2015). Further increasing the potential for NRI related recall hindrance. This will be explored throughout the thesis to examine whether interest interacts with MW and reduces NRI effects.

Meaningful Material

To measure the effects of interest on learning and recall it is important first to choose the stimuli that best elicit it. Sadoski et al. (1993) examined the characteristics of stimuli, including interest, and concluded that ease of imagery was the most important factor in determining recall. Following from this, and understandably, the type of stimuli has been shown to have a large influence on the level of information lost to RI. For example, Bower et al.'s (1994) study showed that if the stimuli list was congruent (consonant with consonant, numbers with numbers) rather than mismatched, then the recall would be much greater. With the nature of the stimuli being shown to be largely important in relation to the elicitation or resistance of RI, it is important to understand what type of information/material helps to facilitate learning. This provides further support for Craik and Tulving's (1975) semantic processing hypothesis.

As seen previously, the study of text-based interest and of deeper processing theories of learning contain a strong semantic/verbal component. In exploring interest and RI together there must be some cohesion in the stimuli used. Exploring forgetting through the use of meaningful verbal stimuli would allow for greater parsimony to be found between these factors.

In line with the shallow-processing theory, an experiment into RI by King and Cofer (1960) used Miller-Selfridge lists which contained a series of passages which differ in contextual constraint to differ the degree of connectedness of the stimuli. This uncovered a complex link between meaningful connectedness and RI. By utilizing prose stimuli, King and

Cofer concluded that with no connectedness RI occurs, but with complete connectedness RI had rarely been obtained. Anderson and Myrow, (1971) argued that this was due to the verbatim recall used within King and Cofer's experiment combined with rote learning and Young (1974) argues that this results from the participant anticipating the recall phrase immediately following one phrase, as they are presented in the same order. This would encourage recall in order of presentation rather than revealing potential links between connections and meanings of the stimuli.

Although meaningful verbal prose contains a complex link to RI with a potentially weakened (though important) impact (McGeoch & McKinney,1934), the nonsense syllables used in historical RI studies would not elicit measurable or comparable interestingness effects between stimuli, as measured during text-based interest studies. As this thesis aims to examine the effects of MW and interest on NRI, the stimuli produced should also involve verbal learning. This would be consistent with the previous interest literature, be more akin to real life learning (as opposed to nonsense syllables) and allow for an exploration of the salience of NRI when MW and interest effects are present.

The Current Project

The primary focus of the research covered in this thesis involves taking the epistemological approach of cognitive memory and forgetting research, while incorporating the educational psychology domain of motivated learning through interest development. This enables the exploration of factors which may decrease NRI-based forgetting and thus increase learning potential. Factors such as wakeful rest, MW and various forms of interest were tested within a short-term (five-minute retention intervals) learning and recall setting by comparing conditions where NRI is present contrasted against a control.

As previously covered, there is a lack of congruence within the literature regarding overall effects of NRI. A novel investigation of the findings is provided by this thesis by incorporating condition-order variables into the analyses. This is in an attempt to investigate cognitive load/processing (i.e., TBRS) or temporal distinctiveness models of forgetting, and establish whether these factors influence the likelihood of uncovering NRI effects. The current thesis therefore aims to test the reliability, through replicability, of NRI findings. Secondarily, a behaviouristic cognitive processing account for interest effects on memory will be explored by testing the role and measurement of different forms of interest covered in the literature: Individual and subjective interest, situational interest, and interestingness.

Main research questions

(i) How reliable are the findings of NRI effects on verbal recall? (ii) Are the effects of NRI best explained by rapid decay through cognitive load processing or mechanisms of interference such as consolidation or temporal distinctiveness? (iii) Can interest in the stimuli or environment modulate MW and NRI effects in a short-term learning environment? (iv) How do the various forms of interest increase learning within a short-term cognitive research paradigm?

CHAPTER 2

Experiment 1

NRI, MW, and interest are factors that have been shown to influence recall scores. Specifically, greater interest scores have been shown to have a positive impact on learning whilst NRI and MW has been shown to have an adverse effect. However, a link has not yet been tested between these three factors within an experimental design. These factors will be explored within an experimental design with a correlational element utilizing a regression analysis and measured using self-report scales and the prob-capture method of MW.

As discussed in Chapter 1, the meta-analysis of 60 years of interest and learning studies conducted by Nye et al. (2012) used a regression-based approach to determine that interest was a significant motivational factor of learning, demonstrating that interest in the material is well established as a factor of increasing learning potential. Conversely, a lack of interest in the subject material may lead to a disengagement from it, facilitating MW (Smallwood & Schooler, 2015) as a form of NRI. Measuring MW is difficult due to its role within meta-cognitive functioning and awareness (explored in page 33), however, Schooler (2004) states that the probe-capture method which measures MW through occasional overt prompts/probes does not require meta-awareness and thus is a useful baseline for measuring the frequency of MW occurrences.

Following this, Smallwood et al. (2009) conducted a study which tested the extent to which interest influenced TUT of a prospective or retrospective nature. A participant's interest in the stimuli was measured on a self-report scale from 1-5. Results showed that interest greatly reduced both retrospective and prospective TUT (or MW), leading to greater recall scores. However, the study failed to take into account that there are two types of situational interest. This meant that situational interest generated by the task itself was not measured and the increased focus resulted from the participant's interaction with the interestingness of the stimuli. Consequently, the results may be attributed to the influence of interestingness (naturally generated stimuli-based interest (Krapp et al., 1992), and state-dependent situational interest was not accounted for and will be explored within the current experiment to test whether state-dependent situational interest reduces instances of MW. This then relates to NRI as attention is one of the primary components of WM, as one of the main functions of WM is the ability to resist the distraction (both internal and external) and disruption of encoding or consolidation of the memory trace caused by irrelevant information (Fougnie, 2008; Oberauer et al., 2012) and task irrelevant information is a primary form of NRI. Finally, eliciting NRI with use of S-T-D tasks will further test the null NRI findings of Fatania and Mercer (2017) and provide greater context to the mixed findings of NRI salience covered in (Chapter 1 pp.16-18).

Rationale

With a re-emergence of RI as a research focus, along with the recent attempts at contextualisation and reaching uniformity on the concept of 'interest' as a factor of memory, it is important to increase the knowledge surrounding potentially influential factors surrounding RI, and to distinguish what role interest plays within an interference-filled environment. For example, it is important to understand whether interest in the stimuli or the experiment (learning environment) could provide a greater amount of resistance to forgetting caused by RI whilst testing the reliability of NRI effects.

This study will measure the relationship between state situational interest, topic interestingness, and MW to observe the influence this has (if any) on a memory's resistance to RI.

Firstly, it is hypothesized that there will be a negative effect of NRI on recall. Secondly, the higher the score of MW the lower the recall score (vice versa). Thirdly, it is hypothesised that high scores of both situational and topic interest will reduce the influence of MW, leading to greater recall in both the control and interference groups, indicating a reduction in information lost due to RI and a greater potential for consolidation (Krakauer et al., 2005). Conversely, with the link already established by Smallwood et al. (2009), lower topic interestingness ratings will lead to a more significant amount of MW than situational interest in the experiment, with interest mediating the effects of MW. Finally, it is hypothesised that if no overall NRI effects are found, including condition-order variables may enable further investigation into the nature of NRI.

Method

Participants

Participants were first year undergraduate psychology students from the University of Wolverhampton. There were 121 participants in total (101 females, 17 males, 3 unspecified) aged 18 to 53 (M = 23, SD = 7.59). All students were assigned to one of six groups for the university module; therefore, sample size was determined by the opportunistic nature based on module group attendance of the practical.

Materials

A projector was situated at the front of the classroom which displayed a PowerPoint presentation which contained facts lists (A and B). There were 40 facts in total (see appendix A_1) which were gathered via a Google search for facts/interesting facts; each fact was of approximately similar word length, and the facts spanned different topics (history, sports, animals, etc.). They were chosen at random. The accuracy of the facts was simply assumed, and all facts were randomly assigned to either List A or List B, keeping a reasonable spread of topics within each. Below are some examples of facts used:

"Camouflaging polar bears cover their black noses with their paws".

"The average NFL game consists of 12 minutes playing time".

"The Bible is the most shoplifted book in the world".

A consent sheet was used which informed participants of the ethics involved. An answer booklet was provided containing eight sections. Firstly, there was a demographic information sheet requesting details about participant sex and age. This was followed by the list 1 section which included 20 interest scales for each fact (40 in total, one per fact). Interest was rated from one (not at all interested) to five (extremely interested). Three MW prompts were used and

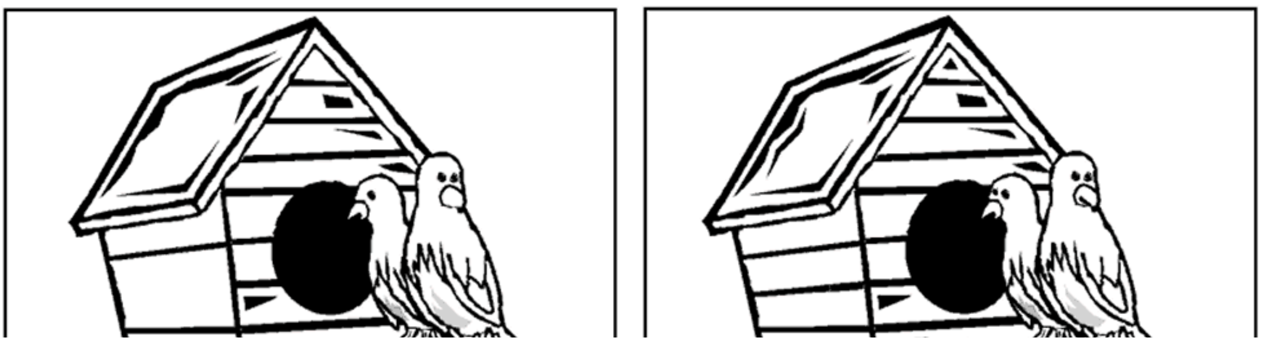

Figure 2.1. S-T-D task example.

included the prompt "*Please rate the extent to which you were mind wandering*." Participants responded on the MW scales from one (not mind wandering at all) to 10 (mind wandering completely) as part of the probe-capture method (Schooler, et al., 2004). The next part of the booklet included either the control waiting sheet ("*You will now be asked to wait for five minutes in silence. Please do not turn over the page until instructed to do so")*, or seven random and simple S-T-D tasks (See Figure 2.1 below) which were obtained by free online sources from a quick Google search (see appendix B_1).

Section 4 contained a free recall answer sheet for list 1. The second half of the answer booklet repeated sections two and four whilst replacing section three with the opposing condition. Finally, the answer booklet concluded with two self-report scales. One measured situational interest (using a 1-5 scale) where participants rated how interesting the found the study as a whole. Another 1-5 scale rated the interest of the spot-the-difference tasks (this applied to the interference condition only (see appendix C_1). Finally, a debrief was used to detail the purpose and aims of the study.

Design

The present study contained a repeated measures design which provides a greater control over participant (individual differences) variables, and a large sample of volunteer participants. In return for their voluntary participation, participants/students received a simplified sample dataset (whereby the demographic information was fictionalised to aid anonymity) to work on in their module. The facts lists were counterbalanced for the six groups as shown in Table 2.1. However, the number of participants available and the opportunistic nature of the sample meant that the final group contained only 14 people.

Table 2.1

Number of participants within each group of the Interference-Control (I-C) and the Control-Interference (C-I) conditions

	C-I	I-C
A-B	19	49
B-A	39	14

The study employed an experimental design at its core, with a correlational element. As a repeated measures design, all participants were subjected to both of the (IV_1) conditions: control (C) vs. interference (I). These conditions were presented in two separate orders: I-C, C-I (IV_2). The number of facts correctly recalled was measured (DV).

For the correlational component the study also measured the influence of different predictor values on recall (DV). These were levels of MW (PV_1), topic interest (PV_2), situational interest (PV_3) and interest in in the interference task itself (PV_4).

Procedure

The experiment took place on two consecutive days. Each day consisted of three consecutive groups (one group per hour) and each group experienced both the control and interference tasks. Participants on the first day received the control condition first then the interference condition (C-I order), whilst the participants on the second day received the conditions in a reversed order (interference followed by control; I-C).

Under exam conditions, participants were presented with a PowerPoint presentation at the front of the classroom, then briefed on the process and aims of the experiment, along with information on ethical issues (the demographic dataset returned to students was fictionalised to aid anonymity) and rights to withdraw/voluntary participation. Following this, participants were handed the consent form to sign before participation, and the answer booklet. On the first page of the booklet participants were required to write down their demographic information (sex and age) before the experiment started.

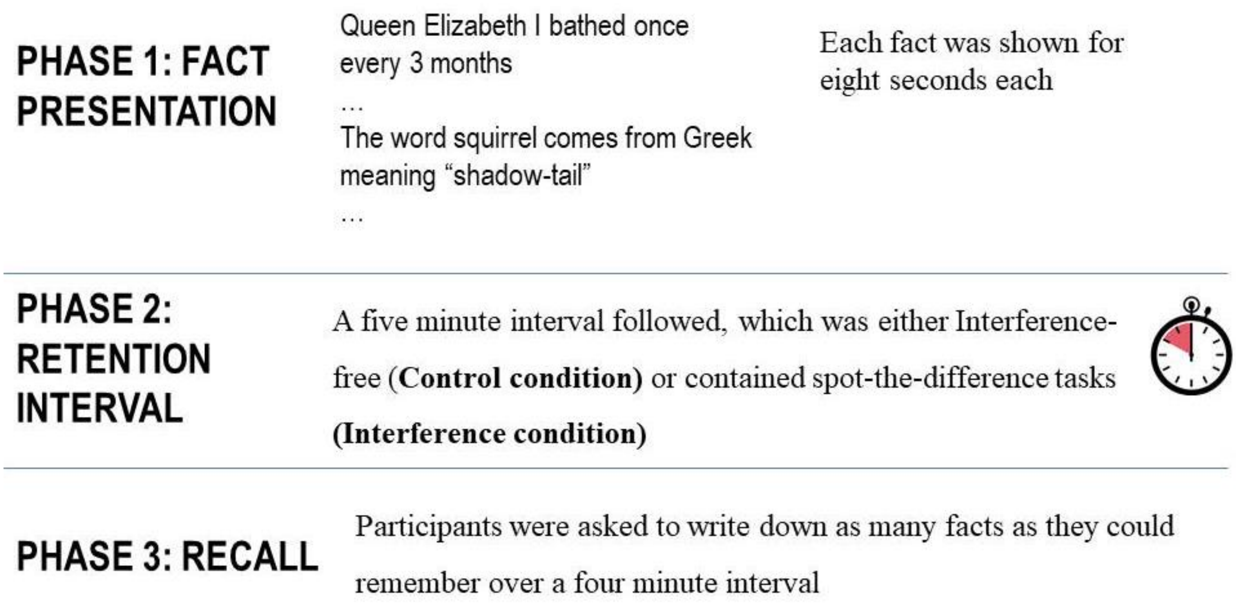

Figure 2.2. Three phase methodology used in Experiment 1.

From this stage each experiment took approximately 30 minutes from start to finish. The timings were pre-set into the presentation to ensure that the structure was followed, with different versions of the slides being used to provide the order necessary for that group. The arrangements for each separate group are shown in Table 2.1 above. Each group experienced the same design, differing in the list order and condition order.

As Figure 2.2 shows, each condition (interference/control) contained three phases. Phase 1 was the fact presentation. Participants were shown 20 facts from either List A or List B. These facts were presented individually, for eight seconds each, during which participants were asked to report in the answer sheet how interested they were in the fact presented. This was reported via a Likert scale provided within the answer sheet (one per fact). The slides changed automatically after eight seconds, with no delay between the slides. After the sixth, fourteenth and twentieth facts, participants were prompted with a MW question, where participants rated the extent to which they mind wandered or engaged in TUT at that moment in time. These three scales were positioned at the bottom of the page. Participants were provided with nine seconds to do this.

Following the fact presentation was phase 2: The retention interval. Both the control and the interference condition's retention interval were equivalent in time (five minutes), and during the control condition participants were prompted to remain silent for a quiet resting period. They had previously been informed not to use their mobile phones in an attempt to reduce interference and replicate the "wakeful rest" arrangement used by Mercer (2015). However, in some instances this proved to be difficult to quietly prevent within the large classroom. During the interference retention interval participants were instructed to attempt the S-T-D tasks within the answer booklet. This was included to facilitate NRI.

After the retention interval participants were asked to write down as many facts (or partial facts) as they could remember, in Phase 3 of the experiment. Participants had four minutes to recall as many as possible. This process was then repeated for the corresponding condition. If participants experienced the controlled waiting period first, the interference task was next, and vice versa. Similarly, if the participants experienced List A first, List B would be second, and vice versa. At the end of the experiment participants were requested to fill out a final self-report sheet. This contained two Likert scales reporting the level of interest (situational) in the experiment, and the level of interest in the distractor task. Finally, participants were thanked for their participation and reminded that an X at the front of their booklet would omit their responses from being collected and analysed.

Results

Data scoring

A strict scoring procedure for marking the accuracy of the responses was adhered to and was as follows: If the participant had reported half a recalled fact which is still resembling a fact, it was given ½ a mark. A fact which was fully incorrect scored 0, however, if the full phrase was half correct, half incorrect, it was awarded ½ a mark. Also, if the fact was different in only one way (i.e., number) it was classed as correct and awarded 1 mark, but only if the new meaning was not incorrect. Finally, if a fact was presented and correct but details were lost that are greater than one difference, ½ a mark is awarded (see Appendix A4 for a marked example). To account for missing data for interest scores of each fact (20 per fact list), the total interest scores were averaged, as long as the number of missing variables did not exceed five per variable, in which case the participant data was omitted. An average was also provided for the MW scores to account for similar instances of partial responses (i.e., one missing scale of six would lead to the sum divided by five). To deal with the missing data an average score across all probes provided an indication of the overall level of MW without removing the whole participant data.

Fifteen participants' responses were removed for attempting to recall the S-T-D tasks, missing five or more interest ratings, or attempting to recall the same facts list twice. This left 121 participant data for analysis from the original 136. Intrusion recall errors from prior lists were uncommon (less than 20 from all participants).

Individual list comparisons

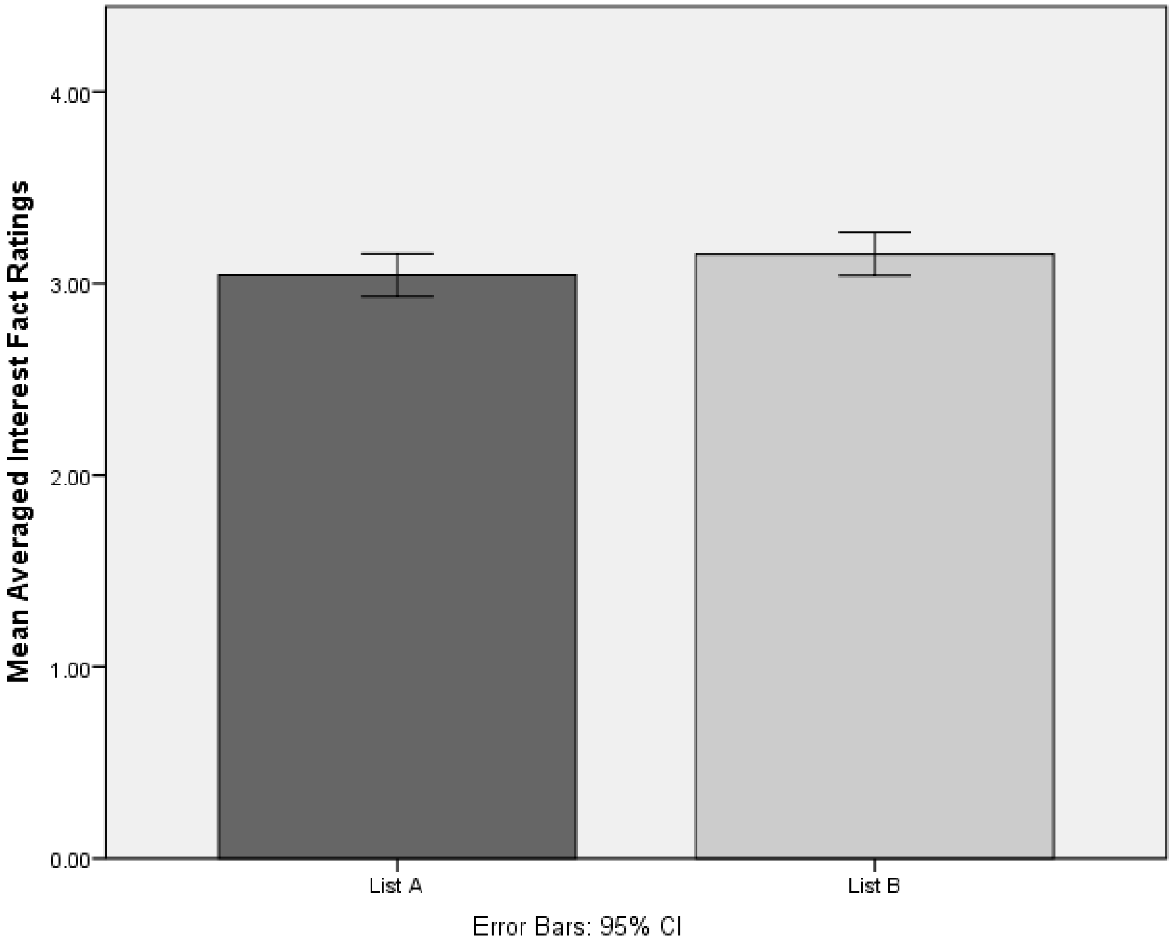

Figure 2.3. Total averaged interest scores per participant for List A and List B.

Figure 2.3 shows mean averaged interest ratings per list per group, indicating that there was a slight overlapping difference between List A (M = 3, SD = .63) and List B (M =3.2, SD = .63).

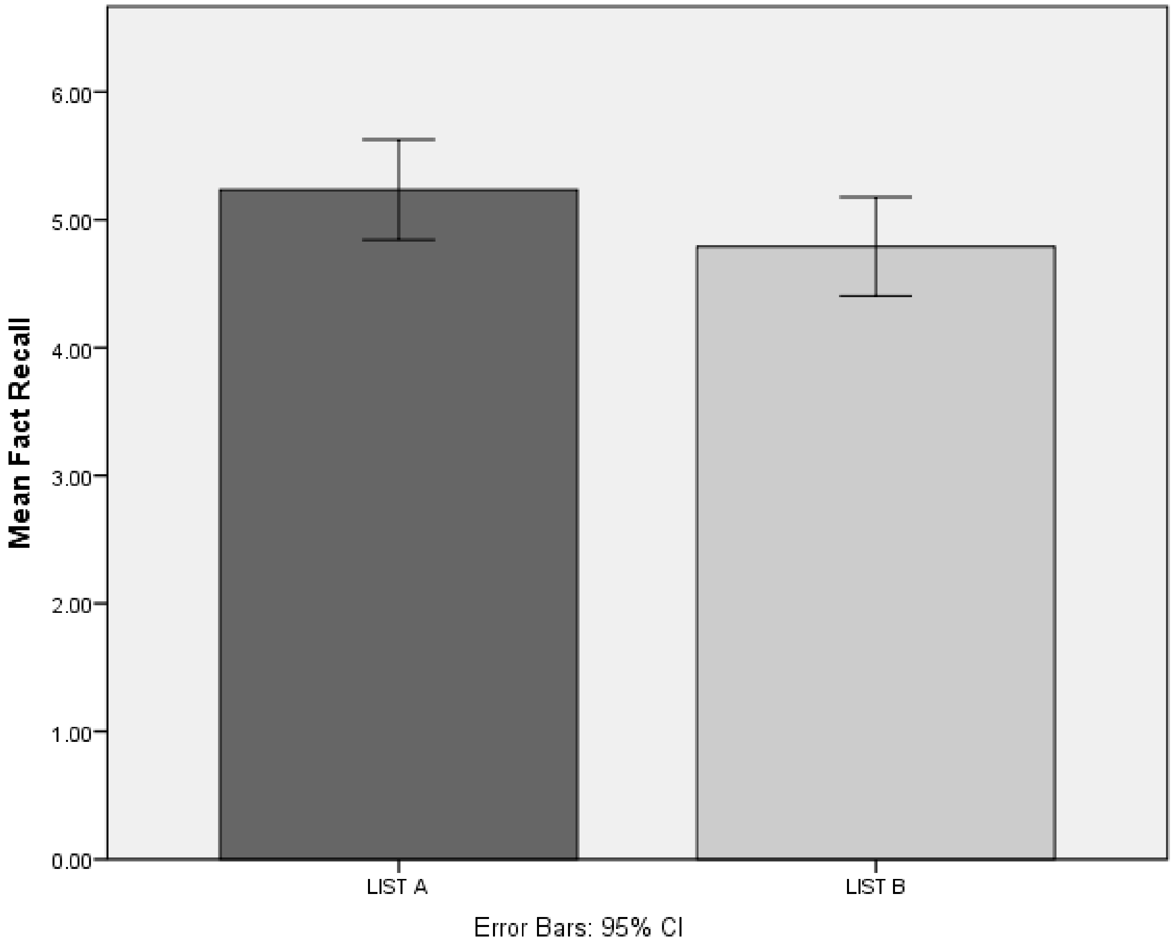

Figure 2.4. Mean Fact Recall for List A and List B.

The *t*-tests found a significant difference between List A (*M* = 5.24, *SD* = 2.18) and List B (*M* = 4.79, *SD* = 2.15) (*t*[120] = 2.1 *p* =.04, *d* =.19) for recall, indicating that more facts were recalled from List A than List B, in spite of the overlap shown in Figure 2.4. List A facts (*M* = 3.04, *SD* =.63) were rated as slightly less interesting than List B facts (*M* = 3.15, *SD* = .62) on average as well, with a mean difference of .11 (*t* [121] = -2.3, *p* =.02, *d* =.21) indicating that there is a slight increase in recall for List A. The extent to which this impacts the experimental phase was measured using an ANOVA for List A and List B in Appendix E_1.

The Effect of Interference

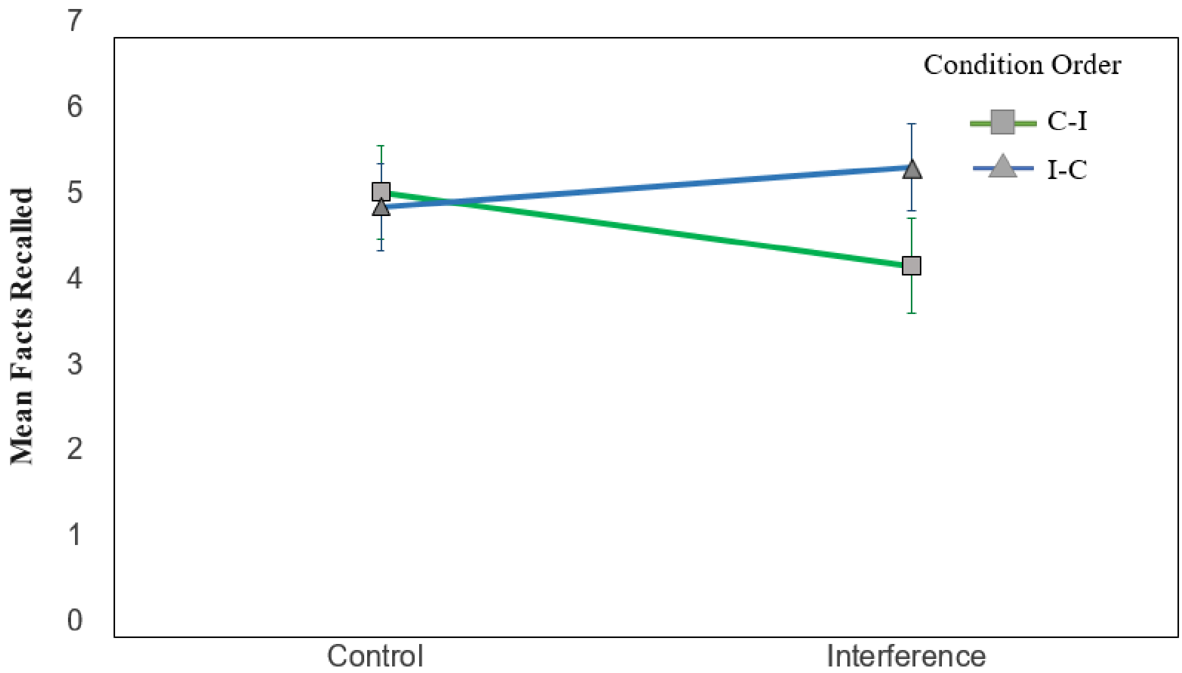

Figure 2.5. Mean recall of the facts split by Condition and Condition Order with 95% Confidence Intervals.

Figure 2.5 shows a decline in mean recall from the first task to the second task for I-C, with overlapping confidence intervals indicating a small difference. A larger decline occurs for the second task in the C-I condition. For the between-subjects' comparisons, the control conditions show very similar recall occurred whilst the comparison between the two interference conditions show a larger difference with no overlap. In summary, having the interference condition after the control condition led to the lowest recall scores.

A Two-Way Mixed ANOVA was conducted to compare recall scores in the control and interference conditions, along with the condition order, to test whether one memory task condition influenced the other within a repeated measures design.

Condition had no significant effect on recall scores, $F\ (1, 119) = 0.9$, $p = 0.34$, $\eta_p^2 < .01$. This suggested no difference between recall in the control ($M = 5.1$, $SE = .21$) and interference ($M = 4.9$, $SE = .18$) conditions. For the between-subjects effects, the order of the conditions was non-significant ($F\ [1,119] = 2.22$, $p = 0.14$, $\eta_p^2 = .02$), therefore whether the experiment was completed under order I-C ($M = 5.25$, $SE = .23$) or order C-I ($M = 4.76$, $SE = .24$) caused no significant difference on recall scores. However, the results showed there was a significant interaction between condition order and condition itself, ($F[1, 119] = 26.40$, $p = 0.002$, $\eta_p^2 = 0.08$), as both conditions (interference and control) experienced lower mean recall scores for the second memory task when compared to the respective condition's mean scores in the first memory task (see Figure 2.5).

To explore the interaction further, paired *t*-tests were conducted to compare recall scores for the control and interference conditions when split by order. The difference between recall scores was not significant when the control condition was second and interference first (I-C; $t[62] = -1.5$; $p = 0.14$, $d = 0.19$). However, the results for C-I – where interference occurred after control – show that the difference was significant, $t(57) = 3$; $p = 0.02$ $d = .39$. Combined with Figure 2.6, it is clear that recall scores were significantly lower when interference was the second memory task.

A second set of independent *t*-tests show that when interference was the first condition (I-C) compared to when interference occurred later (C-I), there was a significant difference $t(119) = -3.18$, $p < .01$, $d = 0.58$. This shows that participants in the late-occurring interference group had greater interference effects and hence lower recall scores compared to those who experienced interference in the first task. All *t*-tests *p* values were corrected using the Holm--Šidák correction.

This decrease was not present for the early control vs. late-occurring control, $t(119) = .42$, $p = .68$, $d = 0.07$. Decreases in recall scores for the late condition only occur between groups for the interference condition, which had significantly lower recall scores for both within and between-subjects comparisons.

