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THE EFFECT OF VISUAL DISTRACTION ON MEMORY FOR WORDS, PICTURES AND COMPLEX EVENTS.

by

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Abstract

This thesis aims to provide further understanding of how visual distraction disrupts retrieval from long-term memory. Eyewitness testimony research shows a fairly consistent picture: visual distraction (or its removal though eye-closure) decreases retrieval-accuracy of details embedded in an event. However, research on verbal memory suggest that distraction effects may be selective: Glenberg, Schroeder and Robertson's (1998) widely cited study found distraction to impair recall of mid-list words from multiple word-lists but Rae's (2011) single word-list studies found no such effect. The investigation thus began with a part-replication of Glenberg et al. with tighter control of materials including using Dynamic Visual Noise (DVN) as a distraction. Experiment 1 replicated the findings on mid-list recall. Experiments 2 and 3 investigated whether the effect on mid-list words was due to poor encoding or interference however, found no detrimental effect of distraction on word-recall whatsoever.

Experiment 4 confirmed that DVN does impair retrieval accuracy for an event. Therefore, the focus of the thesis moved to exploring whether distraction selectively impairs cognitive processes involved in event but not word-list retrieval. Experiments 5 and 6 manipulated Experiment 4's event so that the original video-clip became more like a list. Together with the serial presentation of details in Experiments 7 and 8, these studies explored four possible moderators of distraction: modality of detail; bimodal presentation; source monitoring; flowing movement. A meta-analysis of effect sizes showed visual distraction to have stronger detrimental effects on recall of flowing visual details. This is explained by both the Cognitive Resources Framework (Vredeveldt, 2011) and Event Segmentation Theory (Zacks & Swallow, 2007) which

together imply that visual distraction may disrupt memory by selectively impairing visual-spatial imagery.

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Chapter 1: Literature review and theoretical background to the thesis

1.1 General introduction to the thesis

Inspiration for this thesis comes from eyewitness testimony research. Eyewitness testimony is often thought of as a persuasive type of evidence in judicial proceedings, yet, eyewitness memory is vulnerable to interference. In other words, eyewitness testimony is fallible. Numerous factors have been shown to detrimentally interfere with eyewitness testimony accuracy. One of these factors is external environmental distraction. Thus, for example, an eyewitness interviewed at a busy road side may be less accurate or remember fewer details, than an eyewitness interviewed in a quiet police interview room. In sum, the environment within which a person recalls a detail may determine how well that detail is recalled.

However, although there is a well-established connection between distraction and memory, the exact mechanism with which distraction disrupts memory is not known. It is not clear whether distraction distorts memory per se, or, distorts specific elements of memory. For example, eyewitness researchers have tested the effect of visual distraction on memory for visual and verbal details of a witnessed event. Some researchers found evidence to support a modality specific mechanism of visual distraction. This is because they found visual distraction had a greater detrimental impact on recall of visual details than on recall of verbal details. In contrast, other researchers found evidence of a general load effect whereby visual distraction detrimentally disrupted memory for visual *and* verbal details to a similar extent.

Understanding how the physical environment affects memory is important to the field of eyewitness testimony and beyond. While there is no doubt that understanding distraction and memory is of importance to all affected by judicial proceedings, it is also of importance to all who rely on or use personal memory accounts as a matter of course. There are, for example, educationalists across all subjects and levels of teaching, committed to creating environments beneficial to their students' learning and examination performance. There are physical and mental health clinicians committed to professionally caring for their patients through gathering the most accurate and thorough health histories they can. In all these examples, it is important or at least useful to know what elements of memory the environment may affect during the retrieval of the memory.

Thus, inspired by eyewitness research exploring the effect of environment on accuracy of testimony, the aim of work presented in this thesis is to investigate what types of memory are most likely to be detrimentally affected by visual distraction.

1.2 Overview of Chapter 1

Visual and auditory sensory perception is inherent in safe navigation through day-to-day life. Being alert to sight and sound can serve to protect from danger or orientate towards fulfilling a need. However, everyday environments, from bustling shopping precincts to noisy open-plan offices, are also replete with irrelevant visual and auditory distractions. Some environments are so laden with distraction that it is even challenging to think. The research literature reveals a broad field of inquiry investigating how distracting environments influence and impact on our internal cognitive processes. This diverse field sweeps in sea divers and eyewitnesses, journeys though busy New York streets and quiet research laboratories exploring the effect of sights and sounds on memory and imagination. Within this rich body of work sits the research strand of visual distraction and memory: the strand which lies at the heart of this thesis. To set the scene for the experimental work reported herein the opening chapter of this thesis begins with a broad review of literature concerned with understanding the relationship between the external and internal world. Following this, consideration is given to the theoretical accounts put forward to explain the detrimental effect of external distraction on internal cognition. The close of this chapter briefly introduces the first experiment of the investigation. Research questions and rationales will naturally unfold throughout the experimental chapters of the thesis and so they are not all listed here in the introduction. However, for clarity and coherence, the final discussion chapter will begin by bringing these strands together in an overall summary.

1.3 Literature review

The literature review is presented in two main sections. The first section (1.3.1) will review studies whose findings imply the external physical environment is distracting and detrimental to cognitive processes. This includes studies demonstrating a relationship between disengaging from the environment (gaze aversion, eye-closure) and improved cognitive performance. In addition, research exploring the association between blinking and internal thought processes is also reviewed here. The second section (1.3.2) will focus on studies which purposefully manipulate levels of distraction in the external environment and test the effect on cognitive processes. Research areas here include manipulations of visual and auditory distraction, the effect of social presence and the effect of changing or reinstating entire environments.

1.3.1 The physical environment is distracting

When trying to recall a detail from memory people often avert their gaze away from or close their eyes to, the immediate environment. One explanation for this behaviour is that it serves to suppress external stimuli and focus attention inwardly to the task in hand (Baddeley, Lewis, Eldridge, & Thomson, 1984; Glenberg et al., 1998). The implication of this is that external stimuli in the environment are distracting to internal processes.

1.3.1.1 Gaze aversion

While research has demonstrated that gaze aversion has a distraction-suppression function, there is evidence that it also plays a role in human interaction and communication. Therefore, this section will consider both social and distraction-suppression functions of gaze aversion in order to attempt to tease out the latter.

Early studies exploring the social role of gaze aversion have focussed on its function as a turn-taking signal between speaker and listener during conversation (for example, Kendon, 1967). More recently Terburg, Aarts, and Van Honk (2012) argued that averting gaze from a face is driven by social submission or social anxiety. Weeks, Howell, and Goldin (2013) found that people with social anxiety disorders avert their gaze more in social interactions than those who are not socially anxious. However, other authors in this field have emphasised that observations which simply record whether or not gaze is averted from the face of an interlocutor are too narrow. For example, Kret, Stekelenburg, de Gelder, and Roelofs (2017) used an eye-tracking method with socially submissive participants and found that the direction in which gaze was averted was not arbitrary. Rather than looking away to a random location, participants were averting their gaze to attend to emotional signals from the interlocutor’s hands rather than from their eyes.

In contrast, Glenberg et al. (Experiment 1, 1988) observed and recorded gazes which they clearly define as being averted away from an experimenter’s eyes and body and towards the floor, wall or ceiling. That is, they observed gaze aversions that held no obvious alternative social communication. Their participants took part in a retrieval task and were unaware that gaze aversion was being observed. Glenberg and his colleagues found that participants were increasingly likely to avert their gaze during retrieval the further the target memories were back in time. This suggests that as the memory task becomes more difficult, people spontaneously avert their gaze away from the immediate environment because the environment is distracting to retrieval processes. In a separate experiment with different participants (Glenberg et al., 1998; Experiment 3) the authors found additional compelling evidence that gaze aversion suppresses environmental distraction because this time, participants were asked to perform a retrieval task in the absence of an experimenter. Participants were aware that they might be videotaped but were unaware that gaze aversion was being monitored. In the absence of any social interaction, the authors once again observed that the frequency of gaze aversion increased as the retrieval task-difficulty increased.

Work by De Schuymer, De Groote, Desoete, and Roeyers (2012) suggests that humans use gaze aversion to facilitate internal processes from an early age. Their study in the field of infant development found that while prematurely born 6-month old infants display higher frequencies of gaze aversion than those not born premature, there is evidence to suggest that this is not simply due to increased parental (social) stimulation as is often claimed. The authors used an eye-tracking device to monitor gaze aversion during an attentional task. They found the higher rate of gaze aversion in premature infants compared to non-premature was strongly associated with slower shifts in attention in the attention-task. That is, when premature infants took longer to make an attentional shift they also spent more time averting their gaze thus implying that infants use gaze aversion to suppress external stimuli and facilitate internal processes.