Regression

Table 2. 2

Means and Standard Deviations for Interest and MW (averaged) scores split by Condition

	M	*SD*
Interest Control	3.1	.62
Interest Interference	3.07	.64
MW Control	4.06	1.92
MW Interference	4.06	1.92

Table 2.2 shows that MW and Interest scores were very similar for both conditions. It was hypothesised that higher interest scores would lead to higher recall scores, but higher MW would decrease recall scores. Two multiple regression analyses were conducted to determine whether the three predictor variables (MW, situational interest, and topic interest) were significant predictors of recall. Regressions were performed separately for the control and interference conditions.

***Predictors for the control condition*.**

The first regression measured the effects of the three factors (MW, situational interest, and topic interest) on recall scores in the control condition. The results showed that when combined, the model significantly predicted recall scores for the control condition, $F(3, 117) = 6.76$, $p < 0.01$, $R^2 = 0.15$, $R^2_{adjusted} = 0.13$.

Each factor was measured individually to test the strength of the predictors and provide a more detailed understanding of their effects.

The results showed a significant negative relationship between MW and recall in the control condition ($t(119) = -1.98$, $p = 0.05$). This shows that recall scores were lower and therefore negatively affected when MW was high, indicating that MW is a significant negative predictor of recall.

Situational interest was found to be a strongly significant positive predictor of recall, $t(119) = 3.96$, $p < 0.001$. This suggests that the participants who, when thinking reflectively, reported their situational interest to be high achieved higher recall scores.

Topic/individual interest scores (measured during the retention phase) had no significant impact on recall scores for the control condition ($t(119) = -0.25$, $p = 0.8$), indicating that individual/topic interest, when measured during the retention phase, is not a reliable predictor of recall.

Predictors for the RI condition.

The second regression measured the effects of the same three factors (MW, situational interest, and topic interest) on recall in the interference condition. When combined the results of the regression were similar to the control condition, as the overall model was significant, $F(3, 117) = 7.03$, $p < 0.001$, $R^2 = 0.15$, $R^2_{adjusted} = 0.13$).

Again, each factor was measured individually to test the strength of the predictors and provide a more detailed understanding of their effects. This potentially reveals a difference between the predictors of recall within an RI setting vs. a control.

For the interference condition, topic interest was a strongly significant positive predictor of recall for the interference condition, $t(119) = 2.92$, $p < 0.01$. Therefore, the higher the averaged interest score for the facts, the better the recall.

Like with the control condition, MW was shown to be a significant negative predictor of recall scores for the interference condition, $t(119) = -2.45$, $p = 0.02$.

The final factor measured within this regression, situational interest, was shown to be a non-significant predictor of interference recall, $t(119) = 1.35$, $p = 0.18$. This suggests that situational interest is less impactful upon recall within an interference setting.

Mediation analysis for control condition

To test hypothesis 3 of a potential link between interest, MW and recall, a mediation analysis was conducted to test whether situational interest mediated the effect of MW on recall for the control condition. MW did not predict situational interest scores with the model only explaining 1% of the variance, $F(1, 199) = 1.29$, $MSE = 1.11$, $p = .26$, $R^2 =. 01$, $b = .06$, $t(1, 119) = 1.14$, $p =.26$, confidence intervals at 95% [-.04, .16]. Figure 2.6 shows the b coefficients and significance for each pathway. There was a no significant indirect effect of MW on Recall (b =.04 with confidence intervals of 95% crossing 0 [-.03, .13]) showing that there was no significant mediation.

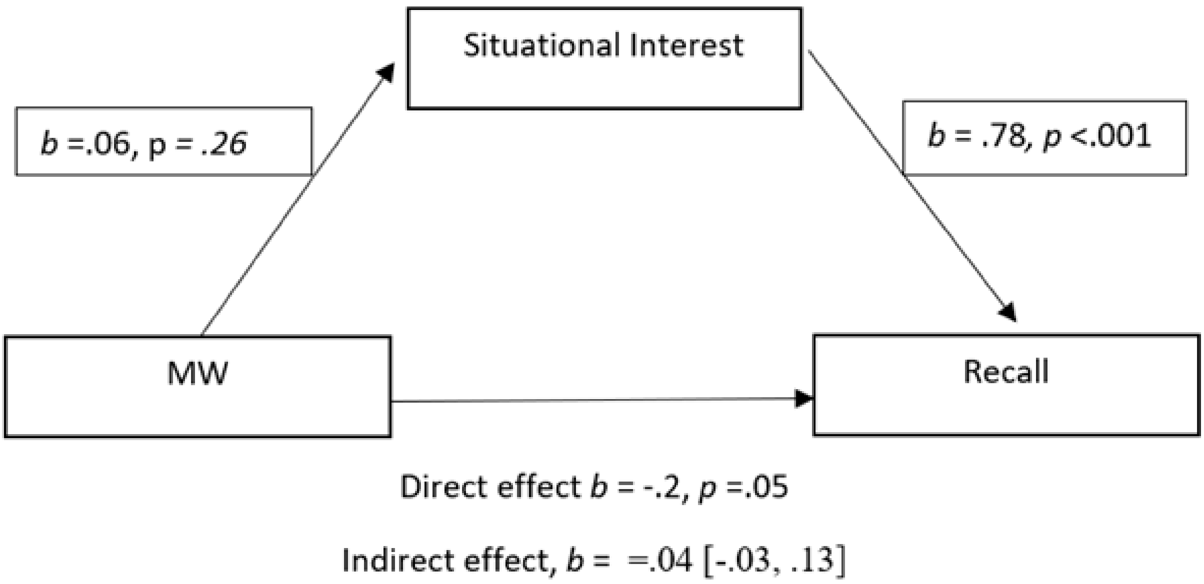

Figure 2.6. Mediation of situational interest between MW and recall.

Mediation analysis for the NRI condition

The next mediation analysis examined performance within the NRI condition. This was tested again with topic interest replacing situational interest to see whether topic interest mediated the direct effect of MW on recall. MW did not predict topic interest scores with the model only explaining .3% of the variance, *F*(1, 119) = .45, *MSE* = .41, *p* = .51, $R^2 < .01$, *b* = .02, *t*(1, 119) = .67, *p* =.5, confidence intervals at 95% [-.04, .08]. Figure 2.7 shows the b coefficients and significance for each pathway. There was no significant mediation effect of MW through topic interest on Recall (*b* = .02, with confidence intervals of 95% crossing 0 [.02, .34]) showing that there was no significant mediation effect.

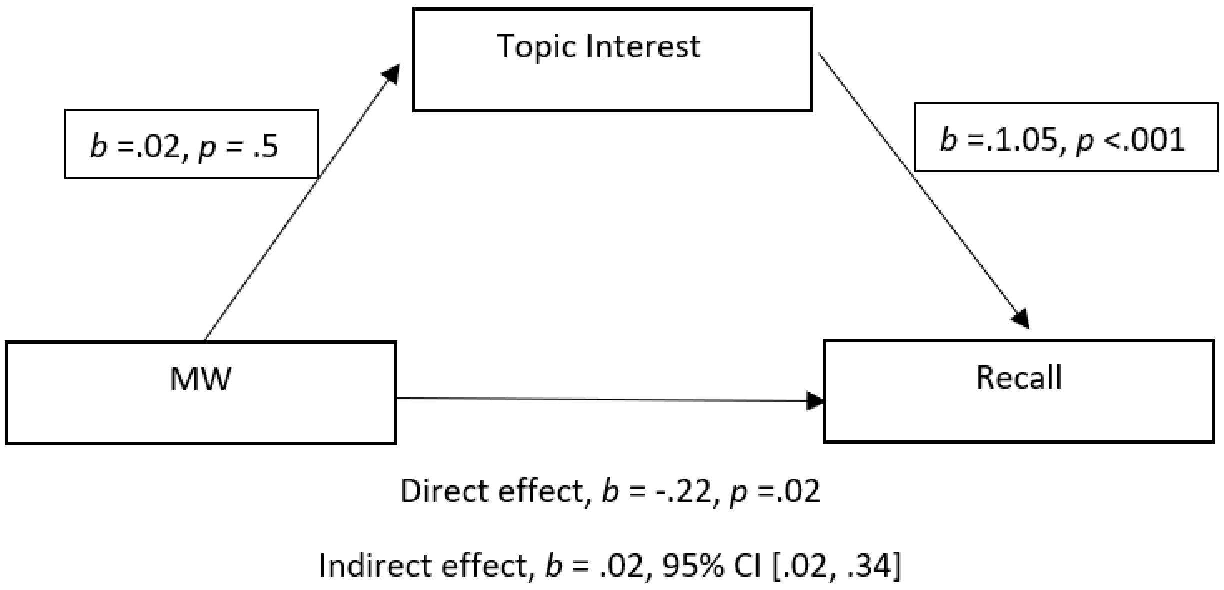

Figure 2.7. Mediation of topic interest between MW and recall in the NRI condition.

Discussion

The experiment aimed to explore the role of NRI effects in hindering recall, while investigating three other factors: the negative effect of MW, the positive effects of interest, and the potential mediation of MW by interest.

MW and Interest

The results for interest differed based on type and condition. State situational interest was associated with increased recall scores during the control condition but not the interference condition. Global topic interest ratings were associated with increased recall in the NRI condition but not the control. As explained by Krapp et al. (1992), state situational interest is a low-level form of interest which is short lasting and environmentally cued. Personal or individual interest, however, is more enduring than situational interest in the environment (Schiefele. 1999; Schraw & Lehman, 2001). Should a subsequent link between interest and NRI be established it would be accepted that the more enduring individual interest was necessary to increase recall during the more demanding task (NRI), whilst situational interest in the environment was sufficient to increase recall during the less demanding task while not salient enough to carry over to a more demanding task.

The results for both regression analyses within this experiment further support previous literature that higher levels of MW during the encoding phase results in impaired recall (Risko et al., 2012; Smallwood et al., 2009). One possibility for this is the theory that MW such as that elicited by autobiographical thinking provides an internal form of concurrent NRI within the encoding phase (Craig et al., 2014; Dewar et al., 2014), and poorer encoding of the memory trace or a failure to encode (Fougnie, 2008; Risko et al., 2012). This concept is supported within this experiment, which found a hindering effect of MW on recall in both conditions, though a cumulative effect of NRI could explain the larger effect found in the interference condition, when compared with the control.

Contrary to the findings of Smallwood et al. (2009), a link between either global topic/individual interest or state situational interest and MW was not established. However, as MW was measured directly at various points using thought probes, it is possible that any TUT resulting from external distractors would be measured by participants as MW, as the cue itself was too specific and failed to distinguish between task-related interference of thoughts, external distractions, and MW. This means that participants may report any external distraction or deviation in conscious effort as MW (internal distraction; Unsworth & Mcmillan, 2014). Stawarczyk et al. (2011) found that 21% of thought probes were MW-related and 20% were caused by external distraction. Therefore, to explore this effect further subsequent experiments should encompass each possible distraction or TUT to account for each variable's salience. This more in-depth separation of TUT would enable a more accurate exploration as to whether a variable of interest valence would mediate MW within recall, as previously argued by Smallwood et al. (2009) and is included within Experiment 4 of this thesis (see Chapter 4).

NRI

The lack of an overall main effect of NRI on recall falls in line with the prior null findings of NRI (Fatania & Mercer, 2017; Martini et al., 2017; Varma et al., 2017). However, exploring the interaction through condition-order effects provides a more in-depth analysis into the overlooked minutiae effects involved in the function of NRI, providing a more complex view of NRI. One effect revealed here is a potential 'fatigue effect' of RI where the late-occurring[1] interference condition experienced the greater 'drop-off' in recall scores.

Further exploration is needed to uncover the true nature of this unique finding. It seems plausible that participants may have suffered from an increase in cognitive fatigue, which led to a more prevalent effect of RI in the C-I arrangement. However, a number of alternative explanations for these results need to be considered before this hypothesis could be accepted. Firstly, the two recall tasks were equivalent in both duration and nature, differing only in the events of the retention interval. This means that the prior task list contained associative verbal stimuli which may elicit PI, hindering the encoding and thus retrieval of the second task list. Secondly, the lack of a statistical difference between the first and second control groups could highlight the effectiveness of wakeful rest in reducing the effects of RI, PI or fatigue (Ecker, Tay, & Brown, 2015; Mercer, 2015). Wakeful rest refers to a controlled waiting period of reduced to low interference. This has been shown to increase recall scores within relatively short periods of rest (often a few minutes) and the effects remain up to seven days after encoding (Dewar et al. 2012). Thirdly, an accumulative cognitive load of associative stimuli and memory task could produce response competition and retrieval failure which exacerbates interference effects, particularly if this effect requires similar cognitive memory processes (similar type of memory; see similarity-based interference section, page 13). Therefore, if the prior memory task was visual, this could increase distinctiveness (reducing similarity interference, i.e., feature -

[1] Within this thesis late-occurring refers to the latest occurring condition and is not a reference to temporal length. The timeframe of the experiments in this thesis remained short (approximately 30 minutes) consistent with other short-term memory experiments.

overwriting; Oberauer, 2008) effects and allow more encoding and consolidation resources for verbal stimuli (reducing cognitive load effects, i.e. resource depletion; Chen et al., 2017).

Limitations

With interestingness of the facts being measured globally, the true individual differences nature of a potential mediation of interestingness on the amount of MW elicited by an individual is not captured, and prior knowledge of the 'facts' was not measured.

One of the facts in List B was consistently rated low for both interestingness and recall and may have influenced the equivalency. Mean and standard deviation scores showed a large overlap between mean scores between the lists, but the slight differences were consistent. However, List A (which has the higher recall scores) did not influence the ANOVA results as the late-occurring interference group which received the worst overall recall consisted mostly of participants who experienced List A (therefore the effect may have been slightly stronger comparatively). Finally, groups situated nearer to 5pm experience more external distraction from outside traffic which was not accounted for in this study.

Conclusion

Global ratings of interestingness experience differing salience on recall between conditions and must be evaluated or reconceptualised. MW and late-occurring diversion/NRI have been demonstrated to hinder recall scores during this experiment, though there was a nonsignificant effect for *overall* NRI. This presents a more intricate effect of NRI than covered in previous experiments and warrants further exploration. Explanations such as cognitive load, similarity-based interference, and cumulative interference (diversion *and* similarity interference) will need to be explored in an attempt to explore this effect further.

CHAPTER 3

Experiment 2

The following experiment is a follow-up study exploring the potential "Fatigue Effect of NRI" found in the first experiment (Chapter 2). The first experiment found that within a repeated measures design consisting of two memory tasks, the recall of the stimuli was significantly impaired when the second memory task contained interference rather than a quiet waiting period. It appeared that individuals became less capable of resisting RI when they had previously undertaken a memory task, which is termed for the sake of this thesis: The Fatigue Effect of NRI.

"Fatigue is defined as a condition or phenomenon of declined ability and efficiency of mental and/or physical activities caused by excessive mental and/or physical activities (…)" (Tanaka et al., 2014, p.1). Mental fatigue caused by Time on Task (TOT) has been previously shown to impair cognitive performance. In Lim et al.'s (2010) study, fatigue caused by a long period of time (16-20 minutes) on the reaction task caused a significant decrease in reaction time performance when compared to earlier reaction times (0-4 minutes condition). However, the study did find there to be robust individual differences in the rate of fatigue/increased reaction times amongst participants. The study also found neuro-imaging differences (not to be measured within the present experiment) which showed that TOT led to decreased activity of the fronto-parietal network, which plays an important role in directing attention when compared with pre-task activity.

This mental fatigue resulting from task difficulty or TOT is a direct component of cognitive load (cognitive load = difficulty of task/time). Barrouillet et al. (2004) argue that cognitive load occurs from two factors in the form of time and resource sharing (captured by their TBRS model). As outlined in Chapter 1, this model argues for the mechanism of forgetting to be decay resulting from a processing trade-off in WM. The extent of decay is dictated by the level of cognitive load, as the main mechanism of cognitive load within WM is attention which is necessary for focusing the resources on the maintenance and processing of a memory. The time-based aspect is the concept that a memory trace will decay when the attention is swapped away from maintenance and the forgetting is caused by longer durations on the distractor task as a result of increasing the cognitive load (Lewandowsky et al., 2009). Barrouillet et al. (2004) also state that traditional models argue that concurrent tasks (such as the rating of each fact for interest during the encoding phase of Experiment 1) increase cognitive load by using multiple cognitive resources and therefore significantly hinders recall. However, Barrouillet et al. state that this concurrent task is not necessary within the TBRS model, with time constraints playing a more significant role through preventing the refreshing of decaying memory traces by the moving/reprioritising of attention resources within shorter periods of time. In this way, any other attention-demanding task pulls attention away from memory maintenance, leading to decay.

The TBRS model was tested by Oberauer and Lewandowsky's (2008) study, which found that both decay and temporal distinctiveness (which are time-base theories) were inadequate at explaining forgetting. Instead, within their study Oberauer and Lewandowsky tested three models of forgetting: two time-based models and one interference model. The study found that longer delay intervals after encoding did not lead to decreased recall (a finding supported by Mercer's 2015 'wakeful rest' experiment) and rather, the interference experiment provided more reliable predictive impairment when cognitive load was high. This was due to the evidence that event-based experiments remove decay over time while still preventing the refreshing of memory traces. However, the work on TBRS has focused on very short-lived WM for the role of decay in rapid forgetting (see Chapter 1) and may not be fully transferable to forgetting that occurs over the course of the experiment or during the retention intervals used in Experiment 1 (22 mins in total, five min retention intervals). For the fatigue explanation, TOT increases cognitive load, mentally fatiguing cognitive WM resources necessary for learning, making one more susceptible to NRI effects.

Another possibility for the reduced recall within the second memory task in Experiment 1 is PI. PI is interference caused by previously learned information hindering the retention of newly learned information. In the control group of Experiment 1, there was no significantly reduced recall even when the control condition was second. This argues against PI. However, it may be possible that including an interpolated RI task with associative (similar) stimuli within the second memory task may increase the prevalence of PI itself, which could explain the greater degree of recall hindrance to some extent. However, as PI is most prominent with associative stimuli that would be linked with response competition and cue overload theory, this would suggest that both conditions would experience equally hindered recall in the second task. As this was not the case, there must be a more extensive look into the role and prevalence of associative vs interpolated PI on recall performance via exploring the effects of different forms of engaging cognitive prior-tasks.

Rationale

This experiment will provide a deeper understanding of the results found in Experiment 1 by examining the effects of a prior task on NRI. Different prior tasks were provided in different conditions, including a similar memory task (SMT; another verbal fact list) and dissimilar prior tasks (a dissimilar memory task; DMT) and a non-memory task (NMT). The intention was to determine whether different prior tasks experience the same ‘fatigue’ or a ‘cumulative interference’ effect of hindered recall when NRI was present. To focus on the prior-task effect, MW is removed here and is explored within Chapter 5 instead.

The SMT group measured the influence of similarity-based PI or verbal memory resource depletion (cumulative effect). The dissimilar task was included to elicit memory resource depletion but of a dissimilar nature, whereas the NMT (Stroop) contained a mental task to remove the memory fatigue. Finally, a no prior task (NPT) group acted as the control condition. The experiment also tested the different role of interest found within Experiment 1.

Two main hypotheses were tested. HYPOTHESIS 1: By combining the TBRS account of cognitive resource sharing with a potential increase in PI and thus response competition, it is hypothesised that there will be a linear decline in recall performance for these different tasks. Recall will be best in the condition with no prior task, steadily decreasing in NMT, to the DMT, and finally leading to the worst recall in the similar (associative stimuli) memory task.

HYPOTHESIS 2: Situational and topic interest will be significant predictors of recall, with topic interest being most important when interference is most prominent (in line with the results of Experiment 1).

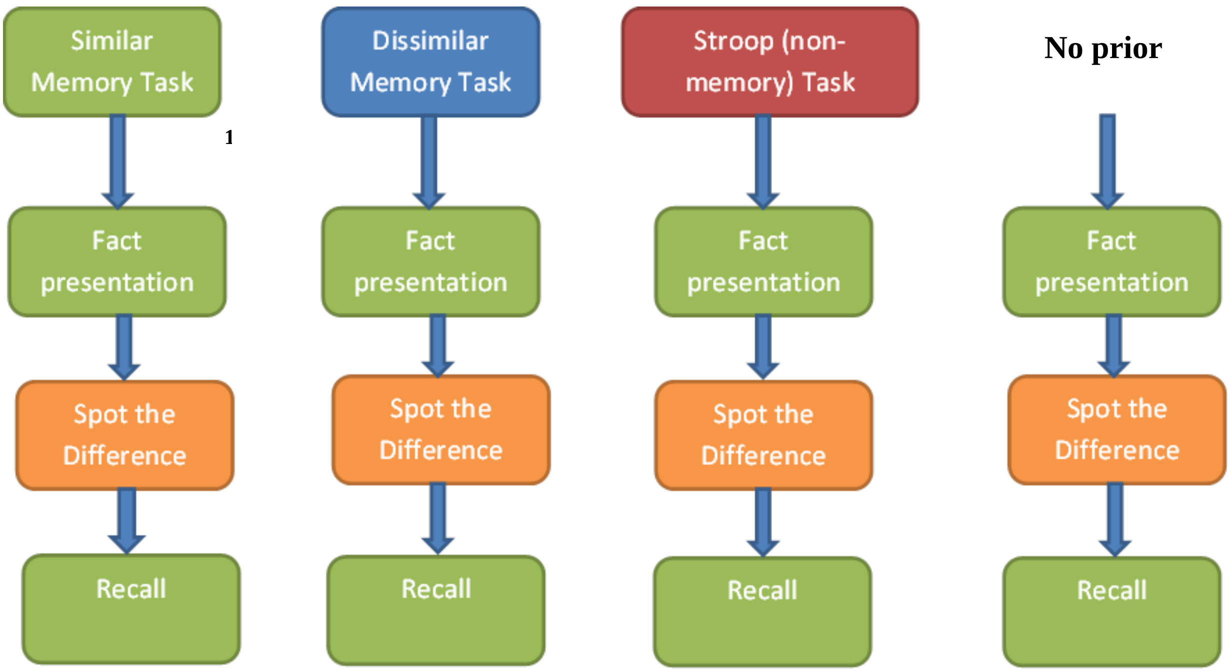

Figure 3.1. Diagram showing the experimental method used with each of the four groups containing identical conditions and order, differing only in the first task condition. The first condition lasted 11 minutes and 30 seconds for the first three groups and 0 seconds for the no prior task, which started with the facts presentation.

Method

Participants

A G*Power analysis based on the C-I effect size ($\eta_p^2 = .14$) in Experiment 1 $\alpha = .05$ and power of 80% indicates a sample of 18 participants per group 72 in total due to recruitment difficulties the experiment consisted of 62 participants (50 females, 12 males) split into approximately 15 per group (17 in the no-prior memory task) were recruited. Participants had a mean age of 26.7 (*SD* = 9.14) and were recruited via an opportunity sample at the University of Wolverhampton. They consisted primarily of undergraduate psychology students volunteering in return for participant pool credits.

Materials

All experiments were conducted within a University booked room which contained a projector for the stimuli. Each experiment had an individualised 'Information sheet' which differed only in the procedure. A consent sheet was used to obtain informed consent from participants via signatures. Each prior condition had an answer booklet consisting of a demographic questionnaire requesting the age and sex of the participant, a series of 'S-T-D' tasks which were identical to Experiment 1 (see Chapter 2), an answer-sheet for participants to write down the recalled facts, and a 'Self-Report' form. This form contained three Likert scales rated from 1 to 10, where participants reported their interest levels for the facts presented (topic interest), the experiment itself (situational interestingness), and the interfering task (S-T-D).

As with the information sheet, the answer booklet differed in the prior task condition (which preceded the 'S-T-D' stimuli). A PowerPoint presentation was used to show the stimuli. The interference task (which succeeds every prior task condition) contained the same set of 20 facts as Experiment 1, with one fact per slide.

Example of facts used across all tasks:

"An individual blood cell can travel around your body in 60 seconds".

"The world's first paper money was created in China".

"The Ancient Egyptians used slabs of stones as pillow".

Similar Memory Task and No-Prior Task

The SMT procedure was identical to the C-I group in Experiment 1 using the same facts, whilst the NPT experienced no control group and proceeded immediately to the facts presentation phase for the interference group (see figure 2.2). With the additional recall phase the SMT contained an additional recall answer sheet, followed by a blank (paused control) sheet.

The Dissimilar Memory Task

Fribbles explanation. To create the DMT, it was necessary to use an activity that uses memory but involves stimuli very different to the fact list. A protocol developed by Mercer (2014) is thought to be suitable as this involves remembering non-verbal visual stimuli over brief delays. The visual stimuli are known as Fribbles and participants performed a same/different matching task (see Figure 3.3). Exemplars contain four different parts (or appendages), and each part is represented by a different colour. After the delay the test exemplar was shown and was either identical to the exemplar or two parts differed in shape or colour. In the example below, the two items differ. Participants were asked to indicate whether these were the same or different, but the scores were not calculated as this was a distractor task. The answer sheet contained two tables (one per level) for participants to respond to the Stroop stimuli.

The presentation contained 22 Fribble trials per level. Level 1 lasted 4 min 2s and Level 2 lasted 6 min 58s. The DMT contained an answer sheet with two tables (one table per level. See Appendix C_2) for participants to respond to the 'Fribbles' task.

Figure 3.1. Fribbles example. Stimulus images courtesy of Michael J. Tarr, Center for the Neural Basis of Cognition and Department of Psychology, Carnegie Mellon University, http://www.tarrlab.org

Non-memory (Stroop) task

The NMT contained two levels with equal time length. The first level of the Stroop involved three changing word colours of changing font colour (49 trials/5min 43s). The second level involved five changing words and font colours (38 trials/5min 42s). To create the NMT the classical Stroop task of executive control was used. As the design was simple and timed two rounds (5m 30s each) were used to reduce the practice effect and maintain participant engagement throughout the 11 minutes. In Figure 3.3 are two of the instruction slides. Participants were asked to respond whether more of the target words are congruent than non-congruent in the answer sheet (see Appendix C3).

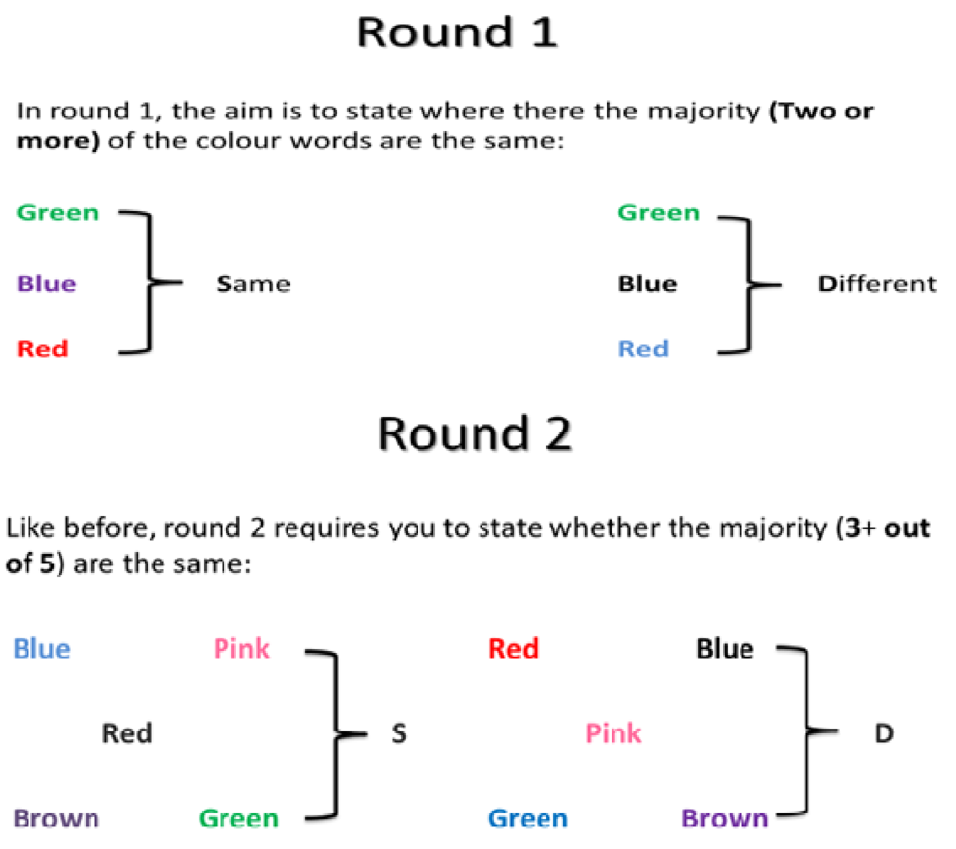

Figure 3.2. Stroop stimuli and task example.

Design

The present study was an independent measures design measuring the differences between four groups, each with a different prior-task (IV). Recall scores were recorded (DV). All prior-task groups (SMT, DMT, NMT, & NPT) experienced the same subsequent interference task. One group, the SMT group, was identical to Experiment 1's C-I group. Situational interest in the experiment was included as a predictor.

Procedure

All participants experienced the same facts followed by an interference (S-T-D) task and a subsequent free recall period. Each group of participants were recruited separately and tested within a small experimental room with a maximum of eight participants at a time (typically recruitment happened individually).

The participants were provided with the information sheet corresponding with the task condition. A projector showed the PowerPoint slides which explained and provided examples of the tasks the participants would be asked to complete, should they consent. The experimenter then explained these slides before reiterating ethical concerns, such as the ability to withdraw, right to self-determination, confidentiality of the results, and how to claim the participation pool credits after completion of the task. Following this, the participants were provided with a consent form. After the participants had decided to consent to the study, they were handed an answer booklet where the participants filled out the demographic information of age and sex, along with their participant pool number for credits.

Once this had taken place, the experiment began. The experiment groups lasted approximately 30 minutes from this point, as the timings were pre-set within the presentation. The timing of the prior tasks of each group (except NPT) were roughly equivalent at eleven and a half minutes each.

As the NPT group began with the facts list of the interference condition, this condition was 11 and a half minutes shorter to conduct. For the DMT, participants were shown an exemplar Fribble for 1s, which had to be remembered, followed by a 2 s or 10s delay (see above). The delay was followed by either the same or a similar exemplar for 5s. For the NMT, a Stroop test was used, where participants had to determine whether the font colour was the same or different to the written word colour. For the DMT and the NMT, participants responded with either "same" or "different" (presented within a table on the answer booklet) for each trial, concurrently. The presentation contained additional blank slides as delay periods between trials to prevent potential performance issues arising as a result of a concurrent task. Within the DMT, these delays were controlled as a level of difficulty, with a 2 s delay for level 1 and a 10 s gap for level 2. As with the DMT, the NMT had two levels of progressing difficulty (to keep the participants engaged). Level 1 contained three colour words (shown for 5 s) and level 2 contained five colour words (shown for 7 s), each with a 2 s gap between trials. Participants were to determine whether there were more consistent (same) font colours than contrasting (different) font colours to the word colours.

After the prior-task, the interference task took place, taking approximately another 11 and a half minutes. The stimuli consisted of 20 facts which were presented for 8 seconds each, shown one after the other. Participants were then asked to attempt the S-T-D tasks provided for them within the answer booklet (for five minutes). Immediately following this, participants were asked to recall all the facts that they could, within any order, and to attempt partial recall if the full facts could not be remembered. The free recall period lasted for four minutes. Once the four minutes were up, the test was over and participants were asked to turn over to the self-report questionnaire to rate how interesting they found the experiment, the facts, and the S-T-D tasks. Finally, participants were thanked for their participation and instructed to present an X on the front of the booklet if they wished to withdraw their data at that point before receiving a debrief sheet.

Results

Data Analysis

As with Experiment 1, the following approach to scoring recall was used:

- ÷ Half a recalled fact resembling a fact is counted as ½ a mark.
- × If the fact is fully incorrect, it isn't counted.
- ÷ If the phrase is half correct it's worth ½ a mark
- ✓ If the fact is different in only one way (i.e., number) it will be correct (only if the new meaning isn't incorrect)
- ÷ If a fact remains correct but more than one detail is lost, ½ a mark is awarded.

Interest

Due to the experimental room change between experiments (classroom environment in Experiment 1 vs. a small, controlled experiment room in the current study), an independent-samples *t*-test was used to compare the situational interest ratings from Experiment 1 with the ratings for the current experiment (divided by 2 due to a 10 point scale used). This aimed to determine whether a closer interaction with the researcher biased the interest ratings. There was a strongly significant difference between the mean ratings, with participants in Experiment 2 (M = 3.94, SD = .94) rating fact interest as higher and with less variance than Experiment 1 (M = 3.36, SD = 1.08), $t(121)$ = -3.15, p = .002, d = 0.57. Participants scored Experiment 2 consistently as more interesting, potentially indicating participant reactivity whereby participants wish to indicate that the experiment is more interesting due to close proximity to the researcher conducting it.

With the current experiment taking place with smaller groups and involving more experimenter-participant interaction than Experiment 1, interest scores are compared through normal distributions to measure equivalency vs. participant reactivity.

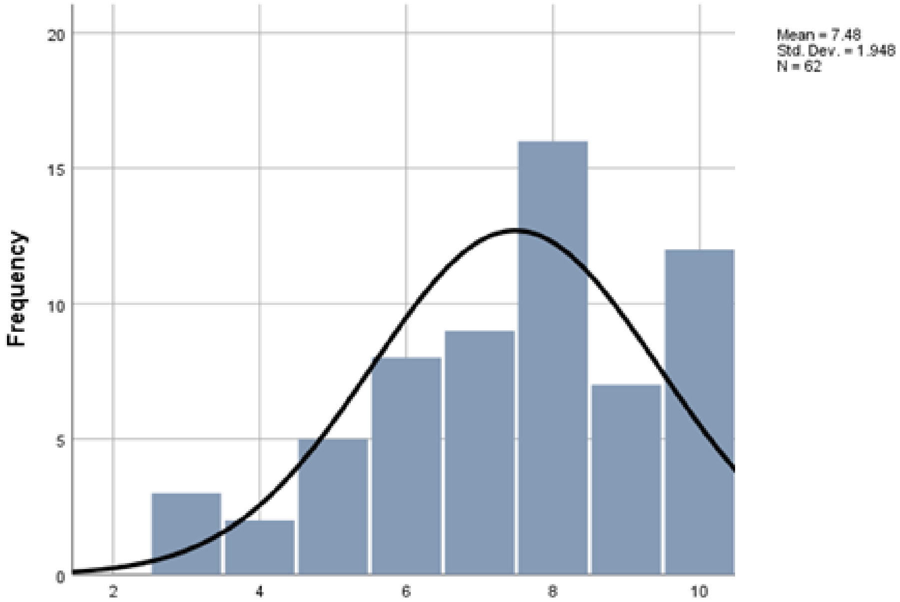

Figure 3.3. Topic interest scores showing that 56.5% of scores are between 8-10 with no ratings of 2 or lower.

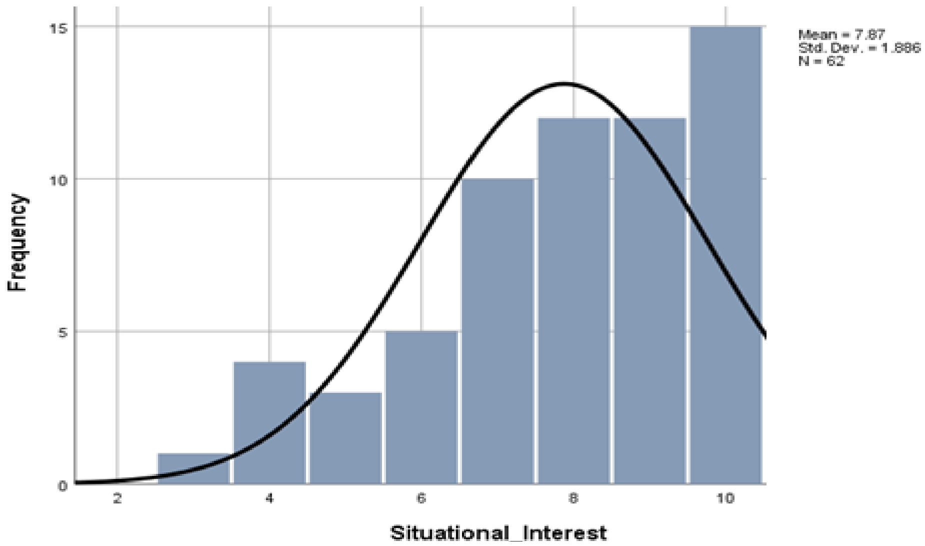

Figure 3.4. Situational interest histogram and normal distribution curve for Experiment 2.

In Figure 3.5 the interest ratings are greatly skewed towards the higher ratings, with no participants rating 2 or lower and only one rating 3.

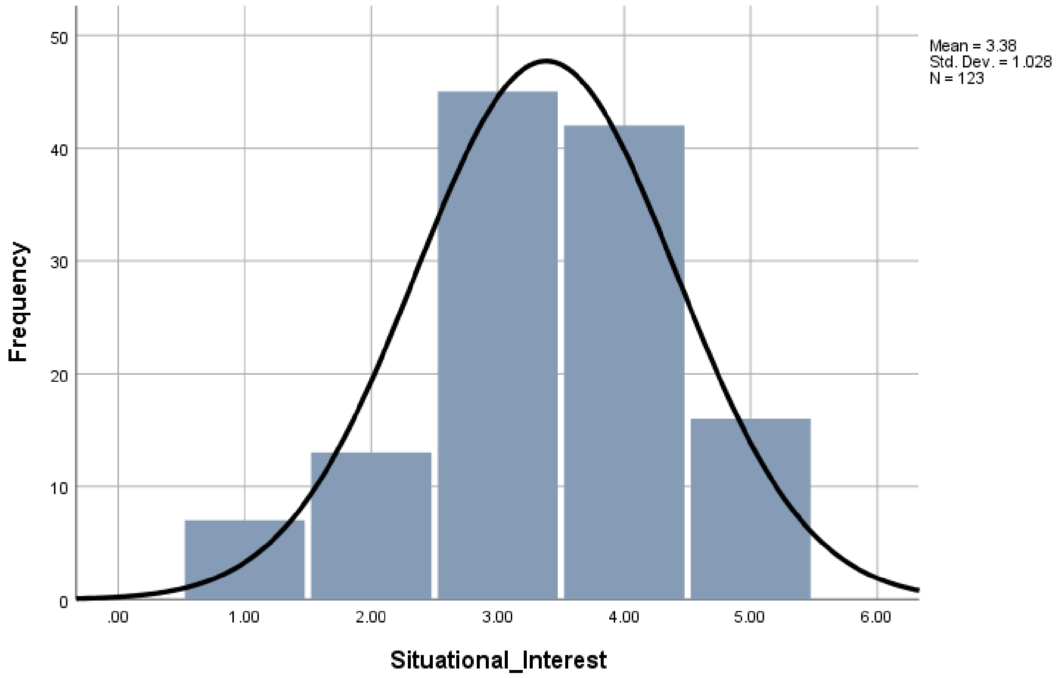

Figure 3.5. Frequency distribution and normal distribution for situational interest in Experiment 1

Figures 3.4 and 3.5 show interest ratings for Experiment 2, which greatly exceed the ratings of Experiment 1 and are skewed from a normal distribution (Figure 3.6) towards higher interest ratings. As the task is highly similar to Experiment 1 this potentially demonstrates participant reactivity. Though participants may be more motivated in the current experiment as they seek the opportunity out themselves (vs Experiment 1, which was part of a practical).

Correlations

As the reported data is skewed outside of a normal distribution, a Spearman's rho correlation compared topic interest, situational interest, and recall which was collapsed across prior task conditions.

The results of the Spearman's rho correlations showed no correlation between topic interest and recall ($rs[60] = .03$, $p = .84$) or situational interest and recall ($rs[60] = .07$, $p = .6$). Ratings of interest in the current experiment did not correlate with recall. However, topic interest and situational interest correlated ($rs[60] = .73$, $p < .001$), with high scores in topic interest matching the high scores in situational interest.

Impact of Prior-task condition on fact recall

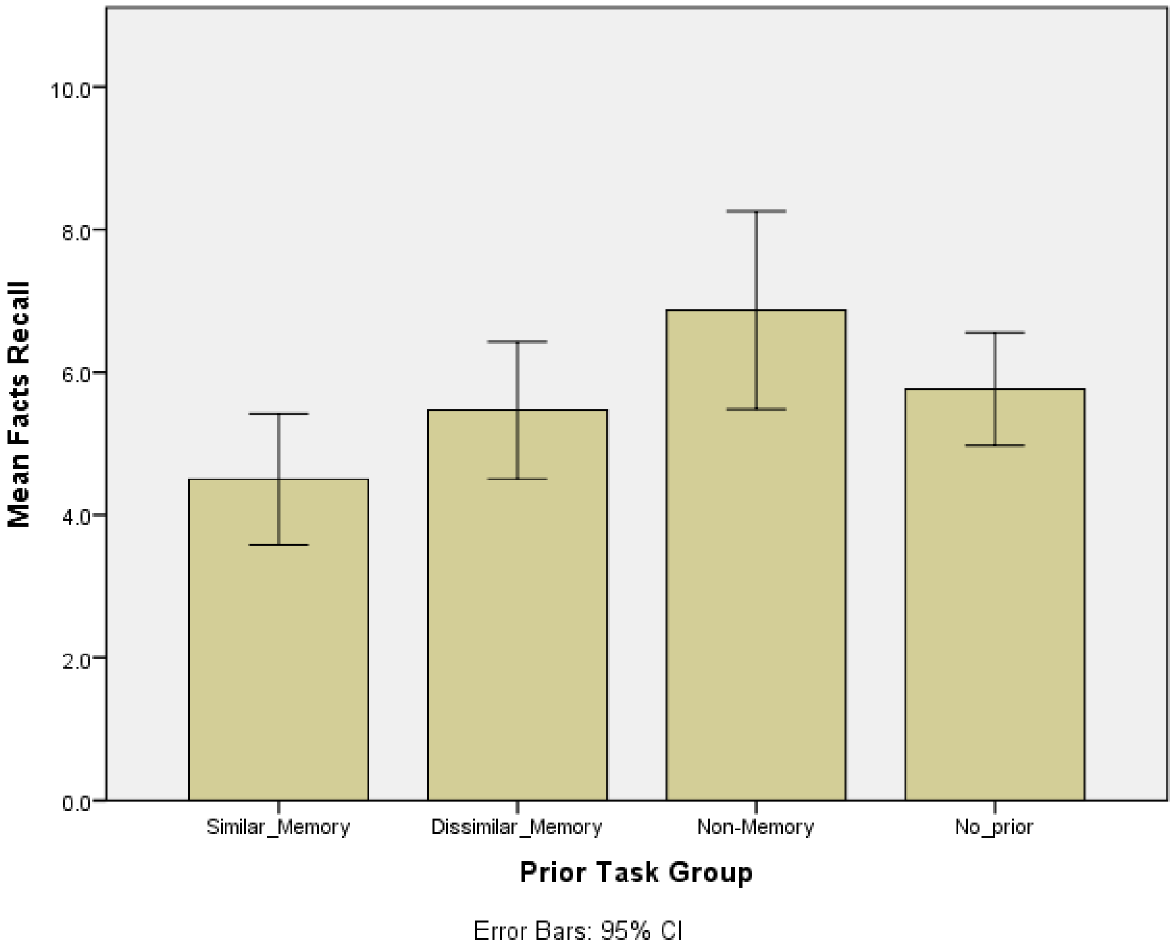

Figure 3.6. Mean correct recall for the four conditions of Experiment 2.

Figure 3.7 shows the mean recall scores for each prior-task group, along with the confidence intervals for each. The graph shows that the SMT had the lowest mean recall (*M* = 4.5, *SD* = 1.66) followed by the DMT (*M* = 5.47, *SD* = 1.74). The control NPT group received the second highest recall score, with participants recalling almost one and a half more words than in the SMT (*M* = 5.77, *SD* = 1.53). Finally, the NMT had the highest mean recall score (*M* = 6.87, *SD* = 2.51)

Preliminary analysis. Levene's test of homogeneity of variance for the four independent groups was non-significant ($F(3,58) = 1.15$, $p = .34$), therefore the assumption of homogeneity of variance for the ANOVA was met.

Main analysis. To measure whether there were any significant differences between recall scores when participants were exposed to different group prior tasks, a one-way ANOVA was conducted. The results indicated a significant difference between the group recall scores, $F(3,58) = 4.00$, $p = 0.01$, $\eta_p^2 = 0.15$.

To further explore the ANOVA recall Tukey HSD post-hoc tests were conducted and found the SMT to be significantly different to the NMT (MD = -2.14) $p = .02$. The Tukey HSD test results also found that the differences between each task group to be nonsignificant $p > .05$. Including the comparison between the SMT and the control group NPT (MD = -1.24) $p = .23$.

To measure whether the SMT experienced a strong NRI/ late-occurring NRI effect expected a paired *t*-test compared recall scores for the early occurring control condition ($M = 6.93$, $SD = 2.02$) vs. the late-occurring NRI condition ($M = 4.5$, $SD = 1.66$). As expected the *t*-test found a strong significant NRI effect $t(14)= 6.01$, $p <.001$, $d = .94$. The results replicate Experiment 1 and validate the G*power analysis for sample power.

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Discussion

The current experiment tested the role of prior-task involvement in the explaining the hindered recall scores from Experiment 1, through either similarity-based PI or cognitive fatigue. The role of interest was also explored.

Interest

A frequency analysis showed that although there appeared to be no impact of either individual or situational interest on recall scores, participants rated both the experiment and the facts as far more interesting than Experiment 1, even though the same facts were reused and so were identical to the previous experiment. Additionally, the experiment followed a very similar format (with the latter half of the experiment remaining identical). Therefore, although the pages were blocked from the view of the researcher, this closer and more one-to-one environment is likely to have increased a reactivity bias where participants responded that the experiment was more interesting in order to avoid offending the researcher. Although less likely, participants may have rated the experiment as more interesting as they chose to participate (vs. Experiment 1 where it was an optional part of a mandatory practical). The previously reported connection between interest and recall may therefore have been masked by ceiling effects of interest salience.

The Fatigue effect

The results of this experiment provide tentative evidence for the importance of temporal isolation of the encoding phase in reducing the effects of both PI and RI, thus increasing memory recall (Brown, et al., 2006; Ecker, Tay, & Brown, 2015; Morin, et al., 2010; Rönnberg, 1980). The NMT was low demanding (with participants often waiting for the slide to change having already answered) and thus may have served as a form of ‘active rest’ (Ecker, Tay, & Brown, 2015) leading to a reduction of any PI caused by prior lectures, seminars, or every day non-specific interfering tasks just as that caused by autobiographical thinking (Craig et al., 2014; Dewar et al., 2014). The low-demanding prior-task group achieved the greatest recall scores – greater than that of the NPT, further supporting the evidence which shows that a passive rest period, though helpful (i.e., Mercer, 2015), is not entirely necessary for consolidation of recall to occur (Varma et al. 2017). A consolidation account could explain the greater recall as the result of the (Stroop) NMT preventing spontaneous rehearsal (or recollection) of prior-to-experiment memory traces (PI memories ‘popping’ into thought), while also preventing autobiographical thinking, thus freeing up consolidation memory processes by reducing memory resource demand (Varma et al. 2017). However, Ecker, Tay, and Brown’s (2015) experiment tested the effect of temporal isolation against the freedom of consolidation process resources within their experiments 1 and 2. Ecker et al. measured recall of two lists (list 1 and list 2) which were separated by differing temporal delays to test pre-study and post-study rest and temporal isolation. Whilst Ecker et al. found strong pre-study rest effects similar to the present study for list 2 recall, a greater consolidation of list 1 (represented by greater list 1 recall scores) was not found, indicating that the improved recall of list 2 following a longer pre-study rest was not explained by a freeing of consolidation processes following successful list 1 consolidation.

Another explanation of these results is provided by the TBRS model and in particular, resource depletion (Chen et al., 2017). According to Chen et al., resource depletion occurs when the prior task hinders performance of the later task by 'using up' the available cognitive resources within the WM capacity, and hindrance is considerably more potent when the two tasks are similar by requiring the same/ similar resources, or are more effortful, thereby increasing cognitive load. This effect is decreased by rest periods which enable the replenishment of the WM and self-regulatory resources (Tyler and Burns, 2008). The results of the current experiment fit within this framework with the SMT performing the worse, followed by the DMT (though the differences between the two were small, the difference between SMT and NPT was approaching significance and may have increased with greater statistical power). The greater recall performance of the NMT over the NPT is coined within this framework as the "spacing effect" as opposed to temporal isolation, though they both contain similarities in functionality. The spacing effect shows an increase in memory retention when information is 'spaced out' temporally vs. the same information presented all at once (crammed). This is sometimes known as the massed vs. spaced effect. Within this paradigm the spacing effect could allow the replenishment of WM resources required for regulating the encoding and retrieval process. The spacing effect is mapped out in a similar fashion to the temporal distinctiveness model, whereby the increased recall effect results from more temporally distinct memory traces. Though this pattern is found the statistical power provided may not be sufficient to make accept this conclusion and instead, the non-significance of the differences between the NPT and the other tasks provides an argument against the role of prior-task involvement fatiguing and hindering the late-occurring recall condition.

Limitations

The skewed interest ratings biased the analysis and so an interest conclusion cannot be obtained. The main issue with the current experiment is that of statistical power due to recruitment difficulties. Due to using the same stimuli as Experiment 1 the second-year group were unable to take part. With few first or third years getting involved with research the recruitment process was halted after taking up most of the second year of this thesis.

Conclusion

Whilst 'Temporal Isolation' and the 'Spacing effect' when combined within a WM resource sharing framework provide a plausible explanation for the results of Experiment 2 and is in line with temporal distinctiveness theory (i.e., Glenberg, & Swanson, 1986), there is insufficient evidence to *fully* account for the NMT's greater recall. In order to show that the Stroop task functioned as a temporally isolating/spacing task which did not drain attention and other WM resources necessary for encoding, rather than simply being a task which primed attention allocation, another experiment must be conducted which explores the impact of prior-Stroop tasks with differing cognitive loads. If a greater, more cognitively demanding Stroop task fatigues participants within the interference condition task and this reduces recall, then it would provide great evidence that temporal isolation and the spacing and distinctiveness of tasks/stimuli are primary components of resource sharing which account for 'the fatigue effect' of increased RI prevalence in hindering second task recall. In other words, the temporal isolation of a task may reduce the resource fatigue which leads to the pervasive salience of RI.

Experiment 3

The next experiment will include the educational psychological method of topic-based ratings of interestingness by measuring 15 facts (five per category, with two topic-specific fact categories and one non-specific fact category). Participants rated their interest in each topic using Rotgans' (2015) six-point topic interest scale prior to the memory experiment.

The current experiment is a short follow-up to Experiment 2 whereby the Stroop test was used as a prior NMT (to elicit extraneous cognitive load). The subsequent recall was then compared and contrasted with different memory prior-tasks and a no-prior control. The group that experienced the prior Stroop task had the greatest recall, which was significantly greater than the SMT, though not significantly different to the no-prior condition. For this reason, the role of the Stroop task as a cognitively fatiguing exercise was further explored within this experiment, in order to test the validity of the fatigue argument for the late-occurring NRI effect.

Rauch and Schmitt (2009) were able to measure mental fatigue by utilising a Stroop-task that lasted just 15 minutes by applying a more demanding task than those used in tasks applied over an hour to two hour period (Boksem & Lorist, 2006; Lorist et al., 2005; McMorris et al., 2018). Their task consisted of 480 single-word Stroop trials and found that over time participants became less effective at the task due to a loss of cognitive control. This occurred when participants were unable to inhibit the automatic process of reading the word and they struggled to maintain the goal-related focus on the colour, a finding which reportedly supported a previous study (Hofmann et al., 2007) and was argued as a cause of distraction.

The exertion of the cognitive control function could theoretically reduce on-task allocation of attention and motivation during the recall phase, reducing recall. However, this was not the case for prospective memory, which is the ability to recall an action at an appropriate time (McDaniel & Einstein, 2007), such as everyday tasks. Cook et al. (2014) found that executive control depletion from a Stroop task did not hinder participant's memory performance. Instead, a correlation was found between the participant's personal reported experience of cognitive fatigue and their subsequent memory performance. This indicates that whilst participants feel that cognitive fatigue played a big part in their performance, not all forms of memory are hindered by the depletion of the executive control function.

So, what of declarative memory? For serial recall, Mccabe et al. (2005) conducted an experiment encompassing both executive function (through the need to inhibit automatic reading processes) and memory load (through sequential recall of the colour trials). They found that the Stroop Task has an Interfering effect (known as 'Stroop interference') which is a function of the memory load, particularly in older adults. This was argued as a function of increased load in WM capacity decreasing the ability to allocate and maintain attention resources in older individuals, leading to an increase of errors (recall of incongruent colours). With the conceptualisation of WM as an attentional resource necessary for task performance within short term memory and executive functioning tasks, and as the Stroop task requires maintenance of this task related focus, it is plausible that a more demanding Stroop-task similar to Cook et al. (2014) would increase the interference effects similar to the Stroop interference found by Mccabe et al. (2005) and thus decrease recall performance.

A cognitive load- based explanation of the results in accordance with TBRS (Barrouillet et al., 2004) postulates that the cognitive load of a task is a function of the length of time it captures attention and impedes other attention-demanding processes and the conceptualisation of WM as an executive attention process (Engle, 2002). It is hypothesised that the more effortful Stroop task will increase cognitive load and decrease subsequent recall performance greater than the no-prior task due to the greater number of trials and cognitive demand of executive processes combined with a longer time-on-task factor (Barrouillet et al., 2007).

Alternatively, an interference-based explanation may be more pertinent due to the RI experimental design which frames the experiment for the specific exploration NRI within the retention interval. This would be in line with temporal distinctiveness theory and the finding that temporal isolation of the encoding phase increases recall by delaying the onset of, and therefore reducing the impact of, interference effects (Ecker, Brown, & Lewandowsky, 2015; Ecker, Tay, & Brown, 2015; Mercer, 2015).

Topic Interest

The traditional approach of measuring interest within educational psychology involves the rating of participants' interest in a topic followed by subsequent learning and testing of the information and concepts contained within a paragraph of prose of the said topic. This is a way of measuring text-based interest and learning (Garner et al., 1991; Hidi & McLaren 1988; Schiefele, 1990; 1991; Schiefele, & Krapp, 1996; Shirey & Reynolds 1988). The general consensus is that for text-based learning, topic interest is a positive predictor, with a recent study by Soemer and Shiefele (2019) finding that topic interest mediates MW which increases during greater text difficulty. Within their study, Soemer and Shiefele measured topic interest by getting participants to rate the subjective interestingness of the topic shortly after the participants had read the text, thus incorporating the situational interest element of "interestingness" with the dispositional individual interest factor (this is considered further in Chapter 4). However, this was not used to test recall specifically, and it would have been useful to see whether the mediation would have continued within an interest, MW, and recall paradigm.

Rationale

The current experiment aims to explore the fatigue effect of NRI interpretation of late-occurring NRI by providing further understanding of the increased recall findings from the NMT in Experiment 2. The Stroop task therefore will be explored for its potential to be a low-level memory task sufficient to produce active rest (thus decreasing interference). It is hypothesised that a simple Stroop task replicating the NMT from Experiment 2 will cause temporal isolation of memory resources, by being a low-demand task attempting to provide a form of 'active rest period' similar to Ecker, Tay, and Brown's (2015) tone detection task, thereby decreasing PI and leading to greater or equal recall to the no-prior group.

For interest, the current experiment aimed to measure interest in a topic by incorporating the previously used pre-study interest ratings design with a modern interest scale measurement – 'the individual interest Questionnaire' (Rotgans, 2015). This measures an individual's prospective anticipation of how interesting they may find the facts within a topic and how that may affect the recall of specific topic facts overall, rather than conceptual knowledge and understanding (similar to curiosity conceptualised as anticipated knowledge seeking; McGillivray, 2013). In line with previous text-based topic interest findings, it is hypothesised that an individual's personal perception of their predisposition to interest when engaging in a specific topic will increase the subsequent recall of that topic's items. It is important to note that any situational interest or interestingness will not be measured, as was the case in the study Soemer and Schiefele, as the positive valence of situational interest/interestingness upon learning and recall has already been well established within the literature. The experiment will contain two different subject categories and one control category (random not topic-specific facts) to test the reliability of prospective interest ratings (based on subjective individual previous interest experiences), rather than concurrent or retrospective interest as a predictor of recall performance (Rotgans, & Schmidt, 2018).

Method

Participants

Participants were recruited online due to the recruitment time limitations caused by Experiment 2 sample saturation. This involved online opportunity sampling through online advertisements and the University of Wolverhampton's SONA participant pool consisting of undergraduate psychology students. Sixty participants, split evenly with 30 males and 30 females, were recruited and aged between 17 and 64 (M = 27.98, SD = 10.73). Participants that did not complete the full process towards the debrief were removed. One participant was removed due to two empty recall phases.

As the current experiment was intended as an extension of Experiment 2 recruitment followed the G*Power analysis in Experiment 2 for replication of the C-I effect. Therefore, current experiment aimed to get at least 18 participants per group. Gorilla recruitment involves setting ratios. Ratios were weighted evenly as 10:10:10 but due to drop-out rates or missing data the group sizes were as follows: No-prior N = 23, Easier Stroop N = 19, and Harder Stroop N = 20.

Materials

A laptop or desktop computer with a computer keyboard and internet access to www.Gorilla.sc was required.

Recruitment materials

Upon clicking the study hyperlink prospective participants were presented with an information sheet detailing the nature of the experiment relative to the group (Stroop vs no Stroop). Following this, participants were provided with a consent box which had to be ticked in order to for them proceed to the experiment. Finally, upon completion of the experiment a full debrief of the experiment was provided.

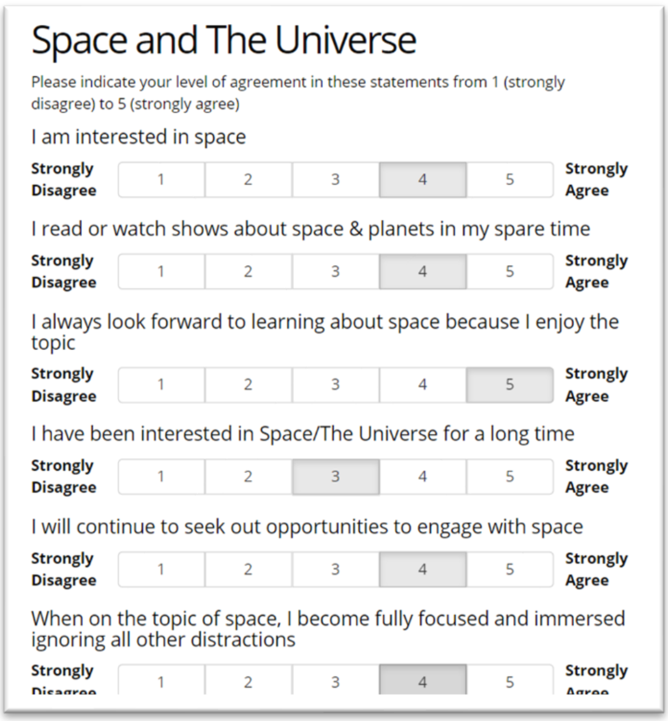
Questionnaires

Following consent participants were provided with a demographic questionnaire to optionally submit information on their sex and age. Then an interest questionnaire consisting of two sets of six Likert scales of interest were created. One set of scales for the topic “space” and one set for the topic “animals” were created. The scales were consistent with Rotgans’ Individual Interest Questionnaire (IIQ; see Figure 3.10 below).

Experiment content

The stimuli involved 15 short facts that were sourced online using Google searches. This included five random facts for a control, five space-related facts and five animal-related facts. These categories were chosen to produce different topics for contrast between topic interest and topic recall and all of the facts were of similar length. The two topics were chosen as they were easy to source and in-keeping with the stimuli of the previous experiments (appendix A_3). The free spot-the-difference task sheets from previous experiments were uploaded and combined with some independently created tasks using clipart and MS paint to prevent copyright infringement (appendix B_2). The stimuli for the Stroop task were created reused from the previous experiment's PowerPoint slides and exported as .JPEG files. The S-T-D tasks were timed and upon clicking the mouse a red square would indicate where the participant believed there to be a gap (Figure 3.8). ***Gorilla.*** The experiment was programmed using Gorilla.sc which is an experimental software website that enables online participant recruitment, and records response data and timings.

Figure 3.7. Spot the difference task screenshot example. Red square representing a



Space and The Universe

Please indicate your level of agreement in these statements from 1 (strongly disagree) to 5 (strongly agree)

I am interested in space

Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree

I read or watch shows about space & planets in my spare time

Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree

I always look forward to learning about space because I enjoy the topic

Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree

I have been interested in Space/The Universe for a long time

Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree

I will continue to seek out opportunities to engage with space

Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree

When on the topic of space, I become fully focused and immersed ignoring all other distractions

Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree

Figure 3.8. An example of the modified Rotgans IIQ.

Design

This was an independent-measures one-way design similar to Experiment 2. Measuring the effect of $IV_{1,}$ Prior-Task difficulty (control, easy Stroop, or hard Stroop), and $IV_{2,}$ topic type (space vs. animal), along with the predictor variable of topic/individual interest rated prospectively on the DV (correct fact recall).

Procedure

Upon clicking on the online experiment link participants read the information sheet, proceeded to the consent form consisting of a checkbox to continue, filled out (optionally) their age and sex, and then completed the interest questionnaire scales. Upon completion of the questionnaires, the main experimental task began. Participants were randomly assigned into one of three groups (control/no-prior task, easy Stroop, and harder Stroop).

The easy Stroop contained 75 one-word trials lasting for 5 s per trial. Participants responded whether the colour word and font colour were congruent or not. If congruent (same), participants pressed 's' on the keyboard, if Incongruent (different), they pressed 'd'. The trial did not proceed until 4 s had elapsed and a timer was presented. This task lasted five minutes.

The hard Stroop was conducted in the same format but consisted of two rounds. Round one contained three Stroop words where participants were tasked with testing the congruency of two out of three words (same 's' or different 'd') for 4 s per trial. This section was timed for 2 min 30 s. Round 2 involved five words where the congruency was tested for three out of five colour words (2 m 30 s). Contrary to the easy Stroop, when participants responded the next trial was started, meaning that there was no rest period between time of response and the next trial. The no-prior group proceeded immediately with the facts

All participants then experienced the facts presentation with 15 facts presented. One fact was shown per slide for 8 s. Immediately after the facts were shown, there were 10 spot-the-difference tasks. One puzzle was presented every 30 s. During this, participants were instructed to click and indicate where there was a difference. This was indicated on the screen as a red dot. Finally, participants received a recall page with a text box to record as many facts as possible for a maximum of six minutes, but they had the option of proceeding by clicking a button which stated that they had recalled as much as possible (bracketed recommendation of four minutes). This terminated the experiment and participants were then shown a debriefing.