Doherty-Sneddon, Bruce, Bonner, Longbotham, & Doyle’s (2002) study observing gaze aversion among young participants suggests that the spontaneous use of gaze aversion to facilitate internal processes further develops through childhood. Participants aged 5 and 8 years old were asked a series of verbal questions (for example, word definitions and spellings) of varying difficulty. The authors found an association of gaze aversion with question difficulty but the association was strongest for 8 year olds. Phelps, Doherty-Sneddon, and Warnock (2006) Experiment 2, compared associations between spontaneous gaze aversion and question difficulty among 5-year olds at the start, middle and end of their first year in primary school. In line with Doherty-Sneddon et al. (2002), they found gaze aversion increased with question difficulty and in addition, found a significant steady increase in the use of spontaneous gaze aversion across the school-year time points. However, even at the end of the school year the 5-year old children in this group still did not use gaze aversion to the same extent as the 8-year olds in the previous study. Thus, while De Schuymer et al.’s work implies that the use of gaze aversion to facilitate cognition is innate, both Doherty-Sneddon et al. (2002) and Phelps et al.’s (2006) findings suggest that the benefit and therefore use of this innate behaviour may be unconsciously reinforced over time.

Doherty-Sneddon and Phelps (2005) explored the social and distraction-suppression function of spontaneous gaze aversion by varying the social proximity of an experimenter while participants performed retrieval tasks of increasing difficulty. Their young participants were interviewed by an experimenter either face to face (FTF) or via a live video-link (LVL). The purpose of the study was to investigate whether gaze aversions were driven more by retrieval difficulty than social factors. Doherty-Sneddon and Phelps selected the two interview conditions for two reasons. The first was based on an earlier finding that participants gaze at each other more when communicating via LVL than FTF (Doherty-Sneddon et al., 1997) which suggests that mediated communication involves different social norms to FTF in terms of gaze. The second was that young participants were less self-conscious and performed better when being interviewed via LVL (Doherty-Sneddon & McAuley, 2000). These two findings imply that LVL interviews increase the social distance between experimenter and participant because they lessen the social impact of the experimenter’s face. Thus, Doherty-Sneddon and Phelps (2005) expected to find fewer gaze aversions in the LVL than FTF interviews. Based on this, the authors hypothesised that if the predominant function of gaze aversion during retrieval was to suppress social self-consciousness when asked a difficult question, then participants in the LVL interviews (who feel less self-conscious anyway) would show no association between gaze aversion frequency and question difficulty. However, if the predominant function of gaze aversion was to reduce environmental visual stimulus during difficult retrieval tasks then both interview conditions would show an association between gaze aversion frequency and task difficulty. The authors found gaze aversion was less frequent in LVL interviews, which implied that the LVL interviews were more socially removed. Furthermore, they also found that regardless of whether the interview was conducted in person or by video-link, the frequency of gaze aversion was driven by the difficulty of the task. This finding confirmed their second hypothesis, suggesting that the predominant function of gaze aversion is to reduce environmental visual stimulus rather than suppress social self-consciousness.

While the above studies observed spontaneous gaze aversion, other researchers have explored the effect on cognition of instructed gaze aversion. For example, Phelps, Doherty-Sneddon and Warnock (2006; Experiment 1) found that young participants instructed to avert their gaze while thinking about answers to difficult questions showed superior performance compared to when they were asked easier questions or compared to a no-instruction condition. Markson and Paterson (2009) also manipulated gaze aversion but with adult participants during performance on a visual-spatial imagination task. Participants across two experiments were shown 2D and 3D matrices, the former were drawn on card and the latter were formed with wooden blocks. Participants were shown a matrix and the experimenter indicated which square was designated as a starting square. The matrix was then removed from view while participants used their visual-spatial imagination to follow verbal directions to journey from the start square through the matrix. During this imagination phase, participants in both experiments were instructed to maintain eye contact with the experimenter, avert their gaze or, close their eyes. In Experiment 1 gaze was averted away from the experimenter towards a blank screen, a picture of a sunset or, a film clip from Lord of the Rings. In Experiment 2, gaze was averted by looking at an upright or inverted photograph of the experimenter. At the end of the imagination phase participants were again shown the matrix and asked to indicate which square the verbal directions had led them to. In both experiments participants performed more poorly on the 3D than 2D imagination task but overall, performance was less accurate when participants had maintained eye-contact with the experimenter than when averting gaze or closing eyes. Thus instructed gaze aversion appears to benefit visual-spatial imagination.

Markson and Paterson (2009) argue that the benefits of gaze aversion are a result of removing the social aspect of eye contact rather than a result of reducing or suppressing environmental visual distraction. This is because in the above study they view the eye-contact condition as a social distraction, the eyes-closed condition as no distraction and the gaze aversion conditions as visual distraction. Thus, from this stand point their data appear to indicate performance benefits when social but not visual distraction is removed. However, there is an alternative interpretation of their results. This interpretation is based on both the role of eye-movement in imagination tasks and the way in which eye-movement was restricted or free to vary in each of Markson and Paterson's conditions. Eye-movement must be kept minimal when maintaining eye contact with an experimenter however, it is freer to vary within the boundaries of looking at a photograph or film clip and completely free to vary with eyes-closed. This observation is important because participants were asked to perform a visual-spatial imagination task and successful performance may have relied on eye-movement. This conjecture is supported by Heremans, Helsen, and Feys (2008) who investigated eye-movement during actual and imagined motor activity with eyes closed or open. Participants were asked to both move and imagine their wrist in a cyclical movement between two spatial points. The authors found that eye-movement during the imagination task closely resembled eye-movement during the motor task. Furthermore, as eye-movement was measured using an electro-oculographic signal of the eye, eye-movement could be measured when eyes were closed as well as open. Heremans et al. found the same pattern of eye-movement in imagination conditions with both eyes-closed and eyes-open. More recently, an eye-tracking and fMRI study by Bone et al. (2018) revealed a positive correlation of both eye-movement and associated neural activity between study phases and visual imagery phases of complex visual pictures. Furthermore, Laeng, Bloem, D'Ascenzo, and Tommasi (2014) found that disrupting eye-movement during visual imagery of previously studied pictures reduced recall accuracy of picture details. These findings suggest that Markson and Paterson's participants may have relied on eye-movement to successfully perform the imagination tasks and because eye-movement was restricted in the eye-contact condition, performance was poorer than under the photograph or eyes-closed condition because of eye-movement restriction and not necessarily because of social distraction.

Buchanan et al. (2014) extended Markson and Paterson's (2009) work by including gaze aversion conditions with varying levels of social distraction. Participants performed the same 2D and 3D visual-spatial imagination tasks as described above while either maintaining eye-contact with an experimenter, gazing at an experimenter whose eyes were obscured by dark glasses, gazing at an experimenter who consistently looked away, gazing at an experimenter who wore a paper bag over their head or, closing their eyes. In line with Markson and Paterson's (2009) findings, Buchanan et al. (2014) also found 3D imagination performance to be poorer than 2D as well as an overall poorer performance in the eye-contact condition. The authors also interpreted this as showing that the social aspect of eye contact is detrimental to visual-spatial imagery. However, as with Markson and Paterson's study there is an alternative interpretation based on the convergence of several arguments with respect to restricted eye-movement, which are explained below.

Buchanan et al. (2014) demonstrated that the detrimental effect of eye-contact versus other gaze conditions on correct responses is weaker for 2D matrix imagery (mean effect d = - 0.55) than for 3D imagery (mean effect d = -1.67). This may be because the eye-contact condition restricted eye-movement relative to other gaze conditions and imagining 3D matrices, which involves imagining on 3 planes as was the case in Hereman et al.'s eye-moving study, may rely more on eye-movement than imagining 2D matrices which involve imagining on only 2 planes. If 3D matrix imagination involves more eye-movement than 2D imagination and eye-movement is restricted there should be a greater detrimental effect on correctly imagining 3D than 2D matrices. In other words, 3D imagination may be more sensitive to restrictions of eye movement than 2D imagination. While the present author is not aware of any work which directly explores this, a neural study by Kawamichi, Kikuchi, Noriuchi, Senoo, and Ueno (2007) suggests there is a difference between 2D and 3D mental imagery because the authors found that distinctly different neural correlates were associated with mental imagery of 3D compared to 2D objects.