Results

Scoring

Scoring was similar to Experiment 1 and 2 with the main content of the fact being most important. Each fact list contained five facts with 15 facts in total.

Prior-task influence on late-occurring NRI

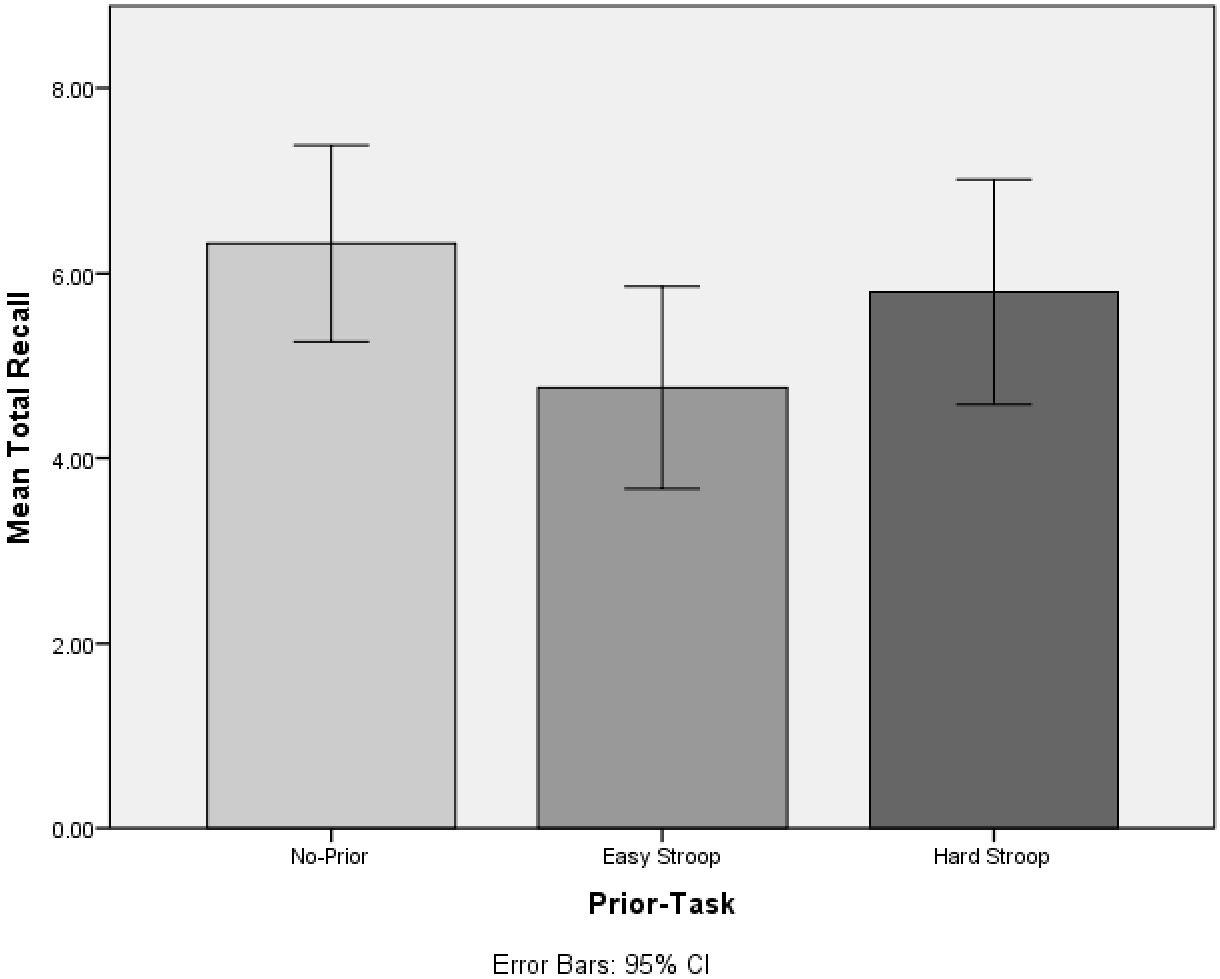


Figure 3.9. Mean total recall scores with 95% confidence intervals for each prior-task condition.

Figure 3.10 shows the no-prior task recalling the most (*M* = 6.33, *SD* = 2.46) followed closely by the hard Stroop (*M* = 5.8, *SD* = 2.6) and finally the easy Stroop (*M* = 4.76, *SD* = 2.6). The confidence in this trend is weakened by viewing the confidence intervals, which show a large overlap in variance between each of these mean scores.

Variance across the three groups was found to be homogenous through a Levene's test, $F(2,59) = .19$, $p = .83$, enabling a one-way ANOVA to be conducted. As foreshadowed by the descriptive statistics the differences were non-significant $F(2,61) = 2.15$, *MSE* =

12.93, p = .13, η_p^2 = 0.07. This shows that although there appeared to be recall differences within the groups, this was not considered to be statistically different within the current sample.

Topic interest

Pearson's correlations were conducted to measure any global effects of topic interest on subsequent topic recall totals for the animal and space facts. As the IV of prior-task group was nonsignificant it was removed; collapsing the variables in this way increases statistical power. Positive trends were found between both space interest and space recall and animal interest and animal recall, though these were non-significant: Space [$r(58) = .23$, $p = .09$]; Animals [$r(58) = .17$, $p = .38$].

However, there was a strongly significant positive correlation between participants animal interest ratings and their ratings of space interest $r(58) = .36$, $p = .005$, indicating that participants rated both topics similarly prior to the experiment. Secondly, recall of space facts was positively correlated with recall of the animal facts $r(58) = .31$, p. = 02, potentially indicating an effect of association or a priming effect which is explored further below.

Priming or Fact Similarity?

Table 3. 1

Total Means and Standard Deviations of Recall for each Fact Category (MAX recall of 5) Collapsed across Condition

	M	*SD*
Space Facts	2.11	1.17
Animal Facts	2.19	1.3
Other (Random) Facts	1.37	1.14

Table 3.1 shows very little differences between the mean recall of the space and Animal facts but with a trend towards a reduced recall of the Other (random) facts.

The assumption of homogeneity of variances for each of the recall groups was accepted $F(2,183) = .4$, $p = .67$. A one-way ANOVA was then conducted to explore the differences between the recall of the three fact categories. This aimed to test whether the interest questionnaire primed individuals to look-out for and thus recall the space and animal facts more so than the "other" random facts. The ANOVA found a significant difference between the recall of the fact categories $F(2,183) = 8.78$, $MSE = 12.74$, $p < .0001$, $\eta_p^2 = .09$, with both space facts and animal facts receiving one facts (out of five) more on average recalled than the other facts category.

As there was no directional hypothesis for category recall, post-hoc tests were conducted in place of planned contrasts. The Tukey HSD tests found the other facts category to be significantly different to the space and animal facts category, $t(183) = 4.17$, $p < 0.001$. The Tukey HSD test results also found that the differences between the space and animals categories were non-significant (MD = -.08) $p < .93$. However, both were significantly different when compared with other: Animal-other = .82, $p < .001$, space-other = .74, $p = .002$. This shows that the random fact category was recalled consistently less than the other categories.

Discussion

The current experiment expanded on the results of Experiments 1 and 2 by further exploring the potential fatigue effect induced by prior-tasks during the late-occurring interference condition. The role of anticipated topic interest was also explored in line with previous literature to explore whether anticipated dispositional interest led to greater learning outcomes when interference was present.

Topic Interest

In contrast to previous text-based research, topic interest was not correlated with recall (Garner & Gillingham 1991; Hidi & McLaren 1988; Schiefele, 1990; 1991; 1996; Schiefele, & Krapp, 1996; Shirey & Reynolds 1988). This may be due to the large priming effect (explained below) overriding any potential interest effects, though it is also likely due to the experimental design for measuring topic interest within this experiment.

Participants' interest with the topic was measured before the presentation of the topic stimuli. McGillivray (2013) found that when participants anticipated curiosity ratings were lower than the interest ratings after seeing the stimuli, there was a significantly greater recall performance. Conversely, this positive attribution was not found when participants' interest rating in the stimuli decreased in comparison to their anticipated curiosity. As the current experiment is designed to measure an individual's dispositional individual interest factor, this would not account for or measure the extent to which the individual experiences situational interest evoked by the stimuli. This form of interest leads to the greatest learning outcomes (Rotgans & Schmidt, 2018) and enables the researcher to measure the progression of developing interest through the four phases (Hidi, & Renninger, 2006), leading to greater measuring accuracy of interest effects and a greater understanding on the complexity of the mutable nature of interest salience, and its implications for recall performance and learning.

In the most recent topic interest study, conducted by Soemer and Shiefele (2019), topic interest was assessed using three item measurements of situational interest and one scale item of individual interest, after the participants had read the text stimuli. This study found a highly significant influence of topic interest and its mediating effect of MW (hence focus of attention). Hitherto topic interest has been considered a factor of individual interest- an individual's inclination towards a certain subject domain (Schiefele, 1996) rather than situational interest. It would instead be pertinent to explore topic interest with an individual interest focus initially (pre-stimuli), followed by a subjective situational interest element post-stimulus to measure what effect this individual interest factor/general inclination towards topic domains has on the situational interest elicited. This would conceptualise topic interest as a factor of dispositional interest – a starting point which determines or moderates the experience of situational interest, the more salient emotional impact in the thirst for knowledge (Rotgans & Schmidt, 2014; 2018).

Priming

Although participants' ratings of topic interest did not correlate with greater recall of the topic facts, space recall and animal recall positively correlated. This shows that recall of the stimuli from one category was linked to recall from the other, which indicates a potential category clustering effect or a priming effect. Clustering defined in free recall paradigms is the occurrence of a sequence of similar or associative material (Bousfield, 1953; Bousfield, & Bousfield, 1966; Bousfield. & Cohen, 1955; Frankel & Cole, 1971). Items in related categories form as sequence order clusters in randomised free recall as participants habitually link relational cues to form a priming response within a learning environment. In this case participants in the learning environment habitually linked information in attempt to impose some form of sequential order as a recall strategy, as argued by Bousfield and Bousfield (1966). In summary, the information became more clustered and was therefore easier to encode and retrieve.

Similarly, the spreading-activation model of memory (Anderson & Pirolli, 1984) argues that the recall of one item actives the concept nodes of related items. This leads to easier recall of associative concepts/items and makes this an effective retrieval strategy. Furthermore, items from both topics (space and animals) were recalled significantly more frequently than stimuli from the random facts category. This could be due to the inclusion of the interest questionnaire prior to the experiment, priming participants and enabling them to anticipate stimuli from the two categories and use them as retrieval cues.

'Priming' refers to the learned pairing/association of one stimulus onto a later similar item. I.e. the learning of the word 'cat' would lead to a faster more certain response of 'dog' through the association of animal/pet than of the response 'fence', with semantic priming being a well-established phenomenon (Friederici et al., 1999; McNamara, 2005). According to the spreading activation model, this results from one cue 'activating' the association with the relational cues. In this way, clustering effects imposed by participants lead to a sequence of associative links between items whereby the recall of one item primes and cues the recall of associative memory items through spreading activation. Therefore, the spreading activation model and the explanation of priming explain the phenomena of clustered recall provided by Bousfield (1953) and combine to provide the best understanding of the category results.

The strong effect of category priming leading to greater recall within this NRI condition is not surprising as the positive effects of priming have been found to reduce RI in a study by Bower et al. (1994). They found that priming increased response certainty, the speed of learning, and thus reduced the effect of RI pairs. It was found that these effects decreased with a greater number of competing items within the response category; however, the current experiment contained just five stimuli items per category making it suitable to elicit a strong priming effect that efficiently explains the results.

Cognitive Load vs. Cumulative RI: Prior-Task comparisons

There were reasonable trends of differences between the recall groups, though these trending differences were statistically nonsignificant. However, the current experiment was specifically intended as a follow-up to Experiment 2 and was based on a power analysis using the effect size from the C-I group of Experiment 1. However, the sample size was likely too low to detect the modest effects shown here, as the effect included a no-interference control looking for late-occurring interference rather than interference more generally. Instead, this experiment should be framed as an add-on to Experiment 2 by exploring the effects of hindered recall when NRI was late-occurring. Unexpectedly, the easy Stroop group had the worst recall, though this could be due to some confusion regarding the experimental set-up reported by participants afterwards; Gorilla had no option to maintain an incorrect ‘x’ signal to participant. After the first response was counted, if it was incorrect and participants then chose the correct answer, this would still show an incorrect ‘x’ each time (even though the answer was correct, only the first response can be counted as correct). This may have led to participant confusion or frustration that the Stroop may not be working, which could provide unmeasured negative effects on performance. Recall performance was then followed by the harder Stroop, then as expected the no-prior group.

It is not clear whether five minutes is a sufficient period of time-on-task to fatigue the cognitive control of attentional resources to an extent which significantly decreases recall performance. As found by Rauch and Schmitt (2009) whose study lasted fifteen minutes and which was considered a short-term approach for this style of experiment. If the current experiment was replicated using a longer 15-minute Stroop task and a greater hindrance of recall is observed then that would provide strong arguments for the temporal argument for the TBRS account of the results (Barrouillet et al., 2004). However, due to the length of time theoretically required to cause this resource taxation when the cognitive task is not memory based, then the TBRS account may better explain the results of the Stroop task in Experiment 2. If the prior cognitive task uses different cognitive resources (such as non-memory resources) to the primary task objective (memory resources through memory recall), and the time spent on the task is short and low in cognitive load, then theoretically this reduces the fatigue of the executive attention resources in WM (Engle, 2002). This reduction may be sufficient to resist the low-level cumulative load effects of NRI provided by the S-T-D tasks, by 'freeing up' enough attention resources within the working memory process, that are necessary for maintenance of a memory trace during the retention interval. This would lead to a less hindered recall performance (not significantly different from a fresh no-prior task participant).

Combining Experiment 2 with the current experiment provides mixed to weak evidence for the fatigue effect of RI interpretation, with Stroop tasks not fatiguing the recall of subsequent stimuli greater than a no-prior control, and the SMT did not differ from the NPT in Experiment 2. Whilst, as explained above, this could be explained due to the low cognitive load and resource depletion argument, the overall lack of fatigue induced within the five-minute prior-tasks of the last two experiments leads to greater strength of the cumulative interference argument for hindering recall scores, with similarity-based PI and NRI combining to decrease recall in the late-occurring interference condition.

Limitations

It would have been useful when comparing between fatigue and cumulative interference to have a condition without a prior-task or distractor for an additional control, along with a greater sample size. However, recruitment limitations such as lack of incentive beyond participant pool credits, and recruitment saturation (re-using of the facts from Experiment 1 for Experiment 2) made this difficult.

Conclusion

The two experiments combine to demonstrate that a Stroop task which lasts for five minutes is a non-fatiguing task upon a later memory recall task, and whilst the current trend of results may fit within a TBRS account of forgetting further experiments would be required to adopt this explanation. Instead, the results of the current experiment better befit a cumulative interference interpretation.

Topic interest when measured prior to the stimuli leads to similar interest scores between participants indicating that they may be thinking of interest in the experiment generally or providing general feedback which was thereafter not significantly linked to recall performance. It is recommended that participant interest ratings are measured pre-stimulus using individual interest items followed by post-stimulus items measuring situational interest. This would measure the dispositional individual interest influence upon the situational interest evoked and it is predicted that situational interest will be most pertinent to learning.

A potentially strong effect of priming/associative memory clusters was found by pre-stimulus questions due to the low number of items for the two categories (five) showing that priming, and relational cues through the usage of categories can provide useful strategies for increasing recall performance during a condition where NRI may be present.

CHAPTER 4

Experiment 4

The current experiment is a follow-up from the findings of interest from Experiment 1 which found that ratings of situational interest and fact interestingness differed as positive predictors of recall scores depending on the experimental conditions. However, for state-dependent situational interest, participants were also asked to report their interest in a self-report manner at the end of the experiment. It may, therefore, be worthwhile measuring interest at various stages during the experiment in order to get an active score and less reflective rating of interest. For example, Chen et al. (2001) argue that the measurement reliability of retrospective situational interest is questionable due to the lack of a cohesive reference point. For example, some participants may be comparing their interest in the stimuli with their interest in a book they had recently read, others may compare it to different subjects, etc. Therefore, to explore whether there is an interaction between interest and NRI it is important to utilise various methods of measuring the different forms of interest. Given that in Experiment 1 the individual fact interest ratings were associated with higher recall scores during an interference condition, it is theoretically plausible that an individual's interest in each fact may increase the resistance of that specific fact's memory trace to endure against RI during the retention phase and therefore lead to greater recall scores. To explore the validity of this hypothesis a different experimental approach is needed to that of Experiment 1, as Experiment 1 used global means and standard deviations to explore the effects. This provided an overall trend of interest effects on recall amongst a populous but not an individualistic view, which accounts for a participant's subjective experience of interest with specific stimuli.

Within the context of Experiment 1 interest was contextualised with reference to Renninger et al. (2014). Topic interest is contextualised as actualized interest, which is content specific with an intrinsic motivational orientation. This means that an individual with personal interest in the topic will be more motivated to continue learning. Situational interest is best conceptualized as a measure of interestingness of the learning environment and, therefore, interestingness of the stimuli and experimental task itself. As Krapp et al. (2014) mentions, situational interest is often collective and short-lasting, whilst actualised interest is personal and longer lasting (more perseverant). This may explain the context specific differing salience of interest. However, as there were two different methods used to measure topic vs. situational interest (topic displayed concurrently, situational explained separately), a further experiment is needed to reinforce the validity of the findings to support this concept and understand the role of interest salience in resisting forgetting/improving recall during a period of NRI. Furthermore, the interest results in Experiments 2 and 3 did not reliably correlate with recall, so this experimental approach will enable a further exploration of whether Experiment 1's individual interest effects replicate.

MW and TUT

Previous research has also found that interest can decrease distraction by TUT. For example, Smallwood et al. (2009) conducted a study in which their second experiment tested the extent to which interest influenced TUT. A participant's interest in the stimuli was measured on a self-report scale from 1-5. Results showed that interest greatly reduced TUT (or MW), leading to greater recall scores. However, the study failed to take into account that there are two types of interest; situational interest (interest generated by the task itself) was not measured. Therefore, the results are to be attributed to the influence of topic interest (naturally generated stimuli-based interest; Krapp et al., 1992). However, whilst MW was found to be a significant negative predictor of recall within both conditions in Experiment 1, there was no significant mediation of interest on MW and recall. One possible explanation is that the MW cue itself was too non-specific. Therefore, participants may report any external distraction as MW (internal distraction; Unsworth & McMillan, 2014). Stawarczyk et al. (2011) found that 21% of thought probes were MW-related and 20% were caused by external distraction. Therefore, TUT probes encompass both MW and external distraction and this experiment will distinguish these to examine any potential relationship between interest and specific TUT occurrences.

Specifically, this experiment will contain probes for measuring MW and external distractions in both retrospective and concurrent conditions (Stawarczyk et al. 2011; Unsworth & McMillan, 2014).

Subjective Interest

The closest experiment relating to individual item interest and recall was conducted by McGillivray (2013) whereby participants rated how curious they were about a question before being shown the answer and were asked to rate how likely they were to recall it. This was linked to the concept that interest and curiosity is about filling a gap in knowledge (Kang et al., 2009). The participants experienced cued recall on half of the 60 questions one hour after and the other half again six days later. A median split based on the participants' average ratings of curiosity was used to split the data into high and low curiosity groups for specific questions. It was found that during the hour delay younger adults recalled more of the high curiosity questions than older adults but there was no significant difference for low curiosity. However, the recall performance was very high with an average of 80.8% (*SD* = 14.2%) and 84.4% (*SD* = 10.3%) for the questions and answers. Of the participants who recalled less than 75% on average, there was a small though non statistically significant impact of curiosity ($p = .08$). Yet after the delay the impact of curiosity was much greater ($p < .001$), with benefits to recall for both younger and older adults (and there was no difference in impact between ages).

In a follow-up experiment, McGillivray (2013) compared the initial curiosity linked as reward or knowledge seeking (Kang et al., 2009; Murayama & Kuhbandner 2011) with subjective interest (rating of the answer) argued as being akin to satisfaction with the curiosity reward. Subjective interest was a significant positive factor of recall performance for both ages during both delay periods. It was found that subjective interest (post answer interest) was correlated with curiosity, though greater recall was found with greater ratings of post answer interest through subjective interest than the pre answer interest of curiosity. When post answer interest was lower than curiosity that led to lower recall than when post answer interest scores were greater than curiosity. There was no attempt of conceptualizing and thus interpreting 'curiosity' or 'subjective interest' within the existing interest literature and so the attempt to interpolate these findings further using the four-phase model of interest development (Hidi & Renninger, 2006) is as follows: Curiosity generated by the question would be the experience of triggered situational interest (TSI) which is influenced further by dispositional factors of individual interest in the topic domain of the question (phase 1 combined with Rotgans and Schmidt’s 2018 research). This develops into maintained situational interest when the answer is considered interesting (phase 2), explaining why greater 'subjective interest' was more pertinent to learning as it would represent more developed and maintained situational interest which is seen as the most important factor to learning (Rotgans & Schmidt). The greater prominence of the effect through the longer delay can be interpreted using two possible explanations: (i) over time the developed situational interest evolved into emerging individual interest (phase 3) and developed individual interest (phase 4), leading to more engagement with the questions (discussing them with peers, spontaneous retrieval, more learning- more chances for rehearsal). Conversely situational interest is argued by Rotgans and Schmidt (2018) to be linked to knowledge acquisition greater than individual interest effects. This should have been evident within the current conceptualisation and hence be present within the hour delay results. This leads to the second interpretation: (ii) The high percentage recall (84-89%) during trials after one hour masked TSI effects, although the results speculatively show an effect, particularly of developed situational interest (post-answer interest). This explanation would negate the need for developed individual interest in providing positive interest effects on recall performance, with developed situational interest and dispositional individual interest elements better explaining the subjective interest and curiosity trends found. This fits in line with current research provided by Rotgans and Schmidt (2018). Before this interpretation is to be adopted it requires further investigation within a scenario whereby recall of most items is not feasible. Therefore, this experiment adopts the conceptualisation of subjective interest as TSI which is to be measured on an individual level.

Rationale

McGillivray's (2013) experiment demonstrated that curiosity as a form of interest can positively impact the retention of a memory in the long term with a trend towards an impact when forgetting is low. The initial lack of an impact within the first hour recall is likely due to the experimental procedure of cued recall as the cued recall paradigm increased "memory performance near the ceiling" (McGillivray, 2013, p. 86). The premise is still open to investigation as an effect of interest was found during the one-hour delay during the second experiment, though recall was again very high at close to 90%.

The current experiment will employ a more efficient way of exploring the initial interest impact on recall over the short term, reducing the speculative nature of the findings, by testing interest salience (split high/low) on learning during a free recall paradigm. The free recall paradigm would remove retrieval cues, which induce greater recall scores and add an unmeasured cue efficacy element to the experimental design. This experiment will also aid in the understanding of the results of MW in Experiment 1 by providing a deeper look at the role of MW as a form of distraction, leading to an evaluation of the different measurement results.

As Experiment 1 showed a trend of decreased situational interest salience on recall scores during the NRI condition which could not be tested within Experiment 2, a more cognitively demanding NRI task was chosen. The NRI task is based on the experiment by Reed et al. (2017) and a non-verbal Sternberg task was implemented. This was intended to increase the cognitive load of the NRI task greater than the S-T-D tasks, but not be so demanding as to produce individual differences or large amounts of fatigue.

A more demanding NRI condition enables further exploration of whether an overall effect of NRI can be found, and if an overall effect is found, whether it will replicate the pattern of results from Experiment 1 of late-occurring interference. This would then be transferable to the understanding of NRI effects more generally. It will also allow for a further link between cognitive load and NRI salience to be tested, as Experiment 2 and 3 has found mixed to weak support for this interpretation.

Hypotheses

It is hypothesised that: (i) Recall will be at its lowest during the late-interference condition. (ii) Retrospective interest ratings will mediate the effect of TUT on recall with higher ratings of interest reducing the effect of TUT, thus increasing recall potential. (iii) Retrospective interest ratings will be associated with higher recall in the control condition, but the concurrent ratings of subjective interestingness will correlate with recall in the interference condition, as more subjectively interesting facts will resist interference greater than less subjectively interesting facts. Secondarily this could reduce the effects of NRI with highly subjectively interesting facts increasing recall during the NRI condition. (iv) Facts rated as high in subjective interestingness will be recalled more than those rated low in subjective interestingness.

Method

Participants

42 participants (33 females, eight males, *N* sufficient to explore condition-order effects from the G*Power analysis in Chapter 3) were recruited through opportunity sampling and consisted mainly of undergraduate psychology students from the University of Wolverhampton. Participant ages ranged between 18 and 57 (*M* = 24.98, *SD* = 9.37).

Materials

Stimuli

The experiment was designed in SuperLab (version 5) which required a desktop computer with a functioning keyboard for responses and a standard monitor for display. A standard consent sheet, demographic sheet (requiring age and sex), information sheet, and debriefing sheet was used. A new set of short facts from 8 to 12 words long were sourced through a 'random facts' google search (Appendix A_4) to prevent participant saturation during recruitment. Participants were provided with two blank recall sheets to write the facts onto. A controlled lab experiment room was used. TUT probes appeared on the screen and each fact contained a Likert scale (from 1-5) for interest. The Sternberg distractor was programmed (see below).

TUT probes.

The TUT probes appeared on the screen for participants to click the corresponding number key on the keyboard which best matched their conscious experience. The probes were as follows:

1) I am totally focused on the current task
2) I am thinking about my performance on the task or how long it is taking
3) I am distracted by information present in the room (e.g. sounds or lights)
4) I am zoning out/My mind is wandering
5) Other

Probe 1 shows task focus and probe 2 shows task specific interference. Probe 3 represents external distraction whereas probe 4 shows internal distraction/ MW.

Sternberg task.

The distractor task is based on the classic Sternberg (1966) task modified by Reed et al. (2017) to increase WM load.

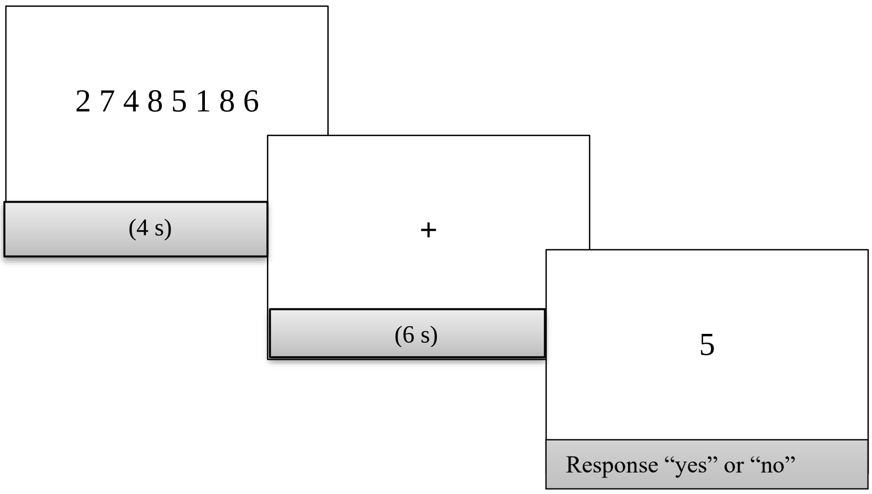


Figure 4.1. Sternberg task example. Participants view a target array of numbers followed by a single probe after a short delay.

The task consists of numbers instead of letters to reduce similarity with the verbal fact stimuli (8 in round 1, 10 in round 2, and 12 in round 3). The numbers were displayed simultaneously for 4 s and followed by a delay slide containing an “+” fixation point in the centre. The delay lasted 6 s and was followed by a probe number. If the number was part of the sequence participants were asked to press a key for “yes”, whereas if it was not part of the sequence participants pressed a key for “no”. There were seven blocks per round, and three rounds in total. The task lasted 5 minutes.

Design

The experiment was approved by the university ethics committee. The design incorporated a quantitative 2x2 mixed experimental design with the repeated measures variable being condition (control vs. interference) and the independent measures variable being condition order (C-I vs. I-C). The experiment contained two elements. Element one (exploring NRI): DV_1 = total fact recall, IV_1) Condition (control vs. interference), IV_2) Condition order (C-I vs. I-C), Element Two (exploring interest): DV_2 = total interesting facts recalled, DV3 = total uninteresting facts recalled $IV_{2.1}$) Initial individual interest rating, $IV_{2.2}$) Retrospective interest rating. IV_3) Task unrelated thought scores (DV_2 and DV_3 are measured on an individual participant level, *see scoring section below*).

I-C and C-I groups were counterbalanced along with Lists A and B in an attempt to reduce list order effects and measure any condition order effects. This provided four groups (see table 4.1) Due to time constraints with the recruitment process, recruitment was concluded early when the C-I and I-C groups and overall list presentations were roughly equivalent in size though differed in list order (Table 4.1). This means that two thirds of participants experienced List B during the late-occurring interference condition which has been shown previously to hinder recall.

To control any primacy and recency effects in recall, facts were placed into six blocks (three blocks per list), consisting of six trials per block with each fact representing one trial. Trials were randomised within a block and each block presentation order was also randomised.

Table 4 1.

Number of participants per group split by list-order and condition-order

	C-I	I-C
A-B	14	10
B-A	6	11

Procedure

As with Experiment 1, participants were split into four groups for counterbalancing condition and list order. Participants typically signed up for the experimental timeslot via the SONA participant pool. Upon arrival, participants were provided with an information sheet detailing all ethical concerns and a consent form. Once signed, they were requested (though optional) to fill out a demographic questionnaire requesting age and sex. Following this, the procedure was presented to the participants by the researcher via a PowerPoint presentation on the computer to increase familiarity with the procedure and prompts and to ensure understanding. The participant's unique anonymous participant pool number was placed on the recall sheets and entered into SuperLab (to link computer responses to written responses).

As with Experiment 1, participants experienced a fact presentation consisting of 18 facts for 8 s each. As each fact was presented, participants were required to rate their initial interest in that specific fact on a Likert scale from 1 (not interested) to 5 (very interested) by pressing the corresponding number on the keyboard. This was followed by the condition manipulation (controlled wait period or interference task) for five minutes. Then followed by a four-minute free recall period. This process was then repeated with the converse condition.

At three fixed points (every six facts) during each fact presentation, participants were prompted to rate their conscious state via a keyboard response: 1 = Focused on the task, 2 = Thinking about the task (task-related interference), 3 = Externally distracted, 4 = mind wandering, 5 = other (see TUT probes above). Once the experiment had concluded, participants were asked to provided retrospective ratings on each fact on a six-item scale similar to Rotgan's (2015) scale of individual interest.

Results

List equivalency

As with Experiment 1, recall scores for each individual fact for both List A and List B were calculated, along with List A vs. List B recall for each participant. This aimed to test for equivalency. There was no significant difference between List A (M = 6.98, SD = 2.41) and List B (M = 6.89, SD = 2.74), for recall $t(40) = .24$, $p = .81$, $d = 0.04$, and no difference between List A (*M* = 3.32, *SD* = .66) and List B (*M* = 3.25, *SD* = .67) averaged interest scores t (40) = 1.08, p = .29, d = .16. Therefore, the lists were equivalent.

Condition and Condition Order (Global statistics)

Next, total recall scores for the control and interference conditions were inputted without inclusion of subjective interestingness for this part of the analysis.

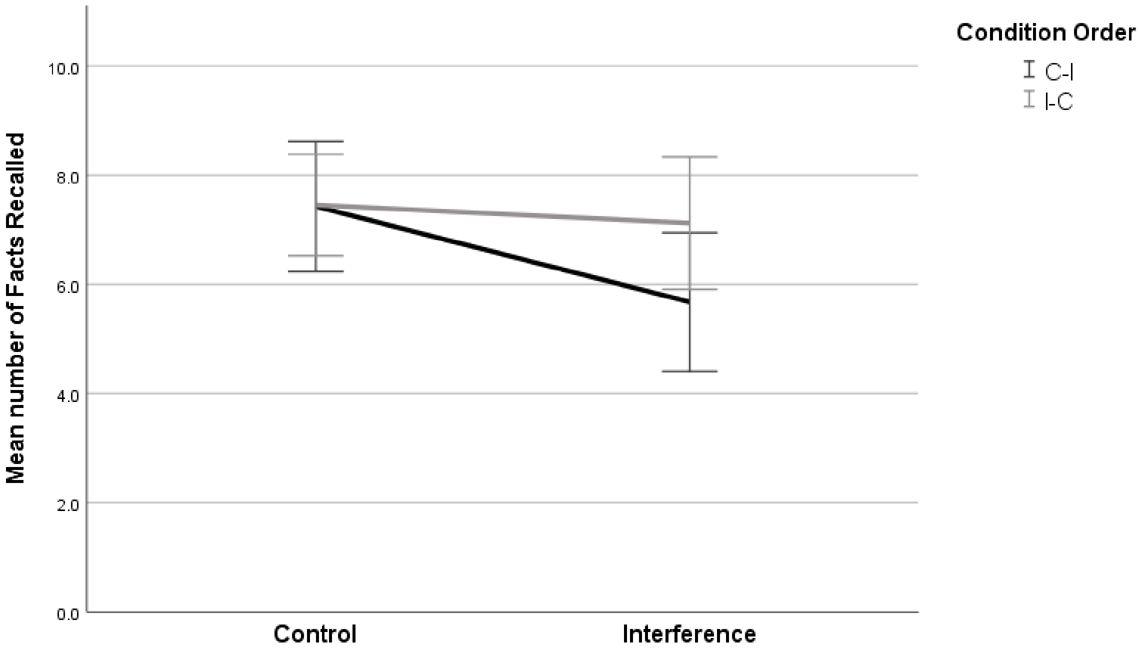


Figure 4.2. Mean fact recall for control and interference conditions split by condition order (C-I and I-C). Error bars: 95% CI.

Figure 4.2 shows the same pattern of results found in Experiment 1 with the greatest recall hinderance occurring in the late-occurring NRI condition. However, there is overlap between the confidence intervals for the difference between the two independent interference conditions.

As with Experiment 1, a two-way mixed ANOVA was conducted to test the replicability of the previously found ‘fatigue effect’ by comparing recall scores of the control and interference conditions according to condition order. There was a significant main effect of condition, with participants recalling more in the control condition (M = 7.44, SE = .36), than the interference condition (M = 6.4, SEM = .42), F(1,39) = 8.38, MSE = 22.23, p < .01, η_p^2 = .18. Conversely, there was a non-significant effect for the condition orders (C-I: M = 6.55, SE = .5, vs. I-C: M = 7.29, SE = .49), F(1, 40) = 1.58, p = .22, η_p^2 = .04. The interaction displayed an effect which was approaching significance, but was above the .05 threshold, F(1,39) = 3.88, MSE = 9.74, p = 0.056, η_p^2 = .09. Though this effect was above the threshold of significance by .006, which appears to contradict findings of Experiment 1, the sample size and therefore statistical power was considerably lower. Additionally, examining the interaction in Experiment 1 as shown in Figure 2.5 and comparing it to Figure 4.2 shows an almost identical trend. Specifically, the greatest drop off for recall scores occurs within the control-interference group.

Further paired t-tests supported this. The difference between recall scores for the control (M = 7.45, SD = 2.04) and interference (M = 7.12, SD = 2.66) conditions for the I-C order were non-significant t(20) = .6, p = .56, d = .13. The greatest difference occurred in the C-I group, which performed significantly better in the control (M = 7.43, SD = 2.55) than the interference condition (M = 5.68, SD = 2.72), t(19) = 3.91, p = .004, d = .87 (p value corrected using the Holm-Šidák correction). Independent t-tests found no significant differences between recall scores for those who experienced interference first (M = 7.12, SD = 2.66) vs. second (M = 5.68, SD = 2.72), t(39) = -1.72, p = .09, d = .54, or those who experienced control first (*M* = 7.43, *SD* = 2.55) vs. second (*M* = 7.45, *SD* = 2.04), $t(39) = .97$, $p = .91$, $d = 0.01$.[2]

Condition, Condition Order, and Subjective interest

Data scoring.

To measure on an individual level whether a participant's subjective interest in a specific fact led to that participant recalling it, a median split was conducted for interest ratings of each fact. These came from a Likert scale ranging from one to five. Ratings of one and two were labelled as low interest, three as medium interest, and four and five as high interest. Values of zero and one represented whether that specific fact (numbered 1-18) was recalled. Three recall variables were then created totalling how many of the facts recalled were rated as low, mid, or high by each participant. When a fact was recalled but a rating not provided, the score was not added to any total. For this reason, two facts from each list (List A and List B) were removed as facts six and eight for List B received a technical fault on SuperLab and the interest ratings were not recorded. Facts six and eight were removed from List A scores for equivalence. Intrusion recall errors from prior lists were uncommon (< 20). Descriptive statistics are shown in Figure 4.3.

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[2] The original p value ($p = .001$) was corrected to provide a family-wise alpha value using the Holm-Šidák correction: (1-(1-0.001)^4), where 4 = the number of comparisons made.

Proportions were calculated for each interest level (low, medium, and high) using the equation: Proportions = (total *N* of facts recalled/ total *N* of facts rated)

Subjective Interest

To test whether differences resulted from interest valence or simply from participants rating more facts as interesting, proportions were calculated (*N* recalled/*N* rated) for high, mid, and low interestingness ratings.

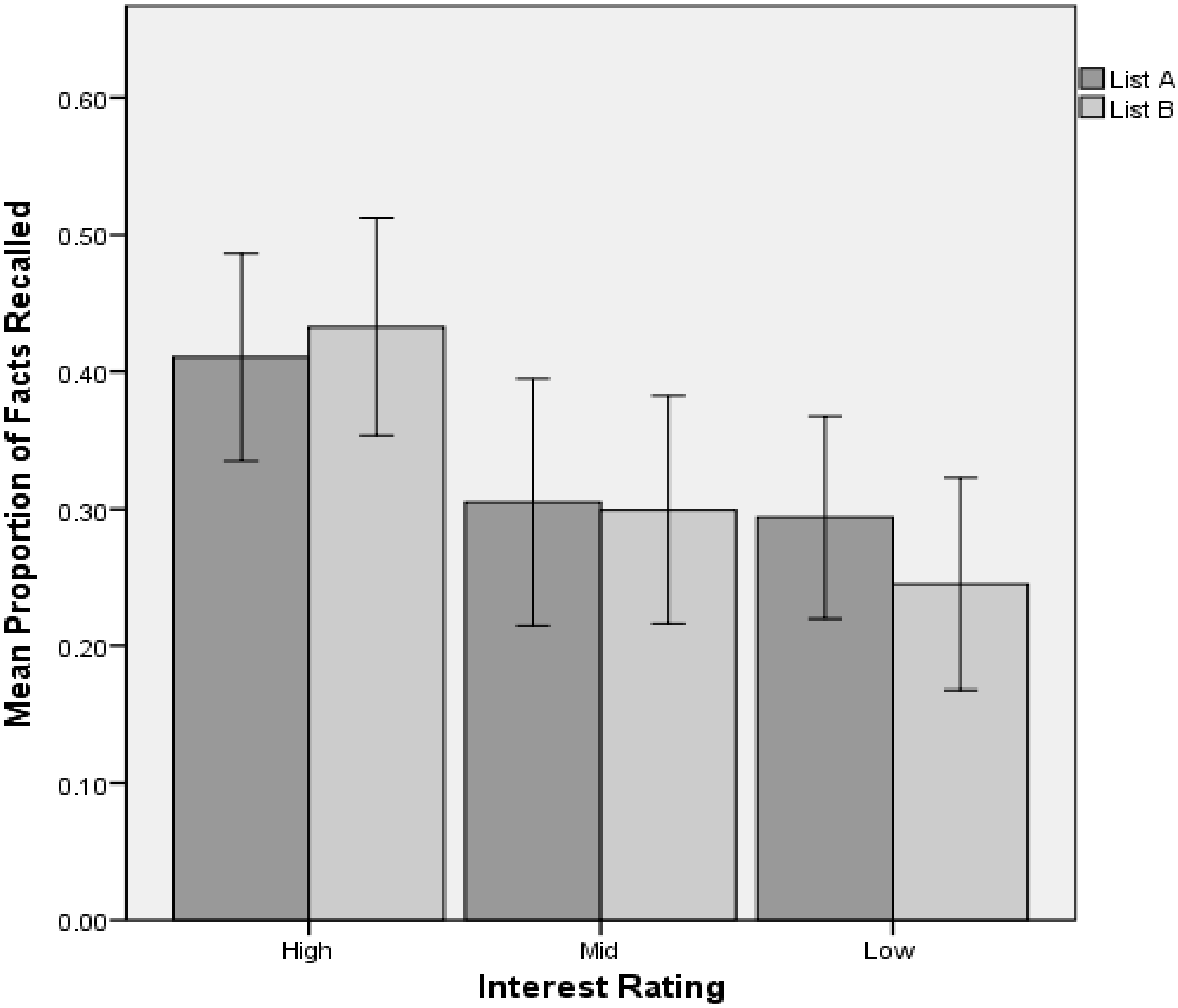

Figure 4.3. Mean recall proportions for interest level split by list. Error bars: 95% CI.

Figure 4.3 shows that mean recall is greatest for facts rated as high in interest than those rated ‘mid’ or ‘low’ for both lists. List B showed a linear decline from high to low.

A 2x3 repeated measures ANOVA tested recall according to condition (control vs. interference) and fact interest (high, mid, and low). Condition was significant, $F(1, 120) = 5.47$, $MSE = .320$, $p =. 02$), with better recall in the control condition than interference condition. There was also a significant effect of interestingness ($F[1, 120] = 7.74$, $MSE = .53$, $p =.02$), with facts rated as high in interestingness being recalled more than medium or low recall scores globally. This was explored further using planned contrasts to measure whether the facts recalled as high in interestingness were recalled more than those rated as medium or low. Facts rated as ‘high’ interest were recalled more than ‘medium’, K=-.12, $p < .01$, ($SE = .04$) and low, K = -.15, $p < .001$, ($SE = .04$) interest. This shows that participants recalled facts which they subjectively rated as high in interestingness more by than the facts they rated as medium or low in interestingness.

There was no significant interaction between interest and condition (F (2, 120) < .01, MSE <.001, p =1). This shows that interest and condition effects are separate factors of recall.

TUT and situational interest

TUT was measured as *N* reports of task-thought or focus/*N* reports of MW or external distractions per condition (three probes per condition). To test whether situational interest in the experiment influenced incidences of TUT and thus mediates a relationship between TUT and recall performance, a mediation analysis was conducted. This included recall as the outcome variable, TUT as the predictor variable and situational interest as the mediator. No significant effects were found in the control or interference conditions for the mediation analyses between variables. The only predictor of significance provided was the predictor of TUT on situational interest which explained 13.87% of variance in the model (*b* = -.75, *t*[30] = -2.2, *p* = .04 [-1.45, -.052]) during the interference condition. It was approaching significance in the control (*b* =-71, *t*[30] = -1.88, *p* = .07). The overall model of these two factors as predictors of recall in the control condition was non-significant interest (*b* = .31 *t*[30] = .66, *p* = .52) and TUT (*b* = .41 *t*[30] = .41, *p* = .69). The direct effect of TUT as a predictor separate from situational interest was also non-significant (*b* = .41, *t*[30] = .41, *p* = .69), and finally, the indirect effect (which represents the mediation effect) was nonsignificant as the confidence intervals of 95% cross 0 [-1.68, 2.51], *b* = -.22. Therefore, there was no significant mediation in the control condition. See Figure 4.4 for a visual representation of the analysis.

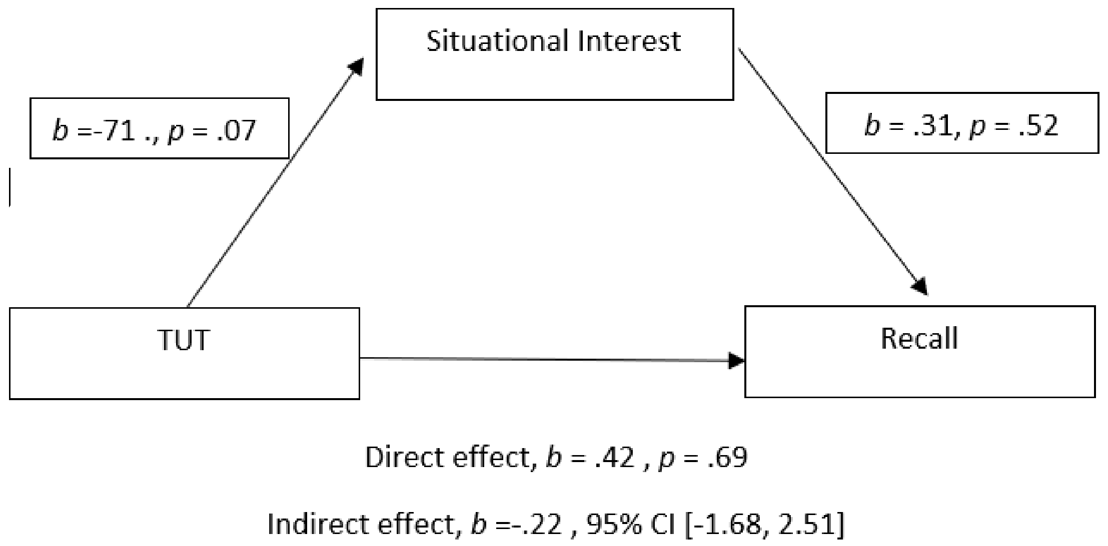

Figure 4.4. Mediation analysis showing Beta values for each pathway for the Control condition.

This was the same for the interference condition with the predictors of recall being nonsignificant for both situational interest (*b* = .79, *t*[30] = 1.4, *p* = .17) and TUT (*b* = -.89, *t*[30] = -.78, *p* = .44). The separated direct effect of TUT on recall was nonsignificant (*b* = -0.89, *t*[30] = -.78, *p* = .44). Finally, the mediation effect of TUT on recall was nonsignificant at confidence intervals of 95% (*b* = -.59, [-2.63, 0.12]). This shows that there is a speculative link between situational interest and TUT as there were trends which indicated that situational interest may reduce the impact of TUT on recall, though this was a nonsignificant trend with TUT not rated as a significant negative predictor. See Figure 4.5 for a visual representation of the analysis.

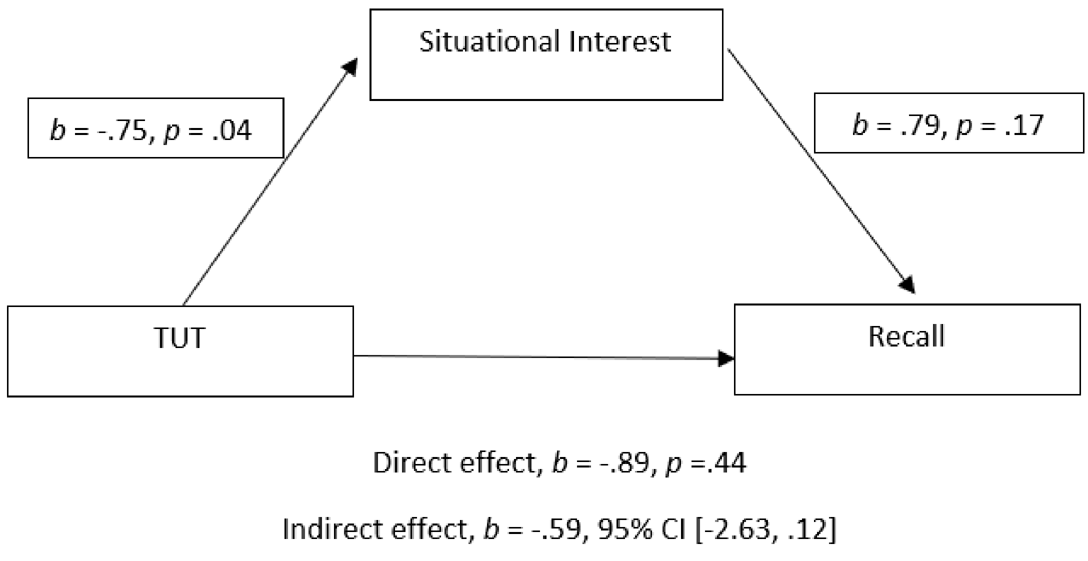

Figure 4.5. Mediation analysis showing the Beta values for each pathway for the NRI condition.

Discussion

Subjective interest conceptualised as the evocation and subjective experience of situational interest modulated by individual dispositions and contextualised through an individual's interaction with specific fact stimuli, was tested for the ability to increase recall, or potentially negate NRI effects. The NRI task itself was more demanding to further test whether an overall NRI based effect would be found, one which may also reduce the positive effects of situational interest in the experiment on recall but be resisted by subjective interest in the facts.

Late-occurring interference effect

The results provided a replication of the greatest decline in participant recall and of the worst recall/greatest hindrance of scores during the late-occurring interference condition, with the interaction between condition type and condition order *approaching significance* ($p = 0.056$). This supports the theory of a 'fatigue effect' or cumulative NRI. However, as Experiments 2 and 3 provide little evidence for the fatigue explanation, instead, the role of cognitive load of the NRI task in inducing further cumulative interference is highlighted. The current experiment differs to the findings of Experiment 1, where no differences were found between the early-occurring interference vs. late-occurring interference groups, or the early-occurring vs. late-occurring control group. This appears to show no cognitive load, or cumulative interference effects in hindering recall. Yet, as the primary issue with this experiment was recruitment and the sample size of Experiment 1 was much larger ($N = 121$), it is plausible that there was not enough statistical power and balancing provided to tease out these differences in the between-subjects analyses. Indeed, the differences between I-C and

C-I interference recall scores was nearly one and a half facts, which was actually a slightly larger difference than Experiment 1 (mean difference of 1.14). This would not be the case for the within-subjects results of the late-occurring interference condition as a G*power analysis was conducted in Experiment 2 which found that for a replication ‘fatigue effect’ of the within-subjects C-I effect found in Experiment 1, a sample size of 19 was sufficient. A greater sample size in the final experiment will provide a more in-depth replication of Experiment 1 to measure the results of any cognitive load effects vs. interference effects in the late-occurring conditions.

Low level NRI vs. memory-based interference (S-T-D vs. Sternberg)

The current experiment used a Sternberg task and found a significant difference between the mean recall scores of the control and interference conditions, without the need for condition order effects to explain them. This is different to Experiment 1 which used S-T-D tasks as the form of NRI and the hindering effects of such interference required condition order effects to explain the pattern of results, with the late-occurring interference group experiencing lowest recall. This may explain the findings of Fatania and Mercer (2017) and Martini et al. (2017), which appears to show that non-specific interference does not greatly hinder recall.

Additionally, the complicated finding of Varma et al. (2017) did not support interference effects or the positive effects of wakeful rest. Each of those experiments were conducted using a counterbalanced within-subjects design similar to Experiment 1, but without incorporating condition order effects. This negated the important interaction caused by the late-occurring interference condition. In other words, although non-specific interference effects are low in salience when compared to other more interfering factors (i.e., associative interference, memory interference etc.) it is a highly prevalent form of every day forgetting, as argued by Keppel (1968), and it contains a strong cumulative element in which the salience of the interfering effect increases the later the interference is introduced within a task. This trend is consistent within the current experiment too. It could be that the Sternberg task intended to elicit larger NRI increased this difference as it was more demanding and therefore induced a larger NRI effect, and thus greater cumulative interference.

Finally, the more intense NRI Sternberg task produced overall main effects of NRI, indicating that the strength of the NRI is highly linked to the likelihood of it being detected overall, providing further evidence for the existence of NRI as a form of forgetting and further context for the salience of the effect.

TUT and Interest.

Smallwood et al. (2009) found a link with self-reported interest in the stimuli reducing instances of TUT and the current experiment provides tentative support for this with situational interestingness in the experiment showing a trend of a reduction too. The TUT probes contained a lot of words which were displayed in a large size and covered most of the screen due to the software used (SuperLab) and were placed for just 8 s, leading to a lot of missed responses. It is possible this caused a lot of confusion as there were a lot of elements to this experiment and participants had to respond to the probes quickly, hindering the potential response accuracy. Though situational interest and TUT appeared to be linked, they were not significant predictors of recall. A measured relationship between situational interest and TUT within this experiment would rely on situational interest to remain stable over the course of both conditions (with participants receiving TUT probes in both), as situational interest was only measured at the end of the experiment rather than each condition. It would be useful to explore the speculative relationship between MW/TUT and interest more specifically within a more straightforward memory design. One possibility would be to explain thoroughly what constitutes MW or TUT before the experiment begins and probe participants at numerous points but have just one condition for participants to rate for interestingness (some may have found the wait period too long to sustain interest but enjoyed the S-T-D tasks and vice versa). This would home in on the interest and attention effects during the specific event rather than over time when interest may later develop or decrease. In the event of numerous conditions, probing situational interest at the end of each condition would provide more accurate measures of interestingness.

Subjective Interestingness and Interference

It was hypothesised that facts rated high in subjective interest would be recalled more in the interference condition and that this would reduce the condition-order effects with highly interesting facts resisting interference during the retention interval. What the experiment found was that subjective interestingness was a highly significant predictor of positive recall scores with participants recalling facts they rated as interesting significantly more than those they rated as low in interest. This occurred consistently regardless of condition type and condition order. Items rated as subjectively interesting, then, were easier to recall during the free recall task but still subject to hindering interference effects. Should a stronger and less speculative link be made between subjective interestingness and a reduction in TUT/MW as a predictor of recall, it would be plausible that high interest in the stimuli increases attentional focus during the encoding of the memory trace. Increasing the likelihood of successful encoding, but the memory trace will then experience the same disruption through RI during the retention interval.

CHAPTER 5

Experiment 5

Situational interest in Experiment 1 was conceptualised as state-dependent interest (Hidi & Renniger, 2006; Krapp et al., 1992) that was measured through a self-reported one-item scale (Fulmer & Tulis, 2013; Tapola et al., 2013). Experiment 1 found improvements with recall performance in the control but not interference-based conditions. This was consistent with previous literature which, as stated by Tapola et al., found weak/small effects of situational interest on academic task performance and learning outcomes (Harackiewicz et al. 2008; Tapola, et al., 2013; Zhu et al. 2009). Experiment 4 found that situational interest when measured as high subjective interestingness led to the greatest recall scores. As situational interest can be shared globally and elicited based on text-based characteristics, the current experiment will measure interest using global situational interestingness ratings of text-based interest (these were taken from Experiment 1 interest ratings).

Within an interference framework the more associative the items are within a list the greater the interference effects. Temporal distinctiveness theory is primarily a time-based account of interference that rates the timescale of a stimulus in comparison to other stimuli as a factor of *distinctiveness*. However, there is another established factor of distinctiveness known as the 'Von Restorff effect', whereby the distinctiveness of a memory trace is a function of its physical dissimilarity to or 'isolation' from other items and therefore a distinct (dissimilar/isolated) memory trace is easier to recall than less distinct items of a similar/associative nature (Hunt, 1995; McGoech, & McDonald, 1932; Mensink, & Raaijmakers, 1988; Von Restorff, 1933; Wixted, 2005). The isolated item then captures attention and receives greater item-specific processing than the other less distinct items (Bellezza & Cheney, 1973; Guérard et al., 2008; Huang, & Wille, 1979). This can explain some of the distortion caused by memory items within a similarity-based interference paradigm such as A-B A-C (Parkin, 1980; Watkins & Watkins 1975; Watkins & Watkins, 1976; Wixted, 2005), with similarity interference decreasing distinctiveness.

The impact of distinctiveness has been found on meaningful material too (Crouse, 1971; Osgood, 1946), making novelty a positive predictor of retrieval efficacy (Reggev et al., 2017). Within the interest literature the novelty of learning material (such as unexpected information in texts) is a characteristic of interestingness which leads to greater learning outcomes (Hidi, 1990). Chen et al., (2001) argue that the characteristics of the learning material should be the base of situational interest measurements and that situational interest should be made using comparisons. Novelty and instant enjoyment were two of the five characteristics/ sources of situational interest (the other three are not relevant to, or explored within, the text-based learning found within this experiment: Challenge, exploration intention, and attention demand). These characteristics were found through a comparison between two learning tasks: Low situational interest task vs. high situational interest task (Chen et al., 1999). Other characteristics of interestingness linked to text-based interest are provided by Krapp et al. (1992) and include novelty, character identification, life themes, intensity of actions, and the imagery value (Anderson et al., 1987; Hidi & Baird, 1988).

With novelty as a factor of both ‘distinctiveness’ and ‘interestingness’, and interestingness being one of the two main facets of situational interest highlighted by Böhm (2017) and a main characteristic of text-based interest (Krapp et al. 1992), the current experiment aims to further investigate the situational interest findings of Experiment 1 which found situational interest to be a significantly positive predictor of recall in the control but not the interference-based condition. In the latter condition, participants’ individual interest in the facts was a salient predictor. The current experiment is a replication of Experiment 1’s experimental design, manipulation, and stimuli facts. However, the facts themselves have been manipulated based on previous interestingness ratings (with facts with interest values close to the median removed- further increasing the interest difference) to measure the role of global ratings of interestingness on recall.

Rationale

The current experiment aims to further test the replicability of the late-occurring interference effect found in Experiment 1 whilst further exploring the role of interest.

By conceptualising situational interest through interestingness of the facts in Experiment 4, rather than state-dependent interest (short-term interest in the environment) as in Experiment 1, the present study aims to explore interest as a factor of distinctiveness by comparing recall of high and low interesting facts within an interference vs. non-interference context.

HYPOTHESIS 1: Interestingness as a form of person-object interest which is linked to both situational and early-developed individual interest will lead to greater recall of the high interest facts than the low interest facts in both control and interference conditions.

HYPOTHESIS 2: State situational interest (interest in the memory experiment) will be a positive predictor of recall in the control but not interference condition.

HYPOTHESIS 3: There will be a linear trend of recall from worst to greatest: Low interestingness/ interference, high interestingness/ interference, low interestingness/ control, high interestingness / control. Interestingness will be less prominent than the condition effects (concurrent with Experiment 1).

HYPOTHESIS 4: Overall effects of NRI will not but found but NRI will be found from the late-occurring interference condition which will recall the fewest facts; replicating Experiment 1.

Method

Participants

The experiment contained 100 participants 84 females and 15 males (one sex unreported). Participant ages ranged from 18 to 52 with a mean age of 23.93 (*SD* = 9.25) and consisted solely of first year undergraduate psychology students from the University of Wolverhampton on an introductory research methods module. The participants were recruited via opportunity sampling within one lesson, split across six student groups.

Materials

The booklets from Experiment 1 were edited to remove the Likert scales for interest and then reused. The booklets differed only in the order of the conditions and consisted of a demographic information sheet requesting the age and sex of the participant followed by either the instruction “please wait five minutes” (for the control condition) or some S-T-D tasks (interference condition). This led to the blank recall page with the instruction “recall as many facts as possible”. This was then repeated with the converse condition. Finally, the back page contained a single self-report Likert scale for participants to rate how interesting they were in the experiment as a whole from one (not interested) to five (very interested).

A PowerPoint presentation, displayed via a projector, presented the information about the experiment/research and how/why it was being conducted (supplementary to the information sheet provided). This was followed by slides containing the facts and timings for each part of the experiment which were presented via a single large projector at the front of the classroom with participant in rows. A debrief was presented on the slides in complete detail as the experiment provided students with learning material used on the course.

Scoring of interestingness

All facts were reused from Experiment 1. A frequency analysis was conducted on the combined total of interest ratings for each of the 40 facts. Twelve of the values closest to the median from the combined total were removed to provide a high/low split between facts rated as highly interesting and facts rated low for interestingness. This provided 28 facts split into two lists, with each list containing 14 facts. These lists were split again with seven high in interest and seven low in interest. The facts were mixed and reordered between the two lists in order to make sure that total interest ratings were equivalent. This resulted in a combined total interest rating of 373.27 for List A and 373.79 for List B. A list of 14 facts was sufficient as the maximum recall scores did not exceed 11.5 in previous experiments, with averages between four and seven.

Design

The design was similar to Experiment 1: A quantitative mixed experimental design consisting of the repeated conditions (control and interference) but independent condition orders (C-I and I-C). The key differences involve interest: concurrent ratings of individual interest were removed, and facts divided into high or low interest based on ratings from Experiment 1. The number of facts recalled were measured through a free recall paradigm. This led to three IVs: IV_1) the within subject variable of condition: control vs. interference; IV_2) the between subjects group variable of condition order (C-I, Vs. I-C); and IV_3) interestingness of stimuli (high vs. low interest).

For the counterbalancing of the groups, 34 participants experienced the control condition first with List A (C-I, A-B) whilst only 16 experienced the control condition first with List B (C-I, B-A). This provided a total of 67 participants for List A, and 33 participants for List B for the control condition. The reverse pattern occurred for interference, with 67 in List B and 33 in List A. Thirty-four participants experienced interference second for List B (C-I, A-B) and 16 experienced interference second for List A. This meant that list order (A-B, N = 51; B-A, *N* = 49) and condition order (C-I, N = 50; I-C, *N* = 50) had equivalent participant numbers independently, but not when combined.

Procedure

The experiment recruitment happened across two days. Fifty participants on day one experienced control followed by interference (C-I) whilst fifty participants on day two experienced interference followed by control (I-C). List orders A-B and B-A were counter-balanced across the six lessons (three per day). However, not all students appeared within their allotted lesson times leading to balancing issues for list order (discussed and explored further below).

Students/participants were provided with an information sheet, consent form, and answer booklet at the desk they were seated at within the classroom (with one chair space between each person). The experimenter informed participants of the reason behind the research and what it would involve using a PowerPoint presentation. Students who did not wish to take part but wished to watch were allowed to do so in silence. Participants were asked to fill in the demographic information sheet provided before the experiment began and then they were presented with 14 facts. One fact was shown per slide, for 8 s, followed by either a controlled wait period or spot-the-difference tasks. Both events lasted five minutes. After the interval, there was a four-minute recall period on the next page of the booklet. This was then repeated with the converse condition. The experiment lasted a total of 22 minutes. At the end there was a Likert scale for participants to rate how interesting they found the experiment as a whole. All participants were debriefed fully regarding the experiment as it formed as part of a lesson. This taught them about the stimuli selection method, group conditions, aims, hypothesis etc.