Another factor to consider therefore is the extent to which each gaze-condition may have restricted eye-movement during the visual-spatial task. The eye-contact condition is the most restrictive in terms of eye-movement because it necessitates participants holding their eye-movement relatively still to focus on a small fixed location: the experimenter's eyes. Eye-movement is still restricted when gazing at an experimenter whose eyes are obscured with dark glasses but less so because the participant cannot see the experimenter's eyes and therefore is free to move their eyes across the surface area of the dark glasses rather than confined to one fixed location. The remaining three conditions however, place very little, if any, restriction on eye-movement. Buchanan et al.'s (2014) reported effects on recall of eye-contact versus other gaze conditions for 2D matrices were of similar size (effects ranged from d = -0.50 to d = -0.57). The similarity in effect sizes may be due to a ceiling effect on improving performance of 2D visual-spatial imagery with freer eye-movement such that a condition allowing slightly more eye-movement (dark glasses) improves imagery to no greater extent than a condition allowing much greater eye-movement (such as closed eyes). Thus, the ceiling effect occurs because the maximum possible benefit to 2D imagery, in terms of eye-movement, is seen between closed-eyes and dark glasses recall conditions. Other recall conditions which allow even more eye-movement than dark glasses provide no additional benefit because the amount of eye-movement allowed in the dark glasses condition (compared to eye-contact) already allows the maximum amount of eye-movement required for 2D visual imagery. Any more eye-movement than that afforded by the dark glasses condition therefore offers no additional benefit to visual imagery performance. This may be because 2D visual-imagery relies on more narrow eye-movements than 3D. However, if accurate 3D visual-imagery relies on spatially wider eye-movement there will be more sensitivity to the same graded restrictions in eye-movement. Interestingly, this is the pattern of effect reported by Buchanan and colleagues. The authors found that relatively, the weakest detrimental effect on correct response for 3D matrices was for eye-contact compared to dark glasses (d = -1.08). The effect size almost doubled in strength for eye-contact versus experimenter looking away (d = -2.04) and eye-contact versus eye-closure (d = -1.98) and although not as marked, was still greater for eye-contact versus bag over head (d = -1.57). Therefore an alternative explanation for Buchanan et al.'s results may also be that restricted eye-movement and not social factors, drove the pattern of gaze-condition effect on correct recall.

1.3.1.2 Blinking

Other researchers have explored the effects of pausing the processing of external stimuli through blinking. For example, Smilek, Carriere, and Cheyne (2010) asked participants to read a passage of text for fifteen minutes. Participants were probed ten times during reading and asked to report whether they were on task or experiencing mind wandering. Blink rate was recorded five seconds before each probe. They found increased blinking was associated with self-reported mind wandering. More recently, Walcher, Körner, and Benedek (2017) compared blink rate and duration between internal (idea generation) and external (reading) focussed tasks. They found that participants blinked more often and for longer durations during the internal idea generation task. Work investigating the neural correlates of blinking (for example, Bristow, Frith & Rees, 2005; Benedek, Schikel, Jauk, Fink & Neubauer, 2014) has found that blinking deactivates cortical areas involved in processing external visual stimuli which lends support to Smilek et al.'s (2010) argument that blinking suppresses the external environment and facilitates focus on the internal environment.

1.3.1.3 Eye-closure

Additional evidence of the distracting nature of the environment comes from the field of eyewitness interviews which has looked at the beneficial effects of reducing environmental distraction via instructed eye-closure. This body of work shows a consistent and robust beneficial effect of eye-closure on recall and is of particular relevance to the rationale for experiments presented in Chapter 3 thus a more detailed review which more closely inspects the effect size of eye-closure is presented later in section 3.1. However, the following provides a summary overview.

Wagstaff et al. (2004; Experiment 2) asked participants to recall details of a prominent past televised event with their eyes open or their eyes-closed. Instructed eye-closure led to more correct answers with no difference in the rate of wrong answers. Perfect et al. (2008) investigated the effect of instructed eye-closure compared to a no-instruction control group in a series of five experiments which varied the nature of the event witnessed (a video-clip or live event) and the recall task (cued recall or free-narrative account). In all studies there was a benefit of instructed eye-closure on recall of correct details and a decrease in the number of incorrect details recalled. Participants were free to withhold responses (respond, “don’t know” to a question, or withhold a detail in free report), but eye-closure had no impact upon willingness to provide an answer. Instead, it increased the accuracy of what was reported. Beneficial effects of eye-closure have also been reported for mental arithmetic and general knowledge tasks (Glenberg et al., 1998; Experiment 4), for recalling videos of violent events (Vredeveldt, Hitch, & Baddeley, 2011; Vredeveldt & Sauer, 2015), for recalling details of a theft (Vredeveldt, Tredoux, Kempen, & Nortje, 2015), for increasing correct recall of coarse-grain visual and auditory details of a violent video-clip and for decreasing incorrect recall of visual details (Vredeveldt, Baddeley, & Hitch, 2012), with a delay of 1 week prior to test (Vredeveldt, Baddeley, & Hitch, 2014), when there is a shift in context between event and test environment (Vredeveldt & Penrod, 2013), when levels of visual and auditory environmental distraction are increased (Perfect, Andrade, & Eagan, 2011), for cued recall with child witnesses (Mastroberardino, Natali & Candel, 2012; Natali, Marucci & Mastroberardino, 2012 but cf Kyriakidou, Blades & Carroll, 2014 Experiment 2) and when compared to recall under environmental visual and auditory distraction conditions (Vredeveldt et al., 2011).

In summary, section 1.3.1 demonstrates that momentarily disengaging from the environment, whether spontaneous or instructed, is beneficial to cognitive processes and memory in particular. This implies that the environment around us can be distracting. Thus, if disengaging from the environment is beneficial to cognition because it suppresses distraction, it stands to reason that amplifications of distraction should be detrimental to cognition. The next section therefore presents a review of research exploring the effect on cognition of manipulations of environmental stimuli, or in other words, of manipulating the level of distraction in the environment.

1.3.2 Manipulating environmental distraction

There are numerous ways to manipulate levels of environmental distraction and research reviewed in this section is broadly categorised by the method used. This includes studies which vary specific aspects in the environment such as manipulating levels of visual and auditory distraction. It is important to note that instructions given to participants in distraction studies generally ask that they ignore the distractor. This is of note because the distraction conditions are thus not designed to be dual-task experiments where participants are expected to perform two concurrent tasks. Dual-task work is discussed briefly below to further explain the fundamental difference between this line of work and that of distraction.

Other studies reviewed in this section include work on social facilitation theory which tests the effect of social presence on cognitive task performance and work on context reinstatement where whole environments are altered. Following the brief review of dual-task studies, the distraction literature is reviewed under four subheadings: visual distraction; auditory distraction; social facilitation and inhibition; context reinstatement.

1.3.2.1 Dual-task studies

Dual task studies test the effect on cognition of dividing attention across two tasks. Participants purposefully perform the two tasks simultaneously. Both tasks require action. The action of either task may be to encode a series of words in short or long term memory (Fernandes & Moscovitch, 2000), to generate a series of digits (Hicks & Marsh, 2000), discriminate auditory sounds with a key press (Dudukovic, Dubrow, & Wagner, 2009), identify semantic categories (Tehan, Witteveen, Tolan, & Tehan, 2019) or walk on a treadmill (Nieborowska et al., 2019). Thus, each task requires an action and each action is measurable. For example, encoding a series of words is measured in terms of recognition or free recall accuracy, generating a series of digits is measured by recording the number of digits spoken aloud in time to a metronome, discriminating auditory sounds is measured by both accuracy and speed of key press, walking on a treadmill is measured using motion analysis. The important point is that participants in dual task studies can be thought of as purposefully and actively performing both tasks. Performance on each task is measured when both tasks are performed at once and when each task is performed alone.

In contrast, participants in distraction studies purposefully and actively perform one single task, not two. Participants perform the task while experiencing distraction however, the distraction itself is not a task that has a measurable action. This is reflected in the typical procedural instructions given to participants. For example Perfect, Andrade and Syrett (2012) told their participants that no response to the distractor was required and Andrade, Werniers, May and Szmalec (2002) explained to participants that the distractor was irrelevant to the task. Another approach in distraction studies is to warn participants about a possible distraction, but include no comment about whether or not to pay attention to it. However, dual-task studies do not include any such instruction. Participants in a typical dual-task paradigm are explicitly instructed to attend and respond to both tasks equally (for example, Fernandes & Moscovitch, 2000). In summary, dual task studies expect participants to purposefully engage with two simultaneous tasks but distraction studies expect participants to purposefully engage with one.