Results

Scoring of recall

Scoring of recall followed the same structure as prior experiments with .5 of a fact rewarded for the recall of half a fact. The scoring was more lenient as participants were instructed that the exact wording was not necessary, but the overall meaning/understanding must be evident. This is more indicative of an everyday learning context. Intrusive recall errors from the previous recall list are not scored but have not been prevalent during the experiments in this thesis. Intrusion recall errors from prior lists were uncommon (< 25).

List equivalence: Overall list recall

To measure list equivalency for recall scores, a paired *t*-test compared total recall scores for List A (*M* = 5.62, *SD* = 2.26) and List B (*M* = 5.14, *SD* = 1.95). The results showed that the recall scores between the lists were non-significantly different, $t(99) = 1.72$, $p = .09$, $d = .23$ This indicates that both List A and B had similar recall overall.

Descriptives

NRI

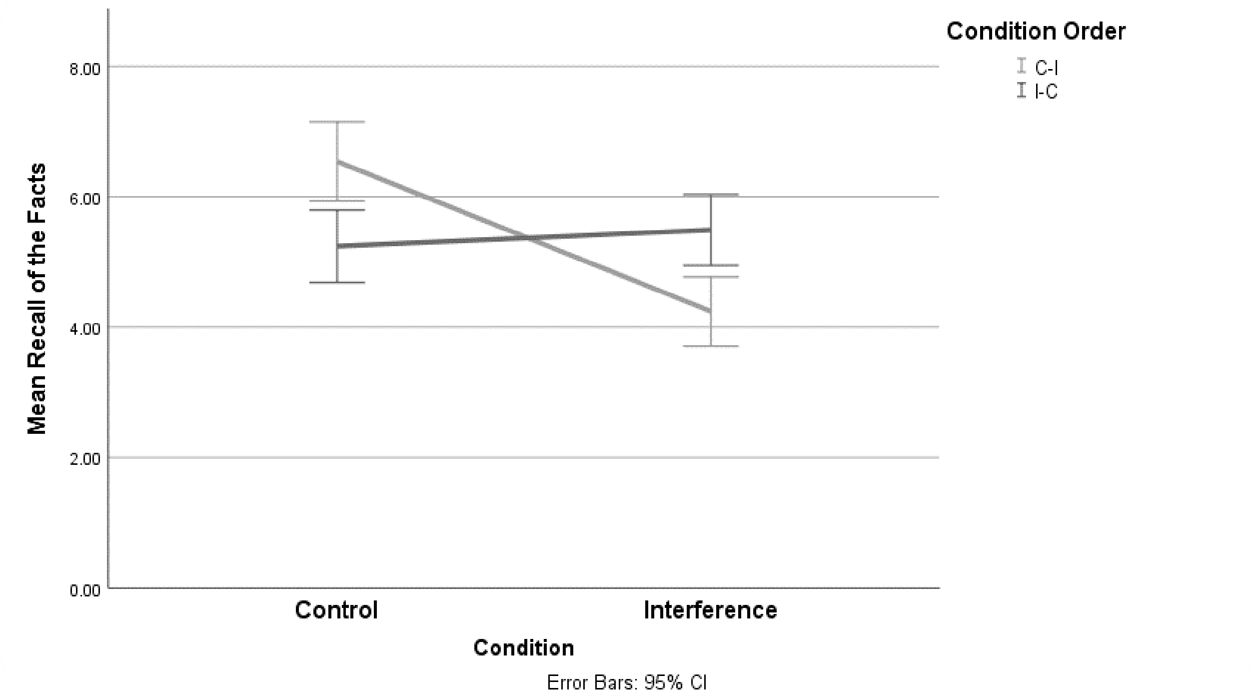

Figure 5.1. Mean recall of high and low interesting facts according to condition and condition order. Scores are out of a maximum possible recall of seven.

Figure 5.1 shows an almost identical pattern of results to Experiment 1 and 3. Late occurring conditions show a drop-off in recall performance; however, the late-occurring interference condition shows the lowest recall performance for both the within (C-I) and between (C-I vs I-C) comparisons.

Interest

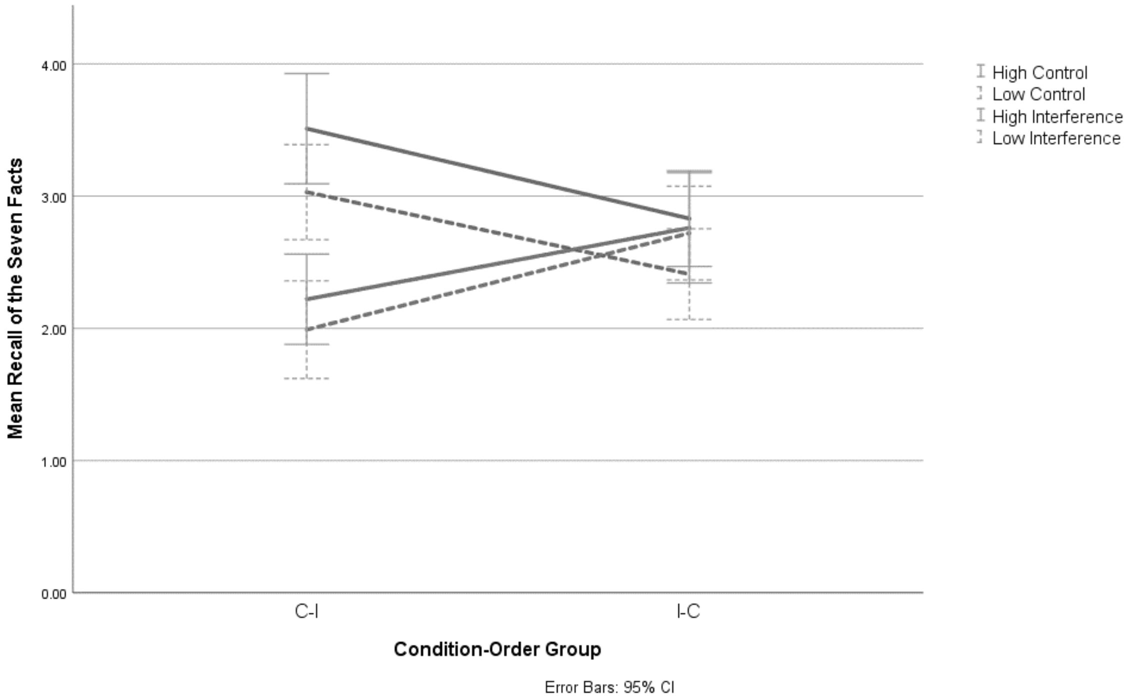

Figure 5.2. Mean recall of high and low interesting facts according to condition and condition order. Scores are out of a maximum possible recall of seven.

Figure 5.2 shows that interference recall scores for high (solid line) and low (dashed line) are very similar whilst control high (solid line) vs. low (dashed line) scores differ, with greater recall for the high interesting facts in both orders. Recall patterns for the control and interference conditions are consistent with previously found condition-order effects regardless of interestingness. The differences between the recall scores are most prominent between conditions, with control recalling more than interference for both high and low interestingness. High interestingness leads to greater recall than low interest for both conditions, though mostly prominent during the control condition than the interference condition.

Preliminary Tests

A Levene's test was conducted to test the homogeneity of variance for each recall condition in the I-C and C-I orders. Results of the Levene's test show that there are no significant difference between the variance of the groups (control high interest: $F[1,98] = 1.26$, $p = .26$; control low interest: $F[1,98] < .01$, $p = .96$; interference high interest: $F[1,98] = 2.99$, $p = .09$; interference low interest: $F[1,98] < .001$, $p = .99$).

ANOVA

A Three-Way Mixed ANOVA was conducted to measure average recall of the high and low interest facts for the control and interference conditions with the between groups factor of condition order.

Interest (high vs low) was a significant factor, with facts previously rated as higher in interestingness ($M = 2.83$, $SE = .11$) being recalled more than those rated low in interestingness ($M = 2.54$, $SE = .1$), $F(1,98) = 5.73$, $MSE = 8.57$, $p = .02$, $\eta^2 = .06$.

Condition (control vs. interference) was a strong significant factor too, with the control conditions ($M = 2.95$, $SE = .1$) recalling more than the respective interference conditions ($M = 2.42$, $SE = .09$), $F(1,98) = 27.1$, $MSE = 27.30$, $p < .0001$, $\eta^2 = .22$ This shows a main effect of NRI.

The between-subjects effects of condition order showed a non-significant difference between the two groups overall, $F(1,98) < .01$, $MSE = .01$, $p = .97$, $\eta^2 < .001$, highlighting equivalency in overall recall for the two counterbalanced groups; C-I ($M = 2.69$, $SE = .12$) and I-C ($M = 2.68$, $SE = .12$).

There was no significant interaction between interest level and condition type, $F(1,98) = 1.69$, $MSE = 2.48$, $p = .2$, $\eta^2 = .08$, and no interaction between interest level, condition, and condition order, $F(1,98) = .07$, $MSE = .11$, $p = .79$, $\eta^2 < .01$.

However, as with Experiment 1, there was a highly significant interaction between condition and condition order, $F(1,98) = 40.98$, $MSE = 41.28$, $p < .0001$, $\eta^2 = .3$. Subsequent *t*-tests explored whether this replicated the late-occurring NRI effect. An independent *t*-test compared recall scores between groups for when control was presented first ($M = 6.54$, $SD = 2.13$) vs. second ($M = 5.24$, $SD = 1.95$). There was a strongly significant difference $t(98) = 3.17$, $p < .01$, with the first control task experiencing superior recall. The same test found a strongly significant difference between when interference was presented first ($M = 5.49$, $SD = 1.92$) compared with second ($M = 4.24$, $SD = 1.86$), $t(98) = -3.31$, $p < .005$. The pattern of Experiment 1's late-occurring NRI results are replicated.

Two additional paired-samples *t*-tests were conducted to measure participants own recall scores in the first task vs. the second to measure any potential decline in recall for the interference-control group, when interference was first ($M = 5.49$, $SD = 1.92$) and control was second ($M = 5.24$, $SD = 1.95$). There was no significant difference between mean recall scores, $t(49) = -.84$, $p = .41$, $d = 0.12$. Therefore, there was a non-significant drop off from task one to task two. Unlike with the I-C group, for the group where control was first ($M = 6.54$, $SD = 2.14$) and interference was second ($M = 4.24$, $SD = 1.86$), there was a strongly significant effect, $t(49) = 8.47$, $p < 0.005$, $d = 1.18$. This result shows that there was a large effect and highly significant drop in recall scores when the interference condition was second. All *t*-test were adjusted using the Holm-Šidák correction.

A between-subjects comparison of the group conditions shows that participants who experienced the control condition first had a mean recall score of 6.45, whilst those in the opposing group (who experienced the control condition second) had a mean recall score of 5.24, representing 1.31 less facts recalled on average during the late occurring condition. This between-subject difference was also found in the interference conditions too, with recall when interference was first (M = 5.49) being higher than when interference was second (M = 4.24), This represents a similar though lesser difference of 1.25 fewer facts recalled.

To measure the independent condition positioning difference, an independent samples *t*-test was used measuring late occurring control (M = 5.24, SD = 1.95) with late occurring interference (M = 4.24, SD = 1.86). There was a significant difference between late conditions (t[98] = -2.62, p = .01, d = 0.53). This indicates that although performances between groups for both conditions indicate some fatigue, the hindered recall (lower recall scores) effect was most prominent during the second interference condition.

State Interest

To test whether interest in the experimental task itself correlated with recall performance in both conditions, or replicated the results of Experiment 1's regression (null effect in the NRI condition), two Spearman's correlations were conducted. Results showed that state interest positively correlated with recall scores in both the control (r_s[98] = .27, p <.005) and interference ($r_s[98] = .31$, p <..001) conditions. This indicates that interest in the experimental task overall is linked with greater memory recall performance.

Experiment 1 comparison.

Following the positive correlations in both conditions, a reanalysis of the Experiment 1 data has been conducted to explore state interest using correlations. Although state interest contained a stronger correlation with recall in the control than interference condition, both conditions positively correlated (control: $r_s[119] = .31$, $p < .001$; interference: $r_s[119] = .19$, p =.04). The positive correlations replicate, though weakly, in the interference condition. This may have resulted in the nonsignificant predictor in the Experiment 1 regression when fact interest was an additional predictor, making the regression noisier.

Discussion

The current experiment was a replication and extension of Experiment 1 intending to test the reliability and validity of the late-occurring RI effect. The experiment consisted of the same facts from Experiment 1, differing in their list representation as the stimuli were manipulated based on previous situational interest ratings, as the experiment also aimed to explore the impact of global ‘interestingness’ on the recall of meaningful items.

Condition and condition order had the most prevalent effects on recall (explored further below), which better explain the difference between recall scores, with the effect of interestingness having a lesser, separate, and positive impact. More interesting facts were recalled more than the facts rated low in interest.

The tentative interpretation of a reduction of the positive effect of interestingness caused by interference was not supported by the results of this experiment. High interestingness in the control condition led to the greatest recall scores—though this effect appears to make little difference to the rate of decline when the task is second, showing that the effect does not reduce hindered recall by cognitive load or interference effects. Instead, interestingness within this experiment is best conceptualised as a factor of increased recall independent of NRI and condition order. According to the Von Restorff effect, the more distinct a memory trace, the easier it is to recall amongst the "clutter" of similar stimuli; therefore, novelty increases the likelihood of recall. As novelty is a factor of interestingness highlighted by Krapp et al. (1992), it was originally hypothesised that highly interesting facts would be more distinct within an interference paradigm. Although Experiment 1 indicated that initial individual interest in the facts may be important during the interference condition, the current study found that the same facts and ratings when used as a measure of salience for interestingness improved recall scores regardless of the condition. A reanalysis of the Experiment 1 data finds (and is replicated with the current study) positive correlations of state situational interest in both conditions. Therefore, as interest in the facts and state situational interest in the experiment itself both increased recall independent of condition, the hypothesis was not supported. This suggests that interestingness of the stimuli and experiment task can have a positive impact on learning of meaningful material, but the salience of this improvement occurs separately from interference effects (and interference does not decrease interest effects).

Why does interest not reduce/interact with interference effects? Rather than being a strong cognitive factor of maintenance during retention it could be argued that prior studies find increased learning effects of interest through a more motivational factor, leading to a greater willingness to engage and persist with more demanding tasks (Krapp & Prenzel, 2011). This larger impact would not be measured within the initial cognitive experiment (which found small positive improvements of recall but primarily in controlled and less demanding conditions) but may be indicative of rate of learning over time given multiple trials, with greater interest leading to more frequent engagement (Krapp & Prenzel, 2011, Schiefele, Krapp, & Winteler, 1992). Instead, a cognitive argument for could be made for the importance and salience of interestingness during the **encoding phase**. Within this explanation interestingness contains an emotional valence factor (Schiefele, 1999), or a sense of novelty to the individual which in turn makes it more isolated and 'distinct' (Von Restorff, 1933) and provides that memory item with greater item processing (Craik & Lockhart, 1972; Craik & Tulving, 1975; Guérard et al., 2008) thus increasing recall. With situational interest being linked as a form of emotional valence and the Von Restorff effect being shown to contain an emotional factor that captures attention during encoding (Wiswede et al., 2006), both may lead to increased learning and recall. This connection contains merit within the literature.

Late occurring conditions and interestingness

In the previous experiments (1 & 4), the between-subject comparison of control condition recall in the C-I and I-C conditions showed a small non-significant decline when control was positioned second. This experiment found this effect to be more pronounced and thus significant. So why is this difference more pronounced in this experiment than the previous two? The method of investigating interest effects of the stimuli in this experiment is different from the previous two methods: Exploratory research of interest effects of equivalent stimuli (Experiment 1 & 4) vs. confirmatory research through deliberate interestingness manipulation in the current experiment. Participants in the late-occurring control condition recalled high interest facts at the same rate as the interference condition but experienced the same rate of decline from one task to another for the low interest facts.

These findings further support the interestingness evaluation above with interestingness being a positive indicator of recall performance during the early control condition group but experienced the same rate of decline (same amount of hindered recall) during the late occurring control period due to the increased difficulty of the task through either associative PI of the prior-condition or increased cognitive load effects.

Overall and Late-occurring RI effects

The pattern of results showing hindered recall during the late-occurring interference condition from Experiment 1, 2 (when comparing control vs interference recall in the SMT), and 4 are replicated for the fourth time, providing high confidence in the replicability and scientific validity of this finding. Interestingness had no impact on the hindered recall found in the late-occurring interference task. However, the current experiment differed from the findings of Experiment 1 by finding an overall effect of NRI. So why is NRI from the same distractor more prevalent in this experiment than in the initial experiment?

The current experiment found overall NRI effects, and the main manipulation of this experiment was provided by changing the method of measuring interestingness valence. In Experiment 1 participants were asked to rate how interesting they found each individual fact. This involves a greater level of individual evaluation and reflection of each item, providing a deeper level of cognitive processing (Craik, & Lockhart, 1972; Craik, & Tulving, 1975). This contrasts with more passive (or maintenance) rehearsal of the facts in the current experiment. Once the NRI task occurs the maintenance rehearsal strategy is interrupted thus preventing maintenance and increasing interference effects. This would mean that participants in the current experiment experienced a greater drop-off in recall due to the absence of elaborate encoding and the interruption of the maintenance rehearsal.

Limitations

As noted above, there were some issues with counterbalancing in this experiment. However, List-A and List-B were equivalent for recall. The two experiments by Tapola, et al. (2013) and Tapola et al. (2014) failed to replicate the situational interest effects on increasing task performance as found in their initial study (Niemivirta & Tapola, 2007). Such conflicting findings are found again for grade scores with situational interest as either a positive predictor (Harackiewcz et al., 2008) or a non-correlate (Harackiewicz et al., 2000). Rotgans and Schmidt (2017) argue that these findings result from the operationalisation of the measurement, lack of repeat testing and lack of experimental manipulation. Similar to Tapola et al. (2013), the current experiment operationalised situational interest using a singular item self-report scale. Tobias (1994) noted that participants may use different reference points to compare how interesting the stimuli is. An example of this is provided by Chen et al. (2001), who state that some participants may rate the text as more interesting by comparing it to previous texts, whilst others may rate it as less interesting in comparison to playing a video game, thus questioning measurement reliability. The implementation of the Rotgans scale (2015), repeated measurements, or repeated testing of the effect would lead to greater confidence in the measurement accuracy. Although previous learning studies may implement more rigorous re-testing and multiple-scale measurements of a topic, these cognitive memory experiments were concerned with the direct short-term effects of the stimuli and manipulations (measuring each 28-40 facts per experiment on a six-point Likert scale is experimentally unfeasible). The previously used Likert-scale provided comparable results with previous literature and was more experimentally testable and comparable with the individual item-specific ratings of individual interest implemented within this thesis and was measured accordingly.

Conclusion

The results of this experiment support the findings of the previous experiments of hindered recall through both cognitive load and interference in the late-occurring conditions (specifically NRI). A more elaborate rehearsal of stimuli during the encoding phase may decrease NRI effects, indicating that NRI's hindrance of recall may occur more prominently when interrupting maintenance rehearsal. The results are also consistent with the previously mentioned literature on the motivational factor of interest and interestingness on learning, with the main result clearly showing that interestingness is a positive factor of recall. This positive valence is independent of the retention phase which is where NRI occurs and hinders. Combining the cognitive literature on distinctiveness and NRI with the educational literature on interest provides a clear picture of increased learning through the positive emotional valence of interest during the encoding phase (increasing the likelihood of a memory being created).

CHAPTER 6

General Discussion

Aims of the Thesis

This thesis attempted to combine two approaches of psychology: Cognitive psychology and educational psychology. All five experiments used a ‘free recall’ experimental design to explore the intricate nature of NRI. The primary goal of the thesis was to contribute to the existing interference-based forgetting literature by providing a greater contextual understanding of NRI, in order to ‘shed light’ on conflicting findings of NRI effects. Experiments 2 and 3 explored the role of differing types of prior tasks and difficulty in inducing late-occurring NRI effects whilst Experiments 1, 3, 4, and 5 explored the educational psychology domain of motivated learning through ‘interest’ in, and ‘interestingness’ of, meaningful text-based stimuli (facts). The intention was to examine the role interest plays in the retention and subsequent recall of these items and to measure, if any, the extent to which interest may reduce interference-based forgetting and MW.

Summary of key NRI findings

A main effect NRI has not been very prevalent in the recent literature (e.g., Varma et al., 2017) and an overall null effect was found in Experiment 1 (Chapter 2). However, the findings of main effects in Chapters 4 and 5 (and the SMT in Chapter 3) provide an effect that is more robust than was initially thought. With this taken into account, NRI appears to be more complex than initially hypothesised.

One key finding which remained consistently replicated across all experiments (1, 2 [SMT], 4, & 5) was the finding of hindered recall performance in the 'late-occurring interference' condition; the condition with the least amount of facts recalled when compared with any other condition and condition order. So, whilst three of the four experiments reported NRI, this was driven by the point at which NRI was experienced; considering the order in which these conditions occur leads to differing recall performances.

These differences were consistently found to be significant for late-occurring interference, whilst the comparisons between the control conditions and condition orders were typically non-significant. This indicates that there was a significantly greater salience of the NRI effect when participants were subjected to interference later into the task which consistently hindered subsequent recall performance.

This was explored as either a 'fatigue effect' or cumulative effect of RI salience. In the current literature NRI is seen as a highly prevalent form of everyday forgetting while remaining a low-level and mild form of interference. The current thesis demonstrates, through use of a low-level RI task (S-T-Ds) of just five minutes, that NRI effects may be resisted to the point of negligible during the start of a task, but this interference phenomena contains a cumulative element which grows in 'potency' the later it occurs in a task. Another function which may modulate the cumulative salience element is that of prior-task similarity. The more similar the prior-task before the NRI to the recall task, the worse the recall scores. The extent to which this can be explained by cognitive load theory, PI or 'distinctiveness' is explored further below.

Understanding NRI

NRI is argued to be the most prevalent source of everyday forgetting (Keppel, 1968, Wixted, 2004) as the 'nonspecific' description encompasses any stimuli/information that is not considered to be related to the learning material or memory event. NRI was operationalised through a post-encoding condition consisting of S-T-D tasks (and a Sternberg task in Experiment 4) and is considered a form of diversion interference (Dewar et al., 2007). The interference condition was contrasted against a post-encoding 'wakeful rest' control condition of the same length.

The Experiment 1 results from a large sample size (N = 121) showed no significant overall main effect of NRI, which appeared to support the similar null findings of Varma et al. (2017). However, the experiment contained highly significant condition-order effects with the later-occurring conditions experiencing a drop-off in recall performance. This drop-off was non-significant for the control condition, indicating that wakeful rest may be effective at reducing cognitive load effects and the trend of results did not support rehearsal effects as the I-C recall scores were not significantly different (see Chapter 2). Most prominently, the strongest main effect indicates a potential 'fatigue effect of NRI' whereby the late-occurring interference group experienced the most hindered recall performance between-subjects and the greatest within subjects drop-off in recall. To understand the nature of these findings within the literature other alternative explanations needed to be explored. Subsequently, Chapter 3 explored the role of prior-tasks in causing cognitive fatigue and cumulative interference, while Chapter 4 utilised a stronger form of RI task to measure overall main effects for this late-occurring interference interaction.

How reliable are the findings of NRI salience? The recent literature on the presence of pervasive NRI effects has lacked congruence (Fatania, & Mercer, 2017; Martini et al., 2018; Martini, Martini, & Sasche, 2019; Martini et al., 2017; Varma et al., 2017). Within this thesis, however, there has been a consistently replicated effect of late-occurring RI hindrance greater than that of any condition or condition order in Chapters 2, 4, and 5; with Chapter 3 providing understanding of the similarity function (stimuli, and or memory task) and Chapter 4 utilising a stronger form of NRI. The experiments showed that the point at which NRI was experienced was crucial to the presence or absence of NRI. Therefore, in prior experiments which measured NRI effects, the main effects may have 'masked' the more intricate function of NRI induced by S-T-D tasks. Also, Chapter 5 (N = 100) found an overall effect of NRI in an almost identical experiment whereby the concurrent rating task was removed. Why was an overall effect found in Experiment 5 but not Experiment 1? In Experiment 1 participants were asked to rate how interesting each individual item was, creating a form of elaborate encoding (Craik & Lockhart, 1972; Craik & Tulving, 1975). As NRI occurs whilst interrupting maintenance rehearsal, the influence of a deeper and more elaborately rehearsed encoding phase may have enabled participants to resist NRI, but not the cumulative (thus more salient) late-occurring interference effect.

Similarly, Chapter 4 utilised a Sternberg task (a quick item-recognition task with meaningless numerical stimuli) during the retention interval to elicit a greater amount of NRI and compare recall patterns. With the more demanding NRI task, an overall main effect of NRI was found within the same experimental design. These results of Chapters 4 and 5 also followed the same late-occurring interference drop-off for recall performance, indicating that more demanding RI tasks which produced main effects may have continued to experience the same increased salience in the unexplored late-occurring interference group. Due to this, it is firstly argued that overall effects of NRI (particularly from distractions such as S-T-D tasks) were more prevalent than expected. Secondly, NRI is a low-level form of diversion interference and this interference becomes more pervasive the later it occurs within a task and can accumulate with similarity interference. There are two current explanations which could explain this consistent pattern:

(i) The greater hindrance of recall may result from a cumulative interference effect whereby the prior memory task created a form of associative PI from recall of List 1, which interferes with the subsequent learning (though this is not supported by the prior control groups) and maintenance of List 2 stimuli during a NRI task. Tentative evidence for this is provided by the SMT during Chapter 3, which reported the lowest recall performance. This supports the concept of 'distinctiveness' of the memory trace through attention and maintenance, and of cue-overload theory (PI) during retrieval. Within this paradigm, the positive effects of wakeful and active rest result from breaking-up and preventing the cumulative interference build-up, thus increasing recall scores.

(ii) The second explanation relies on cognitive load or mental fatigue (with cognitive load of the tasks increasing interference whilst mental fatigue may increase susceptibility to interference). Specifically, prior-tasks and TOT makes an individual more susceptible to NRI and increases the salience of NRI effects, in particular through resource depletion. This would explain the greater decline resulting from C-I than I-C along with the *trends* in Chapter 3 whereby the similar task incurred the most hindered recall performance, followed by the dissimilar task, with the role of executive functioning playing a *slight* role. However, this explanation is a speculative deduction based on non-significant differences but trends within a small sample size. This would mean that the cognitive resources needed for the declarative semantic memory task may have been depleted by the SMT, while the DMT used declarative memory resources but of a different (visual) memory system enabling slightly better recall, and the executive functioning task was a mental NMT, which would lead to lessened taxation of these memory resources and thus enabling greater recall. Within this framework the benefit of 'wakeful rest' found by Mercer (2015) would reduce cognitive load and allow the replenishment of these resources. This effect can also be found using a low-level active rest as long as the task is of a dissimilar nature to the primary memory task, as found by Ecker, Tay, and Brown (2015).

Chapter 3 provided a deeper understanding of the results found in the Chapter 2 experiment by looking into the role of the prior-task condition and measuring whether similar or dissimilar stimuli and memory prior-task groups experience the same 'fatigue' or a 'cumulative interference' effect of hindered recall when the NRI condition was late-occurring. As expected, the worst performing recall group consisted of a similar prior memory task using associative verbal stimuli, followed by the dissimilar task group. However, the group which experienced a NMT (Stroop) achieved the greatest recall, which was significantly greater than the SMT but not significantly different to the control group who were fresh and received no-prior task. The results of Chapter 3 highlight the importance of the type of cognitive prior-task on subsequent recall performance. The greater performance of the NMT provides strong support for the importance of temporally isolating the encoding phase for the to-be-recalled stimuli in order to increase the subsequent recall of those items, by reducing forgetting caused by interference. PI caused by every day thinking, or prior lectures (the participants were students) may have been reduced by the ‘active rest’ provided by the Stroop task by further temporally isolating the encoding phase from resource demanding or interference inducing tasks (Brown et al., 2006; Ecker, Tay, & Brown, 2015; Morin et al., 2010; Rönnberg, 1980), though further investigation is needed to uncover whether a Stroop task could be utilised as a form of active rest. Experiment 3 did not find significant differences between the prior-Stroop task groups and the no-prior task, questioning whether everyday sources of PI were reduced, but supporting the concept that the Stroop provides low cognitive load for memory tasks which does not decrease recall significantly compared to a control. This would fit within the theory of temporal distinctiveness but with an additional cognitive load resource sharing function. That is, whilst an empty wakeful rest period is advantageous to recall (Mercer, 2015), this isolation can be achieved through non-effortful tasks that are different to the task aim (recall, hence memory) and thus lower resource demand (Chen et al., 2017). This would be particularly advantageous prior to a task to reduce PI, though must be treated with caution after learning so as not to induce NRI greater than that naturally elicited during wakeful rest (i.e., MW).

A consolidation account would explain the greater recall as the result of the Stroop task preventing spontaneous rehearsal and autobiographical thinking, thus freeing up consolidation memory processes by reducing memory resource demand (Varma et al., 2017). However, Ecker, Tay, and Brown’s (2015) experiment tested the effect of temporal isolation against the freedom of consolidation process resources within their Experiments 1 and 2. Ecker et al. measured recall of two lists (list 1 and list 2) which were separated by differing temporal delays to test pre-study and post-study rest and temporal isolation. Whilst Ecker et al. found strong pre-study rest effects (similar to Chapter 3) for list 2 recall, a greater consolidation of list 1 (represented by greater list 1 recall scores) was not found this indicates that the improved recall of list 2 following a longer pre-study rest was not explained by a freeing of consolidation processes following successful list 1 consolidation. Instead, this isolation may be best contextualised as a reduction of interference. For this the Stroop task would need to be low enough in cognitive demand to reduce the PI caused by previous everyday interfering tasks such as autobiographical thinking (Craig et al., 2014; Dewar et al., 2014). Experiment 2 further supported this by finding no significant recall differences between different prior Stroop tasks and a controlled no-prior group. This finding is consistent with the literature as it is unclear if the Stroop task which lasted just five minutes is lengthy enough to induce fatigue. For greater reference, a similar study was conducted by Rauch, Wolfgang, and Schmitt (2009) which increased cognitive demand of the Stroop task (see Chapter 3) over a 15-minute period and that was considered a short-term approach with previous studies typically opting for a Stroop task that takes around one to two hours (Boksem & Lorist, 2006; Lorist et al., 2005; McMorris, Barwood et al., 2018). This means that an active prior-task which included a short-duration Stroop task was not sufficiently cognitively demanding to cause interference. This reduced cognitive load demands to non-significantly different to a no-prior task for NRI effects but does not indicate an advantageous isolation from every day forgetting, but further indicates that cognitive fatigue did not induce the late-occurring recall hinderance within this thesis. Finally, when combined, the experiments in Chapter 3 show tentative support (through trends) for the cognitive load explanation, which is worth exploring in future experiments. However, for the current thesis, the results better befit the explanation of cumulative interference rather than a fatigue explanation of late-occurring interference induced hindered recall.

Interim conclusion for NRI effects

It has been established that temporal isolation through wakeful rest is highly advantageous to recall through the reduction of both PI and RI. It is asserted within this thesis – and congruent with the current literature – that isolation of the encoding items can be achieved through a wakeful and active rest period prior to the encoding phase to help reduce sources of everyday PI, and cognitive load. Furthermore, the results of these chapters are better explained as a function of distinctiveness of the memory trace, diversion interference (NRI of the retrieval phase), and cognitive resource sharing (modulating the salience of interference). Combining CRS, cumulative interference, and interestingness explanations together demonstrated that distinctiveness of the memory trace is multidimensional, and that isolation is achieved temporally, physically (text-based stimuli characteristics), mentally/emotionally (interest salience) and through understanding the role of prior-task interference in inducing cognitive load and PI.

It is argued that prior research into NRI has previously missed the important interaction produced by condition-order effects explaining the varied impact of NRI. It is concluded that NRI is a highly prevalent but low-level interfering effect which increases forgetting as a power function of its cumulative function, whereby prior-task cognitive load and/or interference effects combine to hinder subsequent recall performance. This may be reduced by enabling greater elaborate encoding, and through isolation by understanding the role of prior and subsequent mental tasks' load/ interference effects and utilising wakeful rest.

Interest

Summary of key interest findings

Various forms of interest were explored in a number of different ways within the current thesis, including situational interest, topic interest, overall interestingness (of the stimuli) and subjective interestingness. The most substantial finding was found in Experiment 4 This experiment applied a relatively new approach with an individual differences, item-specific focus of rating subjective interestingness of the facts. Most prior research in interestingness and memory applied global main effects that measure overall interest/interestingness with overall recall/ recall type (categories etc.). This misses out the important individual differences found with the personal, subjective level of interest experienced by the participants for each specific fact. This means that if a fact is rated by the sample as uninteresting overall, another participant may rate the same fact as highly interesting and therefore be more likely to recall it – this interaction would be missed. By comparing Experiment 4 (of subjective interestingness) and Experiment 5 (of overall interestingness), it is clear that the individualistic way of measuring interest provides a clearer view of the impact of positive interest valence on short-term learning performance, with facts rated as highly subjectively interesting leading to the subsequent recall of those facts. Although both types of interest were significant positive effects, subjective interest had the larger effect size.

The various forms of interest found to increase recall performance were consistently shown to be a separate effect which did not interact with the control or interference conditions. This indicates that over a relatively brief memory experiment, high interest valence increases the likelihood of item recall in comparison to lower interest valence. However, this occurs regardless of the retention period, meaning that interest valence does not aid in the maintenance of a memory trace during retention and does not, therefore, decrease the amount of information lost through interference.

Interest and Interestingness

Interest was conceptualised within this thesis in two main ways; individual interest was conceptualised as 'self-actualised interest' and the 'interestingness' of both the environment and of the stimuli was classed as a factor of situational interest. With a lack of cohesion between researchers on the definitions of interest and, therefore, the optimal way to measure interest (Rotgans, 2015), each experimental chapter assessing interest explored the role of varying forms of interest within the same short-term learning[3] and memory experimental design. This is particularly pertinent as cognitive memory studies which included interest as a factor typically used one scale ratings of interest without exploring or understand the different conceptualisations to provide accurate contextualisation, and hence interpretation of interest effects (for an example see the Chapter 3 introduction for an interpolation of Mcgillivray's [2013] memory findings with the interest literature).

Individual interest and situational interest are each argued to contain two phases of development within the most commonly accepted model – The four-phase model of interest development by Hidi and Renninger (2006). This includes Phase 1 triggered situational

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[3] Short-term here refers to brief learning episodes, not of short-term memory lasting seconds.

interest, Phase 2 developed situational interest, Phase 3 individual interest, and Phase 4 established individual interest. TSI refers to the positive experience of interest which can be shared between groups as an environmental response to a stimulus/trigger (such interest in the experiment, or the interestingness of text). This may develop and be maintained when the task or scenario is seen as meaningful (Harackiewicz et al., 2000; Hidi & Renniger, 2006). This may then develop into individual interest, however, as Hidi and Renniger define this phase as an enduring predisposition to reengage with a specific topic or content, the findings of the current thesis, which measures engagement with the facts over a short-term recall paradigm, are better explained by the first two phases of situational interest development.

Situational interest through interestingness

Chapter 2 found that situational interest measured as overall interestingness of the experiment was a significant predictor of recall, but only when interference was not present, and although there is consistently no interaction between condition and interest this similar *trend* was replicated in the findings of Chapter 5. This indicates a weak relationship that may be worth investigating between task difficulty, interference type, and interest salience. However, the current thesis finds little significant evidence for interest dampening NRI. Instead, situational interest shall be discussed for its positive impact on successful recall and consequently greater learning outcomes.

The positive influence of situational interest conceptualised as text-based interestingness upon learning outcomes has long been established (Garner et al., 1991; Hidi & McLaren 1988; Krapp et al., 1992; Schiefele, & Ulrich, 1996; Shirey & Reynolds 1988) though sometimes weakly (i.e., Chen et al., 2002; Zhu et al., 2009) But what makes a stimulus text (situationally) interesting? There are two main components: (i) characteristics of the text (e.g., novelty, instant enjoyment, challenge, exploration intention and attention demand); (ii) personal aspects to the reader (and the reader's engagement with it; Bernstein, 1955). Chapter 5 explored whether global interestingness captured concurrently with the presentation of the facts (making ratings linked to instant enjoyment and likely elicited by novelty) were transferable across samples to increase recall performance. Chapter 4 explored the relationship between the specific stimuli and the subjective individual experience with it and whether that leads to greater recall of that stimuli item specifically.

The Chapter 5 experiment tested the recall of the facts used in Experiment 1 when the facts were split by high and low interestingness based on global ratings from a separate cohort. As anticipated, the experiment supported the previous literature as the facts rated higher in interestingness were recalled greater than those rated lower. This further supports the assertion that situational interest effects, when conceptualised as interestingness, can be consistent across groups to increase learning and recall outcomes. Therefore, Chapter 5 shows no need for personal identification, and that the positive effects of interest on recall can be found without measuring the subjective individual participant rating. This has benefits for future application, i.e., learning materials used yearly may be rated for global interestingness initially and then reapplied to future cohorts.

What makes the interesting facts easier to remember and recall?

Marton and Säljö (1984) found that students who were less interested in a text demonstrated considerably less understanding of said text. Conversely, those who were interested in the material had a greater understanding which led to greater semantic processing. Craik and Tulving (1975), through the 'Shallow Processing effect', found that this greater or 'deeper' level of cognitive processing during the encoding phase leads to greater recall potential and better comprehension— resulting in a greater learning outcome. These findings were then supported by Schiefele and Krapp, (1996) who found that interest and deep comprehension questions were the greatest predictors of recall. In a later study, Sanford et al. (2006) used 'attentional capturers' within written language such as italics for *emphasis* and word stressors and found that these elicited greater levels of processing through increased focus and change detection. A cognitive explanation for this is provided by the 'Von Restorff' effect whereby novel and more 'distinct' items are easier to recall than non-distinct items (Huang & Wille, 1979; Hunt, 1995; Von Restoff, 1933). For example, a red stimuli item amongst a list of blue items would be more 'isolated' and hence distinguishable.

Merging these findings provides a preliminary model of stimuli recall (see Figure 6.1) awaiting further explanation: The characteristics of a text (such as novelty) influences the level of situational interest evoked and the way the stimuli is presented as a function of its isolation (through attentional capturers or 'the spacing effect' mentioned previously) is an interlinking factor which captures attention and focus during the encoding phase. This leads to a deeper level of cognitive processing which increases both recall and comprehension of the text, resulting in both greater memory performance and overall learning outcomes.

However, whilst this form of distinctiveness has increased memory performance through isolation, it has not been shown (as a function of interestingness) within this experiment to modulate interference effects—unlike time-based isolation discussed below. This shows that whilst physical distinctiveness of – and interest effects from – a stimulus leads to greater recall; this does not decrease the rate of overall forgetting caused by NRI during the retrieval phase. More interesting items are encoded than uninteresting items but experience the same susceptibility to RI.

Subjective interest and topic interest

Chapters 3 and 4 tested elements of the second type of interest, individual interest, as individual interest is argued to be a primary motivator for participants to engage with a more difficult task (Hidi, 2006; Krapp, 2009; Krapp & Prenzel, 2011). This could potentially explain the positive effect of interest ratings found during the interference condition in Experiment 1. However, as this form of interest develops over time from situational interest, a true measure of individual interest is not plausible within this cognitive memory experiment. Instead, factors of interest are measured, such as the efficacy of prospective ratings of participants' interest in the topic (based on their previous experiences of interest and subjective beliefs (Rotgans & Schmidt, 2018) in predicting recall performance of topic-related facts in Chapter 3. Dispositional individual differences factors of interest experience were conceptualised as 'subjective interest' which was then tested in Experiment 4. Subjective interest ratings were measured concurrently for each fact and represent the rating of a participant's subjective experience of TSI evoked by the specific stimuli.

Firstly, topic interest effects on recall were not found when measured pre-stimulus, indicating that a participant's dispositional beliefs or emotions around their interest of a topic does not directly impact immediate recall. Instead, ratings of the individual interest questionnaire (Rotgans, 2015) for both topics were correlated. As the ratings were similar across the different topics ('space' and 'animals'), it is likely that some participants were comparing anticipated interest in the experiment or comparing with other topics not mentioned (Chen et al., 2001). This questions the validity of a pre-stimulus test for immediate recall performance. Alternatively, the more modern approach of incorporating situational interest as the base for topic interest in accordance to the four phase model – and similar to Soemer and Shiefele (2019) – may lead to greater recall performance and be more indicative of a precursor to enhancing developed individual interest but cannot be tested within the current experimental design.

Secondly, as mentioned previously, Chapter 4 investigated dispositional interest factors on an individual- and item-specific level. This aimed to test whether a fact rated as interesting by a participant would lead to the subsequent recall of that specific fact by measuring the subjective/individualistic interest experience. (This was followed by Chapter 5's 'global interest' finding of interestingness to test the individual engagement factor of text interestingness (Bernstein, 1955). The first study to measure subjective interestingness was conducted by McGillivray (2013) whose stimuli included questions rated for curiosity (pre-answer stimuli) as a phenomenon of knowledge seeking (Kang et al, 2009; Murayama & Kuhbander, 2011) and answers rated for interest (post-answer stimuli). McGillivray reported speculative findings of subjective interest leading to increased recall for participants whose recall scores were lower than the average (which approached the ceiling) during the shorter term (one hour) cued recall. These effects were later established during the longer recall period which took place after one week. To account for this, Experiment 5 utilised a more demanding recall task (free recall) within an even shorter memory task (retrieval after five minutes) to increase the validity of the findings and reduce speculation. The results of Experiment 4 strongly supported McGillivray's findings of subjective interest valence, as facts rated as highly interesting were recalled more than facts rated as low in interestingness on an individual level. This means that a participant's TSI experience of a stimuli may directly influence the subsequent recall of that stimulus. These effects were evident within a short-term experimental paradigm negating the need for factors of individual interest such as re-engagement and enduring motivation, and interest effects were more prominent when measured using individual subjective interest vs. Experiment 5's global interestingness. This provides further support for Rotgans and Schmidt's (2014; 2018) assertion that situational interest is the main form of interest to impact learning and that the extent to which this occurs is influenced by dispositional individual interest.

In other words, an individual's dispositional interest factors influence the salience of positive interest valence experienced from the stimuli, modulating the state of TSI evoked from text-based interestingness characteristics of the stimuli items. The greater the experience of TSI the better the encoding of the memory trace is for that specific item and that specific individual, leading to greater recall.

Interim conclusion: The role of interest

The positive impact of interest on recall was found predominantly from situational interestingness of the stimuli (Chapter 5) – the experience of which was modulated by an individual's dispositional interest (see Chapter 4). To provide an explanation within a cognitive memory framework, it is asserted that interest behaves as a function of distinctiveness of a memory trace. This memory trace distinctiveness encompasses both physical and mental properties of distinctiveness: (i) the physical isolation through characteristics of the text; (ii) the mental state of emotional valence, such as interest experience indicative of the ‘individual experience’. Both forms of distinctiveness have a function of allocating attentional resources during encoding thereby enabling a deeper level of cognitive processing leading to greater comprehension and, subsequently, learning. Additionally, it is asserted that a more distinct memory trace is not only better encoded, but it is easier to retrieve amongst less distinct items consistent with cue-overload theory and thus leading to greater recall of those items.

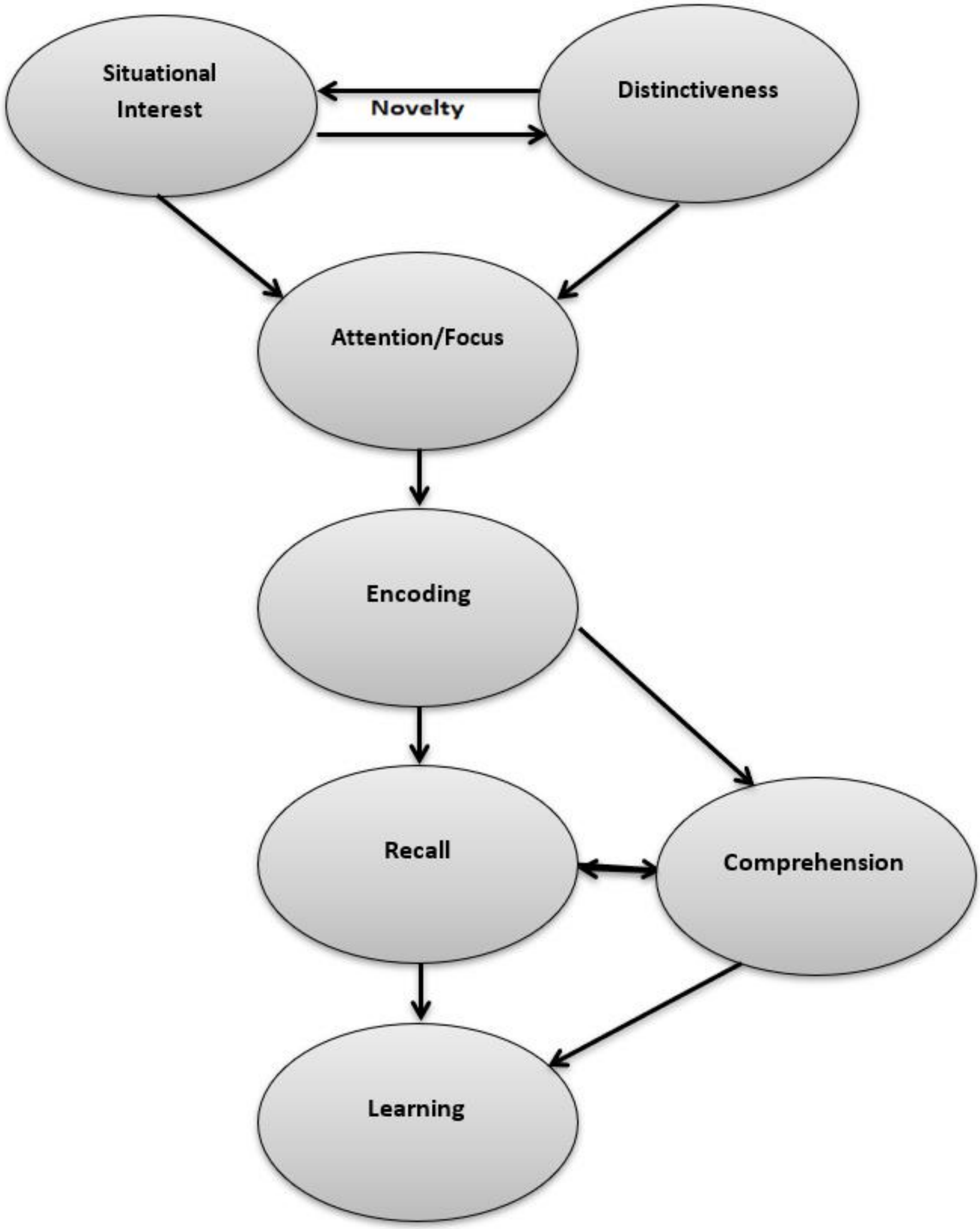

Figure 6.1. Preliminary model graphically representing the link between situational interest/interestingness and recall.

Mind Wandering

The link between MW and Interest as found by Smallwood et al. (2009) was not established within Experiment 1, and the trend between subjective interest or situational interest and TUT (MW and external distraction) within Experiment 4 was speculative and nonsignificant. Although MW and NRI are linked as a form of recall hinderance that occurs when an individual is distracted away from task-related information (Craig et al., 2014; Dewar et al., 2014) the lack of an established link of interest on both MW and NRI meant that the extent to which MW's recall hindrance is the result of- or overlaps with- NRI effects was not measured. As both MW and NRI hindered recall during the current thesis, but operated separately from interest effects, it is put forward that within this thesis both concurrent internal distractions (MW) and retrospective external distractions (NRI) hindered learning and recall, and further experiments must establish the overlap or difference (if any) between the two factors.

Implications

This thesis provides a more intricate understanding of the nature of NRI. When applied, this explains the previously conflicting findings of NRI effects. The emerging focus on distinctiveness as a multidimensional factor could have both theoretical and practical applications. A model of distinctiveness could be created and tested to explore different cognitive explanations such as cognitive load, interference, consolidation, physical stimuli characteristics, temporal, and emotional factors (i.e., interest). This understanding would better aid stimuli presentation during educational settings which also uses meaningful semantic chunks of information, particularly for free recall during exams.

Chapter 4 showed that a stronger form of NRI produces overall effects in a similar pattern to the S-T-D tasks as the more demanding NRI task also followed the late-occurring interference pattern. Therefore, other forms of RI may experience this cumulative interfering effect, thus highlighting a potential function of RI salience generally.

The current thesis provides a cognitive explanation for subjective interestingness and furthermore reinforces the argument put forward by Rotgans and Schmidt (2018) to modify the four-phase interest model (Hidi, 2006) to incorporate dispositional interest factors.

Theoretical implications and development

The results, along with the researcher's current understanding, led to the interpretation of a preliminary model of forgetting and recall (Figure 6.2.). Within the model the forgetting of a memory trace occurs as an inverse function of its distinctiveness across three key dimensions: Physical characteristics (of the stimuli), temporal positioning (e.g., isolation or spacing of the stimuli/task), and experience (person-object interaction with — and emotional significance of — the stimuli or task).

Distinctiveness through isolation is multidimensional (temporal, personal, and physical-stimuli characteristics). This aids in the allocation of attention and subsequent retrieval of items, which can explain cue-overload and diversion interference (by moving attention away and decreasing prominence and therefore distinctiveness and leading to more distracting information).

Temporal isolation helps reduce the cognitive resource depletion caused by TOT or mentally demanding tasks though further research must be done into the role of cognitive load before it is to be included into the model. If a link is found these two factors could potentially be combined to help provide an understanding of interference as the behavioural aspect of forgetting whilst enabling the consolidation account to be the physical neurological explanation. In other words, perhaps interference is another function of distinctiveness and attention allocation which is modulated by mental effort and available mental resources to decide which memory traces become physically, neurologically consolidated. In this way, the behavioural forgetting occurs as a power law of the multidimensional factors of distinctiveness. Evolutionarily it would make sense: A hierarchy of importance (to survival) would dictate the tasks to which an individual should allocate their limited attention. Those which were seen as more important (emotional experience) gained more attention and thus were more distinct and led to greater outcomes and reinforced learning. Those which did not were not maintained and thus were less prominent or less likely to lead to an adaptation (in the case of the memory trace this adaptation would be neuroplasticity). Those actions done repeatedly gain greater consolidation as they are leading to survival. Those no longer used would become weaker and less maintained due to the adaptive nature of memory and survival, and the necessity for current demands, current *fitness,* adaptability and changing needs and demands. More prominent stimuli capture our attention in return for a response. A large bright colour may indicate poison, or attraction (more of an animal/insect example). Conversely, size and boldness may indicate significance (e.g., a Von Restorff effect). Perhaps an individual has been/can be conditioned to find certain stimuli more distinct, through emotional valence and interest. As with the physical and temporal dimension, interest has been shown in this way to increase learning through attention during the encoding phase.

However, interest has been shown to be separate from the effects of interference within this thesis, creating a separate experiential domain/dimension of significance.

This also fits in with directed forgetting; the idea that one can effectively pay attention to maintaining information deemed more important (for an introduction to directed forgetting see Anderson [2015]). Considering forgetting as a function of a power law of distinctiveness in this multidimensional way was initially extracted from this thesis. A study published post-interpretation provided greater credence to this interpretation. Georgiou et al. (2019) demonstrated that a power law of forgetting via a RI model produced patterns consistent with the historical forgetting curve, with the newer information receiving a valence value of importance (power) and this power valence, if greater than previous information, displaces it. It is put forward that a more ‘fleshed out’ explanation of the power function could be that of the multi-dimensional distinctiveness model proposed.

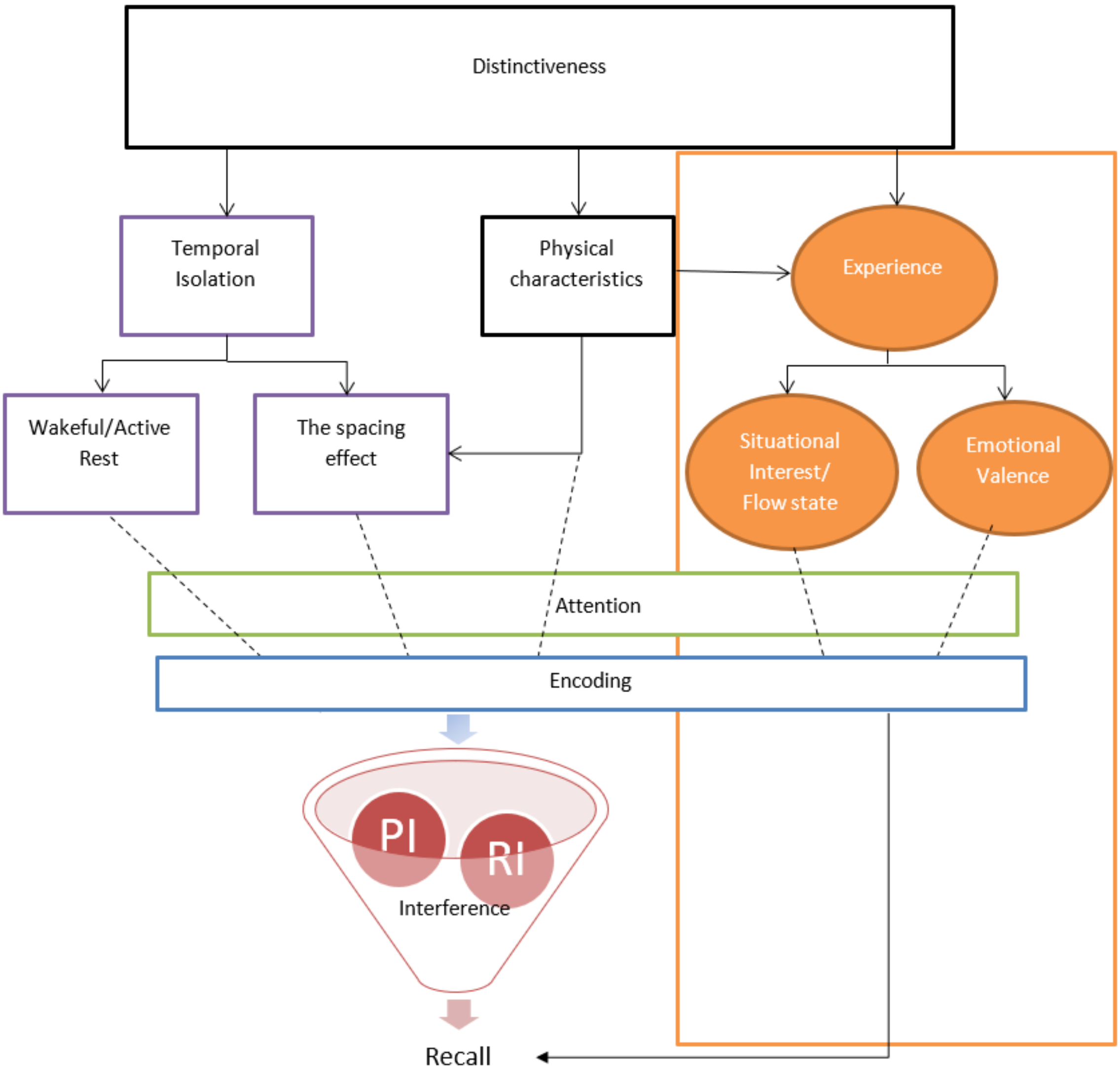

Figure 6.2. Preliminary behavioural memory model: The multidimensional model of trace distinctiveness.

Limitations

With the lack of cohesion over the contextualising and measurements of interest/interestingness, there was a difficulty in exploring these as a factor within a short-term memory experimental design. The six-item IIQ by Rotgans (2015) was attempted to be implemented within Chapter 4 (Experiment 4) but was too numerous to do for each item (36*6 = 216 item responses) and thus produced patterned responses and was omitted. Multiple scales are not feasible during a cognitive memory test and so single item scales were used which captured TSI. Measures of situational interest in Chapter 4 and 5, whilst fitting within the previous literature which suggests that situational interest in an environment is low-level and short-lasting, would have been better measured at the end of both conditions. This would have allowed for a more accurate situational interest measurement and a more in-depth analysis. As the primary aim of this thesis was to measure hindered recall and NRI, this was not feasible (as the environmental situational interest scale may increase interference) but could be explored in future research.

Chapter 3 contains sample sizes calculated by G*Power analysis to replicate the C-I effect from Chapter 2. This means that the conclusions must be focused on the role of late-occurring NRI and cannot fully determine the role of prior-task type and interference outside of that framework. A larger sample size could provide a greater exploration of the cognitive load vs /with interference effects to produce more generalizable findings.

Conclusion

Overall effects of NRI have been found to be more consistent than previous literature, though the most replicated and consistent finding is that of the late-occurring NRI condition, which has been prevalent in hindering recall scores more than any other factor throughout this thesis. The results show that NRI is a highly prevalent form of interference which increases in potency through cumulative effects of similarity interference and (plausibly) cognitive load. Nonetheless, further research must be conducted to fully explain the role of cognitive load and fatigue with respect to NRI. The current thesis provides context for the previous lack of congruence of NRI effects within the literature by presenting NRI as a more complex effect and highlighting the importance of the role of condition-order effects.

The positive effects of interest on recall do not decrease NRI effects during the retention phase but occur separately, indicating that interest increases learning during the encoding and retrieval phases but not the storage phase. While the situational interestingness of an item increases recall potential through the globally rated interestingness of the fact, the most prominent/potent form of situational interest that leads to the greatest recall scores occurs on an individual level. This demonstrates that the experience and extent to which situational interest is evoked is modulated by dispositional individual interest factors, providing further support for the modification of the current Four Phase Model of Interest Development (Hidi, & Renninger, 2006).