Dual task studies generally find that performance is poorer when tasks are performed simultaneously as dual tasks compared to when they are performed separately as singular tasks. One explanation of why participants perform more poorly under dual task conditions than singular, suggests the existence of a response-selection bottleneck (for example, Klapp, Maslovat & Jagacinski, 2019, Pashler, 1994, Alais et al., 2006, Ruthruff, Hazeltine, & Remington et al. 2006). That is, dual-task participants, who have been instructed to attend equally to both tasks, need to select a response to two tasks at the same time. The need to select a response to two tasks rather than just one, interferes with response time because it causes a bottleneck where one response is selected to one task and then another response is selected to another task. When the same tasks are performed singularly, there is no response-selection bottleneck because participants need only select responses for one task. Work supporting this stance have reported finding a dual-task interference with response speed but not with response accuracy (for example, Alais et al. 2006, Ruthruff et al. 2006, Schubert & Szameitat, 2003). That is, when dual-task performance is compared to single task performance, the accuracy of performance can be relatively unaffected compared to the speed with which the response is made.

Dual-task paradigms have been used to explore numerous cognitive processes, including for example, components of Baddeley and Hitch's (1974)'s model of working memory. This research also extends to long-term memory. The effect of dual task paradigms on memory have been tested during both encoding and retrieval processes. While encoding and retrieval processes involved in memory are thought to be similar (for example, Tulving, 1983; Moscovitch, 1992) dual tasks have been used to identify specific differences between the two process. For example, when participants are asked to perform a dual task during memory encoding, performance on later memory tests is substantially impaired compared to when no dual task is performed (Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). However, the same authors, Baddeley et al. (1984) and Craik et al. (1996) found little effect on memory when dual tasks were performed during retrieval. Interestingly, Craik and colleagues found that response speed on the task secondary to the memory task was significantly slowed. The reduction in speed was more pronounced for free recall than for cued recall. This pattern of effect on memory does not follow what is often seen in distraction studies, where participants are less accurate in their recall, whether free or cued, when distraction is presented during retrieval processes.

In summary, both the paradigm and findings of dual task studies make findings from this field challenging to interpret in a way that may shed light on the processes involved in the detrimental effect of distraction. Therefore, an in-depth review is not included here.

1.3.2.2 Visual Distraction

Manipulating levels of visual distraction in the environment can be thought of as the converse to suppressing distraction through gaze aversion or eye-closure.

Therefore, it is not surprising that research in this field reveals a general detrimental effect of visual distraction on cognitive task performance, because this is the converse to the eye-closure effect.

Several early studies by Logie (1986) testing the effect of visual distraction on cognition were designed to test a component of Baddeley and Hitch's (1974) multicomponent model of memory. Baddeley and Hitch's model is described in greater detail in section 1.4 however, in brief, the model posits that visual and spatial information is manipulated in a temporary store termed the visuospatial sketchpad. The authors initially believed the sketchpad to be predominantly concerned with spatial rather than visual information (Baddeley & Lieberman, 1980) however, Logie (1986) showed that visual distraction interferes with visual working memory thus implying that the sketchpad as a theoretical concept was at least as important to understanding visual processes as spatial ones. Participants in Logie's studies were asked to study a series of words using either a peg-word mnemonic ('one is bun' and so on) or, a verbal rote rehearsal method. The peg-word mnemonic method is thought to rely on visual imagery (Paivio, 1971). Visual distraction was presented as a series of visual patterns during recall. The distraction condition disrupted retrieval of words encoded using the visual mnemonic but not retrieval of words encoded using verbal rehearsal.

More recent work has also tested the effect of visual distraction on visual working memory. Santana, Godoy, Ferreira, Farias, and Galera (2013) showed participants sequences of letters printed in four different fonts and later asked them to indicate whether or not a test letter had been previously presented. Compared to a no distraction condition, visual distraction interfered with the ability to correctly recognise previously shown letters. The authors presented the visual distractor as

'Dynamic Visual Noise DVN': a screen of squares randomly changing from black to white. Visual distraction in the form of DVN has also been found to disrupt serial recall of digit-sequences (St Clair-Thompson & Allen, 2013; Experiments 4 to 5), recall of matrix patterns (Vasques, Garcia & Galera, 2016), performance on a visual association task (Andrade, Kemps, Werniers, May & Szmalec, 2002) and the ability to correctly identify visual pattern changes (Dean, Dewhurst, & Whittaker, 2008).

Numerous studies have also demonstrated the detrimental effect of visual distraction on autobiographical memory, visual memory, visual recognition and long term memory. Examples of this work is reviewed in turn, below.

Anderson, Dewhurst and Dean (2017) investigated the effect of visual distraction (DVN) on recall of autobiographical memories. Participants were presented with an on-screen cue word surrounded by a field of visual distraction, or not, and asked to describe an autobiographical memory associated with the word. The field of distraction remained throughout the retrieval and reporting period. Participants in the control condition were presented with the cue word on a blank white screen. Autobiographical memories were coded as 'specific' (a single specific event), 'erroneous' (for example, non-specific repeated events) or 'omitted' (no memory was recalled). Visual distraction compared to blank screen significantly decreased the number of specific memories, significantly increased the number of erroneous memories but, had no effect on omissions.

In a novel paradigm Smyth and Waller (1998) demonstrated a differential effect of visual distraction (DVN) on two visual memory tasks; one relying more on visual imagery than the other. The authors asked experienced climbers to study two in-door rock climbing routes: climbers stood in front of the climbing wall while instructed about the two routes and afterwards performed the climbs until each route had been completed to exact instructions 10 times. Participant climbers were later asked to imagine the same two routes, step by step. One route involved a vertical climb with clearly visible holds and route, the other involved a horizontal climb but holds and route could not be clearly seen from the start point of the climb. The authors thus assert that imagining the vertical route would engage visual imagery more so than imagining the horizontal route. Interestingly, the authors found that participants took longer to imagine the vertical than horizontal route under visual distraction conditions compared to a control.

Visual distraction has also been shown to disrupt visual recognition memory. Wais, Rubens, Boccanfuso and Gazzaley (2010) presented participants with a series of pictures of objects. Objects were presented as either a single object or up to 4 multiples of the same object on the same screen. During the recall phase participants were given a name of an object and asked if it had previously been presented and if so, how many objects had appeared on the screen. Fewer correct answers were given under visual distraction (where distraction was presented as pictures of scenes).

Glenberg et al. (1998; Experiment 5) also tested long-term memory under conditions of visual distraction (moving film clips). The authors found that distraction impaired recall of words which had been presented in the middle of word-lists. Glenberg et al.'s work is particularly relevant to the thesis' experimental work and is discussed in greater detail Chapter 2.

The following two examples presented here of detrimental distraction effects on memory come from the field of eyewitness testimony. As discussed earlier, eyewitness testimony research consistently report strong associations between eye-closure and improved memory accuracy for an event. Two eyewitness studies extended this work by testing the effect of visual distraction on memory for an event and found strong detrimental effects. These studies are of particular relevance to work in Chapter 3 and are discussed alongside the eyewitness eye-closure studies in greater detail later on in section 3.2.

Vredeveldt, Hitch and Baddeley (2011) tested the effect of visual (appearing and disappearing Hebrew words) and auditory (Hebrew words being spoken) distraction on cued recall of visual, verbal and auditory details of a video clip. The authors found distraction to impair overall recall and also found evidence of a modality-specific effect of distraction where visual distraction impaired recall of visual details to a greater extent than verbal and auditory details and vice versa for auditory distraction. Perfect, Andrade, and Syrett (2012) tested the effect of both a simple and complex visual distractor on cued-recall of visual and verbal details of a video-clip. The simple distractor consisted of one moving box and the complex distractor, of two moving different coloured boxes. The complex visual distraction condition led to fewer correct and more incorrect responses overall and although not significant, showed a numerically stronger effect on recall of visual details in line with Vredeveldt et al. (2011).

In summary, this subsection shows that environmental visual distraction has clear detrimental effects on internal cognitive processes including visual working and long term memory, verbal memory, visual imagery and autobiographical memory.