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Appendix A1

Facts for Experiment 1, 2, & 5

List A (Experiment 1; Experiment 2 SMT)

1. Squirrel comes from a Greek word translated to “shadow-tail”
2. People are less likely to remember good news, than bad
3. In Russia beer was considered a soft drink until 2011
4. A giraffe can clean its own ears with its tongue
5. The first fortune cookies were created in the United States
6. Donald Duck was banned in Finland for lack of pants
7. French was the official language of England for 600 years
8. Every year about 98% of atoms in your body are replaced
9. Elvis Presley got a grade “C” in his music class
10. Coca-Cola would be green if colouring wasn’t added to it
11. Earth is the only planet not named after a God
12. A “jiffy” is actually one hundredth of a second
13. Camouflaging polar bears cover their black noses with their paws
14. The average NFL game consists of 12 minutes playing time
15. When breathing your ribs move 5 million times a year
16. Since 1945 British tanks have come with tea making equipment
17. "Rhythm" is the longest English word not containing a vowel
18. Pure honey is the only food discovered not to spoil
19. Just like with your fingerprints, everyone’s tongue print is unique
20. Adolf Hitler was a vegetarian who created animal welfare laws

List B (Experiment 1; Experiment 2 interference task, & 5)

1. Queen Elizabeth I claimed that she bathed once every three months
2. “The last scattering” in space is too dense for light to travel through
3. An individual blood cell can travel around your body in 60 seconds
4. The world’s first paper money was created in China
5. Pound for pound muscle burns 3 times more calories than fat
6. Facial symmetry is highly linked to greater levels of attractiveness
7. The Ancient Egyptians used slabs of stones as pillows
8. Heart attacks are more likely to happen on a Monday
9. Pirates wore earrings because they believed it improved their eyesight
10. The Bible is the most shoplifted book in the world
11. Owls are the only birds that can see the colour blue
12. Sound travels 15 times faster through steel than through the air
13. For every human on earth there are over 1 million ants
14. Handshakes originated to test whether the person had a concealed weapon
15. Two-thirds of the people on earth have never seen snow
16. The dot over the letter ‘i’ is called a tittle
17. School’ comes from the Greek word meaning ‘leisure’ or ‘spare time’
18. Coffee was called ‘Arabic Wine’ when it was introduced in Europe
19. Before mercury, brandy was used to fill thermometers
20. Penguins have an organ that converts seawater to fresh water

Appendix A_2

Facts for Experiment 4

List A

1. Earth is the only planet not named after a God
2. Squirrel comes from a Greek word translated to "shadow-tail"
3. Donald Duck was banned in Finland for lack of pants
4. When breathing your ribs move 5 million times a year
5. Every year about 98% of atoms in your body are replaced
6. Just like with your fingerprints, everyone's tongue print is unique
7. Since 1945 British tanks have come with tea making equipment
8. "Rhythm" is the longest English word not containing a vowel
9. A giraffe can clean its own ears with its tongue
10. Coca-Cola would be green if colouring wasn't added to it
11. The dot over the letter 'i' is called a tittle
12. Queen Elizabeth I claimed that she bathed once every three months
13. Before mercury, brandy was used to fill thermometers
14. A "jiffy" is actually one hundredth of a second

List B

1. Handshakes originated to test whether the person had a concealed weapon
2. Heart attacks are more likely to happen on a Monday
3. The first fortune cookies were created in the United States
4. The Ancient Egyptians used slabs of stones as pillows
5. 'School' comes from the Greek word meaning 'leisure' or 'spare time'

6. Facial symmetry is highly linked to greater levels of attractiveness
7. Coffee was called ‘Arabic Wine’ when it was introduced in Europe
8. The average NFL game consists of 12 minutes playing time
9. Elvis Presley got a grade “C” in his music class
10. An individual blood cell can travel around your body in 60 seconds
11. Two-thirds of the people on earth have never seen snow
12. Owls are the only birds that can see the colour blue
13. Penguins have an organ that converts seawater to fresh water
14. Pound for pound muscle burns 3 times more calories than fat

Appendix A3

Facts for Experiment 3

Animals

1. Bats always turn left when they leave a cave
2. Dolphins are able to sleep with one eye open
3. The heart of a shrimp is located inside its head
4. Armadillo is a Spanish word meaning “little armoured one”
5. A seahorse can move its eyes in opposite directions

Space

1. The face of the sun is 10 earth lengths long
2. Cola was the first drink ever consumed in space
3. A single day on Pluto lasts for over 6 earth days
4. In Greek the name astronaut means “space sailor”
5. Typically clouds cover around 50% of the Earth

Other

1. Human Thigh bones are stronger than concrete
2. Around 100 cups of coffee is considered a lethal dose
3. Leonardo Da Vinci invented the first pair of scissors
4. Water is heavier when it’s hot than when it’s cold
5. The TV remote is the dirtiest item in a typical household

Appendix A4

Facts for Experiment 4

Two lists of facts

1. The average person falls asleep in seven minutes
2. No word in the English language rhymes with month
3. The voice actor of Bugs Bunny was allergic to carrots
4. The electric chair was invented by a dentist
5. More people are killed by donkeys than airplane crashes
6. A giraffe can go without water longer than a camel
7. 90% of all species that have become extinct have been birds
8. Winston Churchill was born in a ladies' room during a dance
9. St. Patrick, the patron saint of Ireland, was Welsh
10. The state of Florida is bigger than England
11. Sarcasm comes from the Greek term “to tear flesh”
12. The world’s oldest piece of chewing gum is 9000 years old
13. 2% of all Accident and Emergency cases are sports related
14. The Great Barrier Reef is the largest living structure on Earth
15. Vin Diesel's name is an anagram of "I end lives”
16. A song that is stuck in your head is called an “Earworm”
17. The man who owned Segway died by riding one off of a cliff.
18. Sound travels 4 times faster through water than through air

1. The music in the “Piracy, it’s a crime” advert was pirated
2. Hercules gave us the saying “Taking the bull by its horns”
3. The first product to have a bar code was Wrigley’s gum
4. The 100 years war lasted for 116 years
5. Apples are a member of the rose plant family
6. A newborn child can breathe and swallow at the same time
7. King Henry VIII slept with a giant battle axe beside him
8. 8 out of the 10 largest statues in the world are of Buddha
9. Baked beans are actually not baked, but stewed
10. ‘Almost’ is the longest word to be written in alphabetical order
11. The like button on Facebook was originally going to say “awesome”
12. Mars has the largest dust storms in the solar system
13. 85% of all known plant life is found in the ocean
14. The first speeding ticket was issued for driving 8mph
15. The U.S has deemed haggis to be unfit for human consumption
16. More languages are spoken in London than any City in the world
17. In France it is possible to marry a dead person
18. Socks were initially invented to go with sandals

Appendix A5

Facts scoring

A strict scoring procedure for marking the accuracy of the responses was adhered to and was as follows: If the participant had reported half a recalled fact which is still resembling a fact, it was given ½ a mark. A fact which was fully incorrect scored 0, however, if the full phrase was half correct, half incorrect, it was awarded ½ a mark. Also, if the fact was different in only one way (i.e. number) it was classed as correct and awarded 1 mark, but only if the new meaning was not incorrect. Finally, if a fact was presented and correct but details were lost that are greater than one difference, ½ a mark is awarded

Facts scoring example 1:

Fact: Queen Elizabeth I claimed that she bathed once every three months

1 Mark: Queen Elizabeth I claimed that she bathed once every three months

1 Mark (one detail incorrect): Queen Elizabeth I claimed that she bathed once a month

1 Mark (one detail incorrect and minor information difference: clear recall): Queen Elizabeth bathed once a month

1/2 Mark (half a fact): Queen Victoria bathed 3 times a month

1/2 Mark: Queen Elizabeth claimed she bathed often

No Mark: Queen Elizabeth did not bathe

Facts scoring example 2: Penguins have an organ that converts seawater to fresh water

1 Mark (one detail missing): Penguins can covert seawater to fresh water

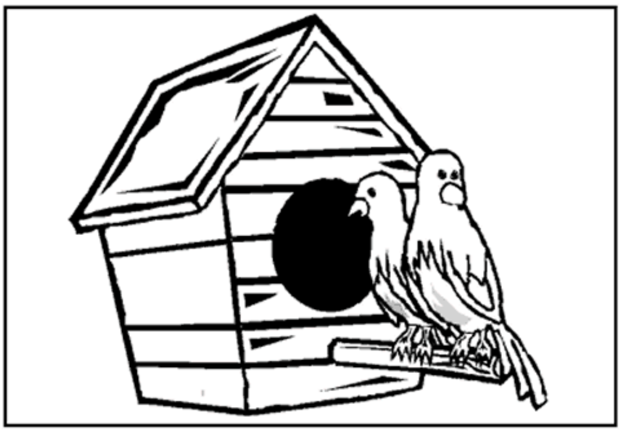
1 Mark (correct and retains understanding): Penguins can make seawater drinkable

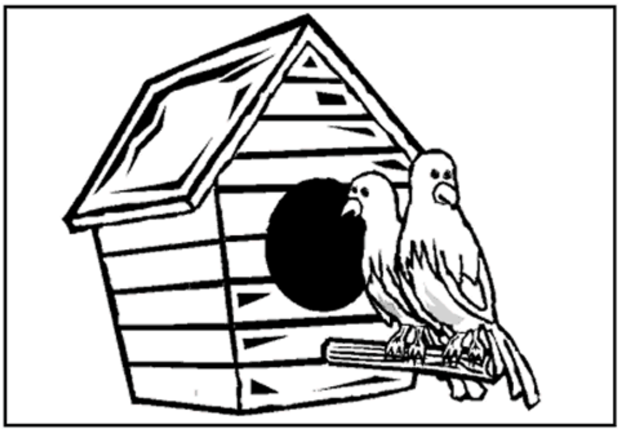
1/2 Mark: Penguins have an organ to drink water

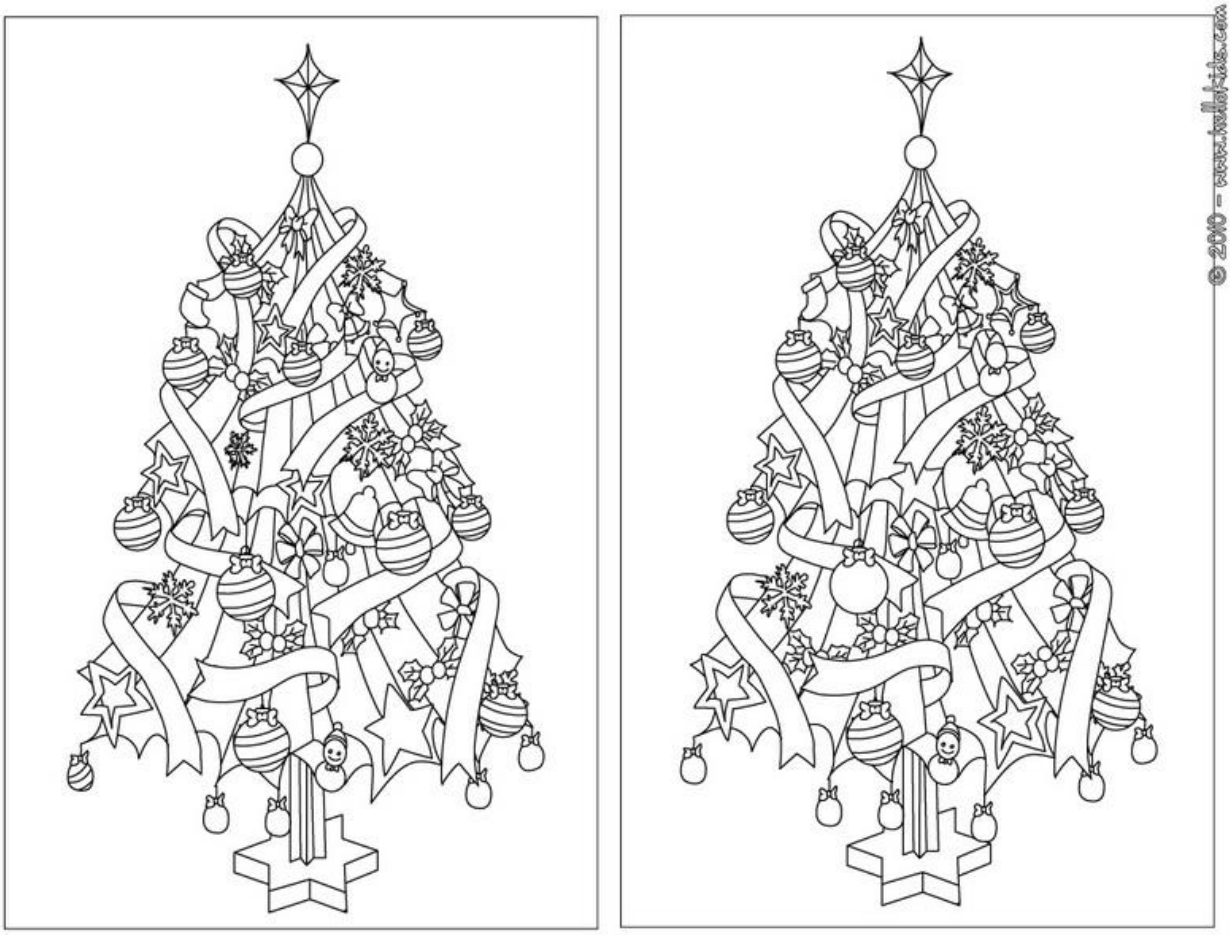
No Mark: Birds drink seawater

Appendix B_1

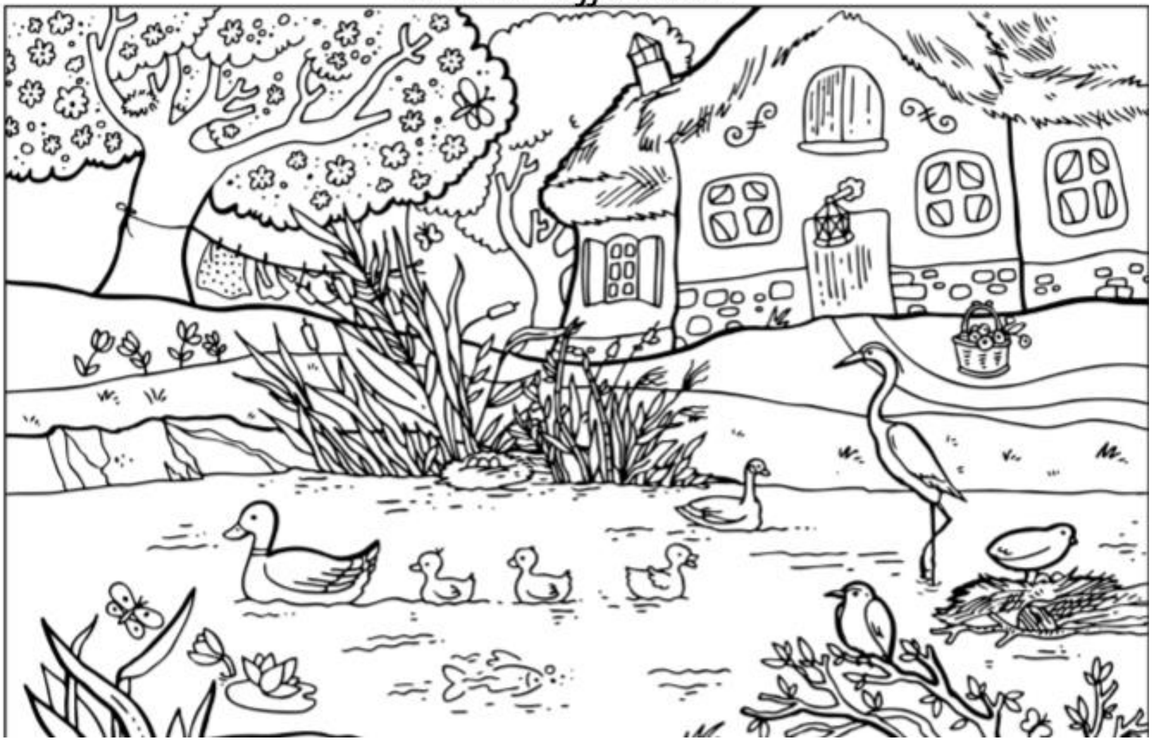
Spot the difference images (Experiments 1, 2, 4, & 5)







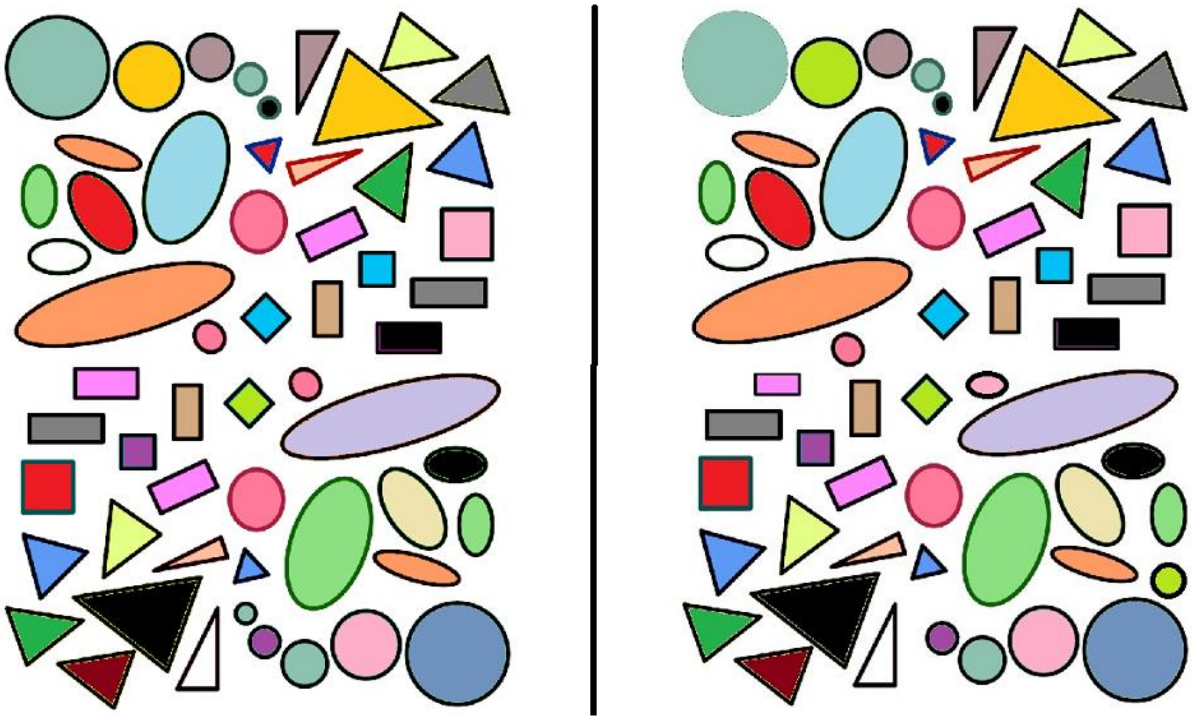
Find the Differences!



Find the differences!

Appendix B2

Spot the difference images (Experiment 3)

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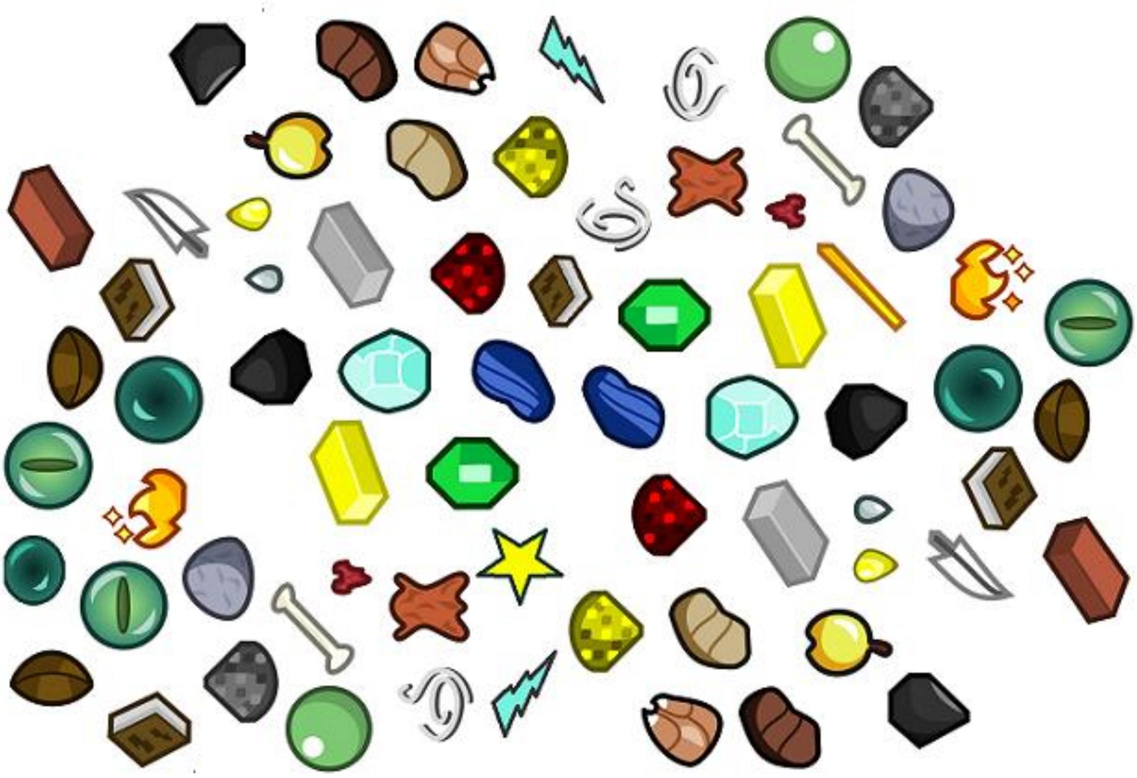
A4 +5
YAHOO!
LINE
A4 +5
YAHOO!



Appendix C1

Self-report interest ratings: Experiments 1, 2, & 4

SELF-REPORT FORM

How interested were you in the facts presented?

Please circle on the scale below 1 meaning not interested and 10 being very interested.

Not interested									Very interested
1	2	3	4	5	6	7	8	9	10

How interested were you in the memory experiment itself (trying to remember as much as possible)?

Please circle on the scale below 1 meaning not interested and 10 meaning very interested.

Not interested									Very interested
1	2	3	4	5	6	7	8	9	10

How interested were you in the interfering task (the task irrelevant to the facts presented)?

Please circle on the scale below 1 meaning not interested and 10 meaning very interested.

Not interested									Very interested
1	2	3	4	5	6	7	8	9	10

Appendix C_2

(Fribbles Answer sheet Experiment 2)

Trial Number: Phase 1	Same	Different
1		
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Trial Number: Phase 2		
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Appendix C3 Stroop Answer sheets experiment 2

13

Trial Number	Same	Different
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14

Trial Number	Same	Different
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Appendix D_1 (Experiment 3)

<u>Individual/Topic Interest</u>

Please indicate in the box below how well each statement fits the fact: 1 (not true at all), 2 (not true for me), 3 (neutral), 4 (true for me), and 5 (very true for me).

"*The music in the "Piracy, it's a crime" advert was pirated*"

1) I am very interested in this type of fact ☐
2) I would be interested in seeing facts similar to this ☐ ☐
3) I really enjoyed this fact ☐
4) This fact stood out to me ☐ ☐
5) I found this fact to be humorous
6) I was curious about this fact

Rotgans, J. I. (2015). Validation study of a general subject-matter interest measure: The Individual Interest Questionnaire (IIQ). *Health Professions Education*, *1*(1), 67-75.

Appendix D2

Measure of situational interest

Please indicate in the box below how true each statement fits your experience of this experiment: 1 (not true at all), 2 (not true for me), 3 (neutral), 4 (true for me), and 5 (very true for me).

1: “I enjoyed working on this memory experiment” ☐

2: “I want to know more about Memory/the results of the experiment” ☐

3: “I think this experiment was interesting” ☐

4: “I expected to perform reasonably well on this experiment” ☐

5: “I was fully focused on this experiment” ☐

6: “I felt bored (reversed)”. ☐

Rotgans, J. I., & Schmidt, H. G. (2014). Situational interest and learning: Thirst for knowledge. *Learning and Instruction*, *32*, 37-50.

Appendix D_4

Experiment: Measurement of TUT

Thought probes:

1) I am totally focused on the current task
2) I am thinking about my performance on the task or how long it is taking
3) I am distracted by information present in the room (e.g. sounds or lights)
4) I am zoning out/My mind is wandering
5) Other

Probe 1 shows task performance focus

Probe 2 shows task specific interference

Probe 3 represents external distraction

Probe 4 shows internal distraction/ Mind Wandering

Probes 3 and 4 Represent TUT

Probes were based on Stawarczyk et al. (2011).

Appendix E_1

Experiment 1 Equivalence ANOVA

List Order (A-B vs. B-A).

To further test the equivalence of the facts list, a two-way mixed ANOVA was conducted for the conditions; control and interference vs. List order to determine whether the order the lists were displayed (A-B or B-A) significantly impacted the recall scores for the interference or control condition. Recall scores for List A and List B did not differ $F(1,119) = 0.72$; $p = 0.4$.

The interaction which tested the order in which the condition was presented compared with the List type was found to have a non-significant difference on recall scores ($F = (1, 119) = 0.43$; $p = 0.7$).

The condition in which the lists were presented (control vs. interference) was found to have a non-significant difference on recall scores, ($F(1,119) = 0.16$; $p = 0.7$) showing that the facts presented were equivalent and therefore useful stimuli for measuring the condition effect providing no significant confounding variables when compared and contrasted.

Appendix E_2

Experiment 4 list equivalency

Table 5.1

Means and Standard Deviations of recall for condition and condition-order

	C-I		I-C	
	control	interference	control	interference
M	7.43	5.68	7.61	7.23
SD	2.55	2.72	2.13	2.65

Order effects equivalency (List order vs Condition)

A Two-Way Mixed ANOVA was conducted to test the equivalence of the stimuli lists' order (A-B vs. B-A) as a factor of recall within the interference vs. non-interference (control) condition.

There was a non-significant difference between list orders (A-B) and (B-A) ($F(1, 39) = .21$, $MSE = 2.12$ $p = .65$, $\eta_p^2 < .01$, There was a robust significant effect of condition type ($F(1,39) = 6.27$, $p = .02$ $\eta p^2 = .14$). With higher recall in the control condition. However, there was no significant interaction between list order and condition type ($F(1,39) = 1.96$, $MSE = 5.45$, $p = .17$ $\eta_p^2 < .01$). with a lack of interaction indicates that differences between the lists result from an interference effect (condition type). Thus, List A and List B are equivalent.

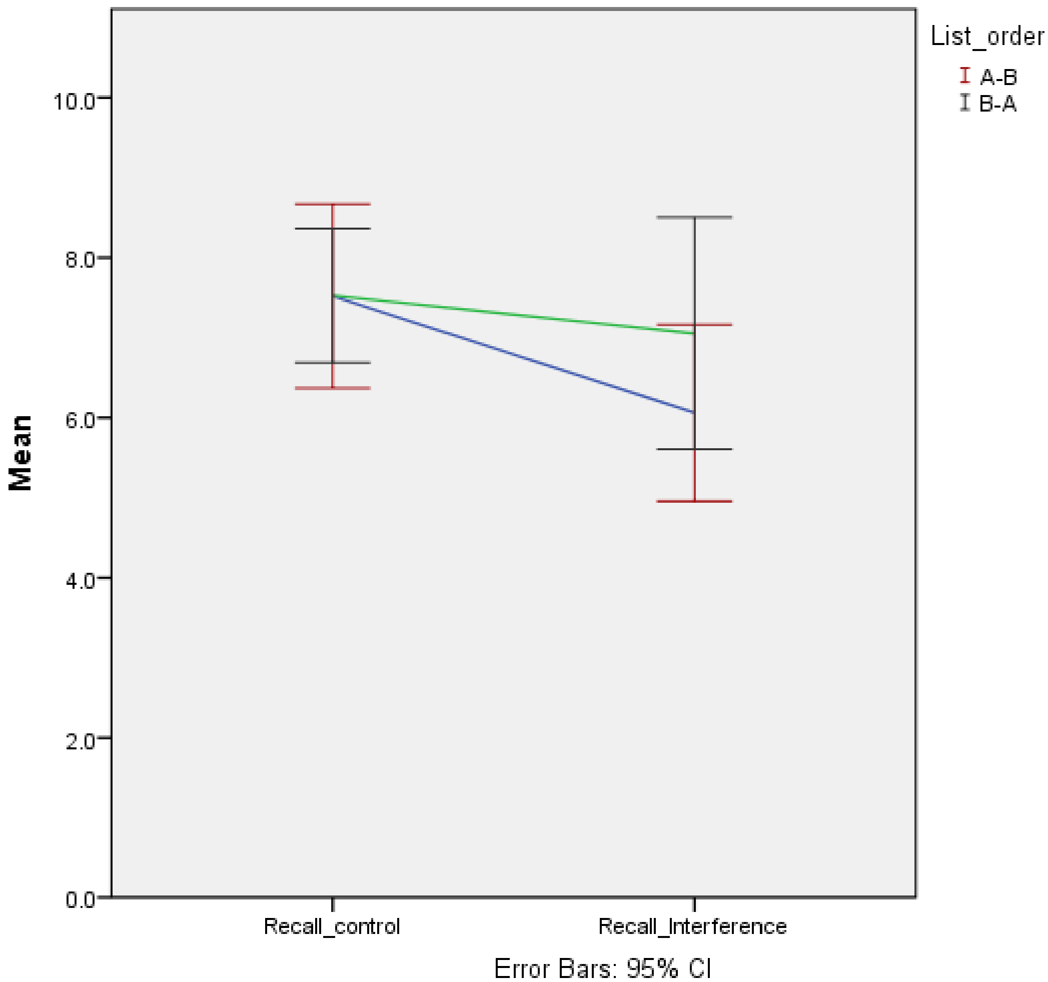

Figure 5.1 Mean recall scores and confidence intervals for condition split by list order

Confidence intervals show large overlap between means for list order a-b and b-a. Differences between the lists for the interference condition is likely to be due to the Late-occurring interference condition, with the graph following the same pattern of the fatigue effect (consistently most hindered recall group between experiments) containing N = 6 participants for A-B vs N = 14 participants in B-A

APPENDIX F1

UNIVERSITY OF WOLVERHAMPTON

Dr Alexandra Hopkins RN PhD MSc MBA RNT RCNT DANS
Dean of the Faculty of Education Health and Wellbeing

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Internet: www.wlv.ac.uk

Date 22.09.17

Luke Fisher (Dr Tom Mercer)
University of Wolverhampton
FEHW

Dear Luke Fisher (Dr Tom Mercer)

Re: Examining the role of Retroactive Interference and Interest on Memory Fatigue submitted to The Faculty of Education, Health and Wellbeing Ethics Panel (Health Professions, Psychology, Social Work & Social Care)

The Faculty Ethics Panel (Health Professions, Psychology, Social Work & Social Care) has considered and reviewed your submission.

On review your Research Proposal was passed and given approval **Code 2 – Approved Subject to Conditions.** The conditions for Approval are below.

A. **Researcher/Supervisor to Monitor.** Please address the minor amendments detailed below. If this is student research, supervisors must ensure the minor amendments have been completed prior to commencement of data collection. A condition of this approval is that Supervisors must read through and check the revised applications and email a confirmation to fehwethics@wlv.ac.uk to confirm they have occurred.

Required Changes

- Efforts should be made that will allow for Anonymity to be assured while still providing the option that post-test any data can be removed. This can easily be done by generating alias or study codes known only to the participant which would allow data to be removed at any time, while maintaining anonymity.
- All held data must be destroyed after a specified time scale and this should be made clear to all participants, as well as how this data will be destroyed.
- In order that the participants do not feel disturbed in the belief they have completed the study incorrectly- the directive in the information sheet should specify there are no right or wrong responses.
- Also who will have access to "the locked cabinet"? Who are the responsible key holders- this should be made clear.

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Page 2 of 2

- Please explain to participants what they need to do should they wish to withdraw, from the research, online.
- There are typographical and factual errors, the documentation will need close proof reading.

Best wishes in the future.

Yours sincerely

H Paniagua
Dr. H. Paniagua PhD, MSc, BSc (Hons) Cert. Ed. RN RM
Chair – Ethics Panel

Richard Darby
Dr Richard Darby PhD, BSc
Chair – Ethics Panel

THE UNIVERSITY OF OPPORTUNITY

APPENDIX F$_2$

UNIVERSITY OF WOLVERHAMPTON

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26th March 2018

Luke Fisher (Tom Mercer and Richard Darby)
University of Wolverhampton
FEHW

Dear Luke Fisher (Tom Mercer and Richard Darby),

Re: Concurrent vs. Retrospective Interest Ratings on Mind Wandering and Recall Within a Non-Specific Interference Setting . (Health Professions, Psychology, Social Work & Social Care)

The Faculty Ethics Panel (Health Professions, Psychology, Social Work & Social Care) has considered and reviewed your submission.

On review your Research Proposal was passed and the Panel believes that the ethical issues inherent in your study have been adequately considered and addressed. The only minor changes are as follows: Include independent persons contact details for complaints on the information sheet and also a section on why participants have been chosen. This was unclear in your application. Therefore the Panel is giving you full ethical approval for your study (Code 1 - Approved).

We would like to wish you every success with the project.

Yours sincerely

Hilary Paniagua
Dr. H. Paniagua PhD, MSc, BSc (Hons) Cert. Ed. RN RM
Chair – Faculty Ethics Sub-Panel

APPENDIX F3

UNIVERSITY OF
WOLVERHAMPTON

Dr Alexandra Hopkins RN PhD MSc MBA RNT RCNT DANS
Dean of the Faculty of Education Health and Wellbeing

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UK: 01902   Abroad: +44 1902

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Re: Minor Amendments to Study

14th November 2018

Luke Fisher (Tom Mercer)
University of Wolverhampton
Faculty of Education, Health & Wellbeing

Dear Luke Fisher (Tom Mercer),

Re: Examining the influence of Interest and Mind Wandering on a memory's resistance to Retroactive Interference, submitted to The Faculty of Education, Health and Wellbeing Ethics Panel (Health Professions, Psychology, Social Work & Social Care)

The Faculty Ethics Panel (Health Professions, Psychology, Social Work & Social Care) has considered and reviewed your proposed minor amendments.

On review your Revised Research Proposal was passed and the Panel believes that the ethical issues inherent in your study remain adequately considered and addressed. Therefore the Panel is giving you full ethical approval for your revised study (**Code 1 - Approved**). We would like to wish you every success with the project.

Yours sincerely

Angela Clifford
Dr Angela Clifford (BSc, MSc, PhD, CPsychol)
Chair – Ethics Panel

APPENDIX F_4

UNIVERSITY OF
WOLVERHAMPTON

Dr Alexandra Hopkins RN PhD MSc MBA RNT RCNT DANS
Dean of the Faculty of Education Health and Wellbeing

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Internet: www.wlv.ac.uk

Re: Minor Amendments to Study

11th March 2019

Luke Fisher (Tom Mercer)
University of Wolverhampton
Faculty of Education, Health & Wellbeing

Dear Luke Fisher (Tom Mercer),

Re: Examining the influence of Interest and Mind Wandering on a memory's resistance to Retroactive Interference, submitted to The Faculty of Education, Health and Wellbeing Ethics Panel (Health Professions, Psychology, Social Work & Social Care)

The Faculty Ethics Panel (Health Professions, Psychology, Social Work & Social Care) has considered and reviewed your proposed minor amendments.

On review your Revised Research Proposal was passed and the Panel believes that the ethical issues inherent in your study remain adequately considered and addressed. Therefore the Panel is giving you full ethical approval for your revised study (**Code 1 - Approved**). We would like to wish you every success with the project.

Yours sincerely

Angela Clifford
Dr Angela Clifford (BSc, MSc, PhD, CPsychol)
Chair – Ethics Panel