1.3.2.3 Auditory distraction

This section reviews work exploring the effect of environmental auditory distraction on cognition. As seen earlier in section1.3.1, observations of spontaneous gaze aversion and eye-closure imply that such behaviour is an effective way to deal with distracting environments however, there is no equivalent observable, physical spontaneous ear aversion or closure. People may hold their hands to their ears however, there is no physical mechanism in the ear which is equivalent to shutting the eyelids of the eyes. This may suggest that the processing of auditory environmental noise is obligatory, however, as discussed later, Cherry (1953) demonstrates that it is possible to *mentally* avert from processing sounds.

Processing auditory noise may serve to alert and protect from potential danger however, the constant stream of processing can demonstrably interfere with internal cognitive processes. A rather mundane and commonly experienced example of this is open-plan office working. Organisational psychologists in the early 1900's were initially concerned with the effects of environmental lightning, temperature and ventilation on workers' productivity (for a brief history see Davis, Leach & Clegg, 2010). However, it later began to emerge that background office noise was commonly reported to interfere with work-related tasks (for example, Boyce, 1974; Keighley & Parkin, 1981). It is not surprising therefore that an overwhelming 99% of open-plan office workers responding to Banbury and Berry's (2005) survey claimed that background noise was so distracting it adversely affected concentration. While organisational psychologists have continued to investigate the effects of open-plan working on stress levels, other researchers have further delved in to the when and how of auditory distraction interference with cognition.

There is a large body of experimental research demonstrating the detrimental effects of auditory distraction on cognitive processes. There are numerous strands of exploration within this field ranging from investigating the threshold of sound intensity at which cognitive performance is disrupted through to identifying the semantic and acoustic contents or patterns of sound which interfere with cognition. Work on threshold intensity has reported mixed results (for an early review see Jones & Broadbent, 1991) but is generally accepted to show that sound intensity needs to be very high in order to disrupt cognition (Hughes & Jones, 2001). This strand of work has useful applications in identifying for example, optimum parameters for auditory warning signals in the workplace (for example, Beaman, 2005). However, work exploring the effects on cognition of content and pattern of sound offer a richer base from which to later consider theoretical accounts of distraction and therefore, the review here is focussed on these studies.

Participants in auditory distraction laboratory studies are typically asked to perform tasks under quiet versus noisy conditions. The type of noise used to create auditory distraction in the laboratory ranges from ambient background chatter to unpredictable sudden tones. The type of cognitive task participants are asked to perform varies from those which are thought to engage working memory to those which predominantly rely on long-term memory. Overall however, this research can be thought of in terms of two streams of exploration. One stream consists of studies which have explored the effect of auditory distraction on cognitive task performance when both distraction and task are thought to engage the same internal cognitive processes. This stream of research is reviewed under the subheading ‘interference-by-process’. The other stream consists of studies which have investigated the effect of auditory distraction on cognitive task performance regardless of whether the distractor is thought to engage the same process as the task or not. These studies are referred to as ‘attentional capture’ studies. While categorising the studies in this way helps to make the review more coherent here, it is also useful to refer to the studies in this way in the later section on theoretical accounts of the distraction effect.

1.3.2.3.1 Interference-by-process

Research investigating distraction effects on cognition when both distractor and cognitive task are thought to engage the same cognitive process typically test the effect of distraction on serial short-term memory: participants are asked to recall a series of items in the same order in which they were previously presented. Auditory distraction may be presented during study or immediately afterwards but, usually prior to recall. The distraction conditions may be presented as a series of acoustic sounds which either change state (for example a spoken series of A,B,A,B or A,G,K,P) or remain in a steady state (for example, B,B,B,B). The changing-state distractor is thus more clearly segmented in to a series of differing sounds as compared to the steady-state distractor which has the acoustic appearance of one continuous stream. Studies using this design show that correct serial recall of presented items can be disrupted by the irrelevant sound of steady state distraction compared to silent conditions (for example, Colle & Welsh, 1976; Jones, 1993; Salame & Baddeley, 1982) however, serial recall is markedly more disrupted by changing-state than steady state distraction (Jones & Macken, 1993, 1995). The key feature of the stronger effect on serial recall of the changing-state distractor appears to be dependent on its changing state (Jones, Macken & Murray,1993). This is because other features, such as whether the distractor consists of speech or music, or has the intensity of a loud voice or a whisper, have little effect (for example, Jones

& Macken,1993; Buchner, 1996; Marsh, Hughes & Jones, 2008). The argument here is therefore that the changing state of the acoustic distractor presents the sound as a clearly defined series in a similar way as the to-be-remembered serial items. Thus, both distractor and recall task engage processes involved with encoding or analysing serial information. A classic example of the changing-state effect was demonstrated by Beaman and Jones (1997) who tested changing and steady-state distraction on both serial recall of items and recall of the items in any order. While they found a detrimental effect on correct serial recall under the changing state distractor, recall of the items per se was unaffected by the changing-state distractor compared to steady state. Thus, serial recall of items but not recall of items per se, share the same process engaged by the changing-state distractor and the processing of the ‘serial’ distractor interferes with the processing of the serial task.

An interference-by-process effect has also been demonstrated for semantic processes. For example, Marsh, Hughes and Jones (2008) asked participants to study and later freely recall a list of visually presented target words from the same semantic categories (such as names of fruit or types of vehicle). Recall was performed after a short retention period during which one of four distraction conditions was presented: a quiet control condition; a series of spoken irrelevant words; a series of spoken non-words; a series of sinewave sounds based on the irrelevant words. The irrelevant words were either from the same semantic categories as studied target words (but different to the target items), or not. The authors found that overall distraction presented as irrelevant words from the same categories as target words was most disruptive to both correct and incorrect recall of target words. Thus distraction presented as words per se or acoustic noise per se was not as distracting to cognition as when distraction was presented as words engaging the same semantic process as the cognitive task. Thus, the detrimental effect of distraction was driven more by the similarity of process than by noise. Jones, Marsh and Hughes (2012) found a similar pattern of disruption for a semantic distractor and cognitive task: performance on a word generation task was poorer under a distraction condition where the words used to create distraction were semantically related to the words being generated. To further expand, the authors asked participants to generate words from one semantic category and distraction consisted of irrelevant spoken words from either similar semantic categories (but not the same category) or unrelated semantic categories. Performance was most disrupted when distraction consisted of irrelevant words from a similar semantic category. Thus, as with the serial recall tasks, distraction was most disruptive when the task and distraction condition engaged the same processes, which in these latter two examples were both semantic processes.

In summary, these types of studies suggest that auditory distraction is most distracting to cognition when both distraction and task engage the same or similar internal processes (Macken, Phelps & Jones, 2009; Hughes, 2014).

1.3.2.3.2 Attentional capture

Studies exploring the attentional capture nature of auditory distraction investigate instances of attention being drawn away from a cognitive task regardless of whether or not similar cognitive processes may be engaged to process both distractor and task. Perhaps one of the most well-known and widely cited pieces of work on auditory distraction and attention was that reported by Cherry (1953). Given Cherry has been cited by over four thousand publications (that is, if Google scholar is accurate) his paper carries the somewhat humble sounding title, ‘Some Experiments on …’ On closer inspection of the paper however, it quickly becomes apparent that Cherry never gives an exact count of the number of trials he ran, except to imply that by ‘some’, he means many. The phenomenon his research reveals is referred to by the author as, ‘the cocktail party problem’ and has since inspired decades of research seeking answers as to how and why the problem occurs. Cherry’s cocktail party problem refers to his finding that participants were able to focus attention on one stream of auditory information while blocking out the verbal content of another concurrent auditory stream. Interestingly, Cherry’s participants were able to recognise whether the blocked concurrent auditory stream switched from a male to a female voice or whether the stream had been a series of clicks or tones rather than speech however, none were able to report any content of the concurrent stream to the point that they could not even report what language speech streams had been presented in. Moray (1959) built on Cherry’s findings and investigated potential conditions under which attention might be captured by the blocked concurrent audio stream. From his numerous studies he found the only effective way that the blocked concurrent stream could capture attention was to include a participant’s name at the beginning of a set of instructions. That is, participants attended the blocked stream when they heard their own name in the stream. However, even then only 33% of participants reported having heard their name.

According to Hughes’ (2014) categorisation of attentional capture studies, Cherry’s finding is an example of ‘specific’ attentional capture. Specific capture refers to auditory distraction which has particular relevance to the listener such as hearing their name being called or perhaps hearing a personalised ring tone. Hughes refers to other examples of attentional capture of auditory distraction as ‘aspecific’, these include unexpected sounds or a break in an otherwise monotonous steady stream of noise. Research investigating these two types of attentional capture is briefly reviewed below.

Specific

Moray's (1959) demonstration of specific auditory attentional capture using personal names was replicated by Wood and Cowan (1995) who tasked participants with repeating a series of spoken target words under an auditory distraction condition in which their name was embedded. Thus, participants heard spoken target words in one ear and to-be-ignored auditory distraction in the other. Wood and Cowan found that participants who reported having heard their name in the auditory distraction stream showed slower response time and higher error rates in repeating the spoken target words which had been presented immediately after their name had been presented within the distraction stream. This finding implies that attention was not only captured on hearing the name but also, was momentarily sustained before being diverted back to the task in hand.

More recently, Roer, Bell and Buchner (2013) compared the effect on serial recall of hearing own name versus another's name within the auditory distractor. Participants performed a serial recall task under silent or distraction conditions. The distraction condition played background office noise and embedded within this were a series of short sentences giving information about a fictitious person. The person was referred to by a name which was either the name of the participant or of a fellow participant who they had just been partnered with. In a post experiment survey Roer et al (2013) found, unlike the previous authors, that almost all of their participants (96%) reported having heard their name within the distractor and almost the same proportion (91%) had also noticed when the name of their partnered participant had been embedded in the distractor. This suggests that both distraction conditions captured attention to a similar degree. Overall, both auditory distraction conditions compared to the silent condition led to poorer correct serial recall. Interestingly however, despite both distractors capturing attention, recall was significantly poorer when the embedded name belonged to the participant.

Roer, Korner, Buchner and Bell (2017; Experiments 1 & 2) investigated whether other semantic content of a distractor would also show evidence of capturing attention away from performing a serial digit recall task. The specific attentional capture nature of the distractor was created with the use of words which were taboo to their participants in terms of language and accepted cultural norms. Distraction was presented as either steady state (a repeated spoken word which was either neutral or taboo) or changing-state (a series of different words where all were neutral or all taboo). Participants studied the serial digit lists under quiet or distraction conditions. There was no difference in serial recall between steady-state taboo and neutral word conditions however, correct recall was poorer for changing-state taboo words than neutral words. This implies that the auditory distractor was distracting because it repeatedly captured attention with each new taboo word due to the semantic content of the word being taboo and thus holding specific relevance to participants. Furthermore, in Experiments 3 and 4 the authors found no effect of taboo compared to neutral word when the steady-state format of the distractor contained a deviant word. For example, a steady-state neutral word distractor presented a series of ‘soda, soda, soda’ where as the steady state deviant format presented this as ‘‘soda, soda, soda, crayon, soda, soda, soda’. Thus Roer et al.’s work suggests that auditory distraction leads to poorer recall when it repeatedly changes but is relevant to the listener.

Aspecific

In comparison to specific attentional capture, studies categorised here as aspecfic are those which have not sought to test the effect on cognition of personally relevant semantic or acoustic distraction but rather, have explored the effect of auditory noise per se on cognitive processes. As with Roer et al.'s (2017) study above, there is some overlap here with studies reviewed under the interference-by-process subsection however, the review in this section is focussed on the overall effects of distraction on cognition.

A recent meta-analysis by Vasilev, Kirkby and Angele (2018) took into account reported findings from 65 studies on the effect of auditory distraction on reading performance and comprehension. The analysis shows that auditory distraction is detrimental to both of these cognitive tasks regardless of whether the distraction consists of background noise, speech or music. Although the size of effect is relatively small, it is consistent. Interestingly the authors also found that auditory distraction containing speech had a stronger detrimental effect than distraction with no intelligible speech. However, these results are based solely on the task of reading and comprehension and therefore it is not clear whether this extends to all cognitive processes.

Other research exploring general auditory distraction effects on cognition includes a study by Radel and Fournier (2017) who varied the level of auditory distraction during 'tip of the tongue' experiences during general knowledge questioning and tested the effect on eventual successful retrieval (resolution). A tip of the tongue (TOT) experience is commonly defined as a feeling that an item of information is known, despite being currently unable to bring it to mind. Auditory distraction in the form of background ambient sound (traffic noise, whistling, boiling water) led to fewer correct TOT resolutions than quiet conditions. Auditory distraction has also, for example, been found to slow writing speed on a word-processing task (Keus van de Poll & Sörqvist, 2016) and on a word identification task (Shelton, Elliott, Eaves, & Exner, 2009). It has also been found to lower later memory accuracy for a lecture (Shelton et al., 2009; Experiment 3a and 3b) and is as disruptive to children as to adults (Roer, Bell, Korner & Buchner, 2018). Research demonstrating the detrimental effect of auditory distraction in specific workplaces includes areas such as air traffic control (Hodgetts, Vachon, & Tremblay, 2014) and security surveillance and monitoring (Hodgetts, Vachon, Chamberland, & Tremblay, 2017). As well as in general open office spaces (for example, Banbury and Berry, 2005).

Despite the ubiquity of research on auditory distraction, there are relatively few studies investigating the effect during retrieval of long–term memory. These are reviewed below.

Wais and Gazzaley (2011) compared recognition accuracy of previously presented visual objects under distraction conditions of quiet, white noise and ambient restaurant sounds. Participants were shown a series of one to four exemplars of the same object and later asked to indicate whether they had previously been shown the object (regardless of the number presented) and if so, how many had been presented. Correct recall was defined as the proportion of responses which gave the correct number of objects shown for any one exemplar out of the number of both correct responses and responses which correctly identified the objects as having been shown but gave an incorrect count of how many had been shown. Auditory distraction presented as ambient sounds reduced the proportion of correct recall significantly more so than quiet or white noise conditions.

This pattern of distraction effect during retrieval bears similarity to earlier reviewed visual distraction studies reporting decreased accuracy under conditions of noise.

This pattern is also seen in the field of eyewitness testimony where both Perfect et al. (2011) and Verdeveldt et al. (2011) examined the effect of auditory distraction on recall of a witnessed event. Perfect and colleagues asked participants to recall details of a staged event under conditions of quiet or bursts of white noise and found participants reported more incorrect visual and auditory details when distracted with noise. In a similar study Vredeveldt et al. (2011) asked participants about visual and auditory details of a previously studied video-clip of a crime scene. Auditory distraction was created by presenting spoken Hebrew letters throughout the retrieval phase. Relative to quiet conditions, distraction led to fewer correct and more incorrect responses for both visual and auditory details.

In contrast however, Vredeveldt et al. (2012) found no detrimental effect of auditory distraction on long-term memory. Participants wrote down answers to questions about an earlier studied crime-scene video-clip under conditions of quiet or irrelevant speech (prose). While the effect on recall of auditory distraction was not significant there was a numerical trend whereby participants were more likely to pass on answering questions about auditory details under auditory distraction than under quiet conditions. The authors suggest the lack of significance may be due to a lack of power or due to the combination of the type of distractor and cognitive task. The latter explanation is certainly feasible given the sensitivity of effects seen in studies discussed earlier exploring potential interference-by-process mechanism of auditory distraction.

In summary, while the review of auditory distraction literature reveals mixed effects on long-term memory, there is clearly an overall detrimental effect on cognitive processes. There is evidence that the effect is driven by the content and pattern of auditory distraction as well as the type of cognitive task being performed.

So far the review has seen evidence that visual and auditory aspects of the environment can impair internal cognitive processes. The next section considers evidence that social presence in the environment influences cognitive performance by either facilitating or inhibiting cognitive processes.

1.3.2.4 Social facilitation and inhibition

The central hypothesis of social facilitation theory predicts that social presence enhances performance of simple or well-learned tasks and inhibits performance of complex or novel tasks. Triplett (1898) has often been cited as marking the beginning of social facilitation theory however, not only does social facilitation work predate Triplett's study but there is actually little statistical evidence of social facilitation in his raw data (Strube 2005, Stroeb 2012). Nevertheless, for over a century the study of social facilitation has garnered a large body of evidence demonstrating the impact of social presence on performance. Early work focussed on the influence of co-acting (performing the same task) versus directly competing with another (see Straus, 2002 for a review). Later work has also explored the effect of the mere presence of another person during task performance. This work extends beyond social psychology and includes areas such as cognitive and neuro psychology, an example of which is given below.

Wagstaff, Cole, Brunas-wagstaff, Blackmore, and Pilkington (2008), Experiment 1, tested the effect of both co-acting and the mere presence of another on performance on two working memory tasks. The authors asked participants to perform tasks which employed executive or non-executive processes. These processes are thought to be akin to complex/novel and simple/well-learnt tasks (respectively) in the social psychology literature, thus the expectation is that the presence of others will inhibit executive processes but enhance non-executive processes. Participants were asked to write down words beginning with one of three given letters (F, A or S) and to write down food items found in a supermarket. The authors measured executive and non-executive processes by analysing switching and clustering of words respectively. Switching is defined as a shift from one word category to another and is thought to be effortful (executive process) and clustering is defined as a set of words which share the same semantic or phonemic stem and is thought to be less effortful (non-executive process). The tasks were performed either alone, in the presence of four other participants with no experimenter (co-acting) or in the presence of four other participants with an experimenter (co-acting and mere presence of another). As predicted by the social facilitation hypothesis, participants made more switches and fewer clusters in the alone than group condition. There was however, no difference between the two group conditions. That is, the mere presence or absence of another in addition of co-acting did not appear to add any additional influence on performance. The authors suggest that this maybe because participants in a group did not perceive the experimenter to be observing them individually but that instead, perceived their attention to be spread across the group. Therefore, in their second experiment Wagstaff et al. (2008) investigated social facilitation with individual participants.

As seen in the earlier section on eye-closure, Wagtsaff et al. (2008) also have a research interest in eyewitness testimony and their second reported experiment extends to this field. Thus, Experiment 2 tested the effect of the presence of others on recall of a simulated crime presented in a video-clip. Participants were asked complex questions (leading and suppositional) about the video-clip by an experimenter who was either alone or joined by one or two other experimenters who sat facing the participant. The authors hypothesise that correctly answering complex questions relies on executive processes and correct recall will therefore be impaired by the presence of other observers. Participants were also asked to give confidence ratings for their answers. Subjective confidence ratings involve a degree of automaticity and the authors therefore argue that Confidence-Accuracy (CA) scores rely on non-executive processes. The prediction here therefore is that CA scores will improve (participants will be more confident in their correct than incorrect responses) in the presence of others. Wagstaff et al. found support for both predictions. However, while the presence of two additional others had a greater detrimental impact on the complex task (involving executive processes) than the presence of just one other there was no difference in CA scores between conditions with one and two additional observers. These results suggest that increasing the number of others increasingly inhibits performance of complex tasks but has no significant additional facilitative effect on performance of simple tasks, compared to the presence of just one other.

Another study in the field of eyewitness testimony explored the effect of the presence of another on task performance through comparing the effect of virtual avatar interviews with face to face interviews (Taylor and Dando, 2018). This is an extension of work by Doherty-Sneddon and McCauley (2000), discussed earlier, exploring young participants' gaze aversion during interviews over live video links versus face to face. In Taylor and Dando's avatar condition both participant and interviewer communicated via an avatar thus this most closely resembles a 'no-presence' interview condition. In comparison, the face to face interview most closely resembles a 'presence of another' interview condition. Participants watched a simulated crime video-clip and were asked to recall details two days later. Recall took place in two phases, firstly participants freely recalled details and secondly, answered probing questions. This second phase is most similar to Wagstaff et al.'s (2008) complex questioning (executive processes) condition outlined above. Interestingly, Taylor and Dando (2018) found no difference in the number of correct or incorrect freely recalled details between the avatar and face-to-face interview conditions however, responses to probing questions were detrimentally affected by the latter. Participants interviewed face to face (presence of another) gave fewer correct and more incorrect responses to probing questions than those interviewed as avatars (no-presence). Overall, Taylor and Dando's work also demonstrates that the presence of another inhibits performance on complex or executive tasks.

Eastvold, Belanger and Rodney's (2012) meta-analysis of effect-sizes across 62 social facilitation studies and 4,405 participants demonstrates that social presence in general has a negative impact on performance but that the type of task performed appears to be moderating the effect. The strongest impairment was found for tasks involving delayed recall (mean effect size on delayed recall tasks d = -0.93; mean effect size on other types of tasks d = -0.08). However, as Wagstaff et al. (2008) and Taylor and Dando (2018) demonstrate, the type of delayed recall (free or cued by questioning) may also moderate the effect.

Overall, social facilitation literature shows that environments can be distracting and detrimental to cognitive processes through the simple presence or absence of others.

1.3.2.5 Context Reinstatement

So far the review has presented research investigating the effect of suppressing or amplifying visual, auditory and social aspects of the environment on cognition. Another line of research has explored the effect on cognition of changing entire environments compared to not changing the environment. One way of considering this work in terms of environmental distraction is to view context shift (that is, a change of entire environment) as a distraction condition and context reinstatement (context remaining the same) as a low distraction or control condition.

Environmental context reinstatement (ECR) studies typically study the effect of environment or context on cognitive processes involved in memory. Memory-retrieval is usually compared between two conditions: when the external physical environment at retrieval is the same as it was at encoding (context reinstatement) versus when the external physical environment at retrieval is different to that at encoding (context shift). One of the earliest studies on context reinstatement of natural environments was carried out by Godden and Baddeley (1975) with sea divers in the sea and on land. Inspired by Egstrom et al.'s (1972) observation that divers struggled to recall details they had learnt underwater once they returned to land, Godden and Baddeley asked divers to study word-lists underwater or on land and either recall the details in the same environment (context reinstatement) or recall the details in a different environment (context shift): on land or underwater depending on the earlier learning environment. The context shift condition relative to context reinstatement creates the greatest amount of environmental distraction because the entire environment is wholly different. Godden and Baddeley's findings on the beneficial effect of context reinstatement are remarkably clear: regardless of sea or land, divers recalled significantly more words when recall took place in the same context as study than in a different context.

A meta-analysis by Smith (2001) demonstrates that 75 ECR experiments published between 1935 and 1997 collectively show a robust and reliable effect of ECR on recall: retrieval improves when the environment is reinstated. Smith explains ECR in terms of automatic environmental processing: information about the environment is automatically processed and 'bound' to the encoded details of whatever details are being studied, when the environment is reinstated at retrieval the environment itself acts as a cue or memory aid from which to retrieve the details. However, this effect could equally be thought of in terms of the detrimental effect of changes in the environment; when the environment is changed (not reinstated and therefore unfamiliar), it is more distracting because there is new information to process whereas an environment that is not changed (i.e. reinstated and therefore familiar), has less or no new information to process. Although Smith (Experiment 1, 1979) argues that relatively poorer recall seen in non-reinstated contexts is not due to the new context's unfamiliarity, it is possible that both bounded-encoding in the reinstated environment and the distraction of the unfamiliar environment are involved in the effect of ECR. For example, in Experiment 1 Smith asked participants to study a word-list in room A, after which they were taken to either room B or C, spending the same amount of time in room B or C as they did in A. Finally participants were taken to either room A (ABA room pattern), B (ABB) or C (ABC) and were asked to recall the word-list. Smith found significantly more words were recalled in room A (ABA), supporting the ECR effect. However, there was also a numerical difference between the other two conditions where more words were recalled in the ABB condition than ABC. The ABB condition did not reinstate the encoding context (room

A) but did have a familiar context at retrieval (room B was familiar), the ABC condition on the other hand did not reinstate the context and nor did it provide a familiar context at retrieval. Should both bounded-encoding and context-unfamiliarity (distraction) explain poorer recall in the non-reinstated conditions, then more words should be recalled in the ABA condition than in the ABB, and more words recalled in the ABB than the ABC condition: numerically, this is what the author found however, the difference between ABB and ABC was not significant (p=.08). Therefore, in ECR studies it could be argued that reinstating the environment holds a relatively low level of distraction whilst changing the environment holds a relatively high level of distraction and, the overwhelming findings from these studies suggest that high levels of distraction (relative to low), impair memory-retrieval.

The effect of ECR is not just confined to physically reinstating the environment, it is also seen when the environment is mentally reinstated (Dietze, Powell, & Thomson, 2012). Mental context reinstatement involves re-experiencing the context in the mind's eye. This may include mentally imagining sights, sounds, feelings and emotions. Positive benefits on retrieval are seen when contexts are mentally reinstated, or conversely, when the environment is not mentally reinstated, recall is poorer. Hershkowitz, Orbach, Lamb, Sternberg, and Horowitz (2002) compared the effect of MCR with ECR on eyewitness statements and found no difference between the two conditions in the number of details reported. However, responses under MCR were more detailed than under ECR. Speculatively, it may be that in terms of distraction, mentally reinstating the environment acts in a similar way to gaze aversion in that it averts attention from the unfamiliar physical environment (suppresses the distraction) but that it also serves to act as a cue from which to retrieve the bounded-encoded episodic memory-details.

While most studies refer to ECR effects in terms only of an increase in the number of correct items retrieved (for example, Ball, Shoker, & Miles, 2010; Emmett, Clifford, & Gwyer, 2003; Wong & Read, 2011) some studies have examined the effect on incorrect recall also. In a word-list recall task, Unsworth, Brewer, and Spillers (2010) found that ECR increased the number of correct responses but did not affect the number of incorrect responses. Participants instructed to use MCR to recall details of videotaped staged crime (Hammond, Wagstaff, & Cole, 2006) gave more correct responses than those in a control condition but, gave the same number incorrect responses. It is therefore not surprising that mental context reinstatement is recommended as a memory-aid technique in eyewitness interviews (Fisher & Geiselman, 2010).

The beneficial effect of context reinstatement has also been found for witnesses with autism spectrum disorder when the scene is physically reinstated (Maras & Bowler, 2012), for correct recall of a video-clip when compared to focussed meditation (Hammond, Wagstaff & Cole, 2006) and, for adult and child witnesses (Hammond, Wagstaff & Cole, 2006). It has also been reported for correct recognition of objects paired with scenes (Doss, Picart, & Gallo, 2018), for recall of cue-target word pairs when presented with background pictures not presented with other cue-target words (Bramao & Johansson, 2017), for accurate recognition of faces paired with background pictures (Hanczakowski, Zawadzka, & Macken, 2015), when reinstating a potent aroma of rosemary (Ball et al., 2010) and for increasing ‘feeling of knowing’ judgements for cue-target word pairs (Hanczakowski, Zawadzka, Collie, & Macken, 2017). However, context reinstatement has also been found to be detrimental to accurate retrieval processes when perceptually similar material is presented for recognition (Doss et al., 2018) and to inflate confidence in identifying an individual in police line-up (Wong & Read, 2011).

Context reinstatement research thus provides further evidence that the environment, or context, within which cognitive processes take place, can enhance or interfere with those processes. In terms of relevance to environmental distraction work, the control condition in distraction studies can be thought of as being similar to the context reinstatement condition in ECR and MCR studies. With respect to a memory task, distraction during retrieval arises from a retrieval context with different aspects to an encoding context. Therefore, memory items encoded in context A and retrieved in context A are retrieved in a control condition because distraction is minimal compared to when the items are retrieved in context B. Retrieval in context B, being different to context A, thus constitutes a distraction condition. In a similar way, context reinstated using MCR also constitute a control condition. Performing MCR can be seen as an extension of the retrieval task rather than a dual task because MCR is targeting the context within which the memory items were encoded and therefore is not a separate task.

Overall, the large body of work on context reinstatement implies that reducing the level of environmental distraction through physically or mentally reinstating the context in which memory was encoded is beneficial to retrieval processes.

1.4 Explaining the effect of distraction on cognition

There is no doubt that the external environment can be distracting to internal cognitive processes. The literature review suggests that averting gaze from the immediate environment serves to suppress at least some of this distraction because gaze aversion is associated with improved cognitive task performance and increases in spontaneous gaze aversion are associated with increasingly difficult tasks. Suppressing distraction through eye-closure is also associated with improved cognitive performance and appears to increase the accuracy of memory but not willingness to report memory. Visual distraction disrupts cognitive performance and generally appears to have the converse effect of eye-closure on recall accuracy. Auditory distraction has been shown to interfere with cognitive task performance when the internal processes engaged in task performance are the same as those engaged in processing the distraction. Auditory distraction has also been shown to disrupt cognition through drawing attention away from the task because it is unexpected or has personal relevance. In addition, the review also showed that the presence of others in the environment can improve performance on some tasks but disrupt performance on others and that changing entire environments between study and retrieval phases of memory tasks is detrimental to recall. In summary, the literature review repeatedly demonstrates, across several research fields, that external distraction interferes with cognition. The question is, why?

The following subsections discuss theoretical accounts put forward to explain why the environment is distracting to cognitive processes. These accounts are based on the literature reviewed so far. As the experiments unfold in later chapters other theories will be reviewed in relation to the findings. The theories discussed here however address each of the four groups of distraction study reviewed above and are presented in terms of how they explain the distraction effect, namely: a general effect; a duplex mechanism; social facilitation and inhibition; mental context reinstatement and visual imagery; modality-specific effect. Following this is a rationale which briefly explains the inspiration for the thesis and a brief introduction to the first set of experiments presented in Chapter 2.

1.4.1 General effect of distraction

One of the most widely cited explanations for why the environment affects cognition is that offered by Glenberg (1997). Glenberg's embodied cognition account is based on three key concepts: the environment is automatically processed; processing the environment requires resource and resource is limited; performing cognitive tasks requires resource. The first concept asserts that automatic processing of the environment is unconscious; it is an inherited trait preserved across generations because monitoring the environment for potential threats has thus far successfully preserved the species. The second concept argues a finite resource account whereby the internal resource available for any type of cognitive processing, including automatically monitoring the environment, is limited and not limitless. The third concept proposes that all cognitive processes draw on this finite resource regardless of whether the cognitive process is automatic or voluntary. That is, regardless of whether the cognitive process is involved in automatically monitoring the environment or in voluntarily performing a cognitive task. The more effort required to perform a cognitive task, the more the central resource is depleted. Equally, the more distracting an environment, the more the central resource is depleted. Distracting environments can be thought of as environments in which stimuli change. Changing stimuli require more processing than constant stimuli because changing stimuli present a stream of novel information which must be automatically processed whereas constant stimuli have already been processed. Distracting environments deplete the limited resource pool which leaves less resource to support other processes such as performing cognitive tasks.

Glenberg's (1997) account also explains gaze-aversion and eye-closure as relatively effortless behavioural methods of disengaging from the environment.

Directing visual senses away from the environment thus suppresses the automatic processing of the environment which in turn frees up the resource pool for cognitive tasks.

In summary, Glenberg's account makes a prediction about distraction effects in general which is based on both task difficulty and level of environmental distraction. When the environment is sufficiently distracting and the task sufficiently difficult, the resource pool will be depleted to the extent that, unless suppressing strategies such gaze aversion or eye-closure are employed, cognitive task performance will suffer. Thus, regardless, for example, of whether the task involves recall of visual or verbal information or the distractor is visual or auditory in nature, task performance will suffer as a result of both distraction and difficulty per se.

1.4.2 Duplex mechanism of distraction

Similar to Glenberg's view, one assumption of auditory distraction literature is also that the processing of environmental sound is automatic. Theoretical accounts of distraction effects suggest a duplex mechanism (Hughes, 2014) which implies that distraction has both a general and a specific effect. As seen earlier, findings from auditory distraction studies can be thought of as providing evidence of either an interference-by-process mechanism or an attentional capture mechanism. Auditory distraction is thought to interfere with cognition either because the same processes are engaged by the distractor and cognitive task or, because the content of the distractor draws attention away from the cognitive task. Macken (2014) refines this further and suggests similarities in the content of distraction and task leads to a distraction effect only if the content of the distractor contradicts the listener's mental model of and thus expectation of, information the sound will provide. Thus, one explanation is that auditory distractors disrupt cognition by capturing attention per se (general effect) and by interfering with specific cognitive processes but only when they are common to analysing both distractor and task. This theoretical approach has similarities with Vredeveldt et al. (2011)Vredeveldt et al. (2011)Vredeveldt et al. (2011)Vredeveldt et al. (2011)Vredeveldt et al. (2011)Vredeveldt et al. (2011)Vredeveldt’s (2011) Cognitive Resources Framework put forward to explain both visual and auditory distraction effects on long term memory. This is discussed later on.

1.4.3 Social facilitation theory

Social facilitation theory also suggests that the environment is automatically monitored. The key difference here is that the theory explains distraction effects based solely on the monitoring and evaluation of social presence. Wagstaff et al. (2008) propose that people are constantly alert to any signs of threat in the immediate environment. The authors draw on principles from sociobiology and suggest that threat can come in the form of another person or people, particularly if the person is previously unknown. Therefore, the mere presence of another is distracting because the automatic response to social presence is to evaluate the presence for signs of threat. The evaluation of potential threat requires cognitive executive processes. An executive process is one that controls attention and action and is involved with conceptual thinking. Thus Wagstaff et al. (2008) offer an interesting explanation for why social facilitation studies report inhibition effects of social presence on performance of complex or executive tasks but facilitation effects on performance of simple or non-executive tasks. Inhibition and facilitation effects arise because of competing versus non-competing cognitive processes. For example, the authors explain that engaging executive processes to evaluate social presence in the environment directly competes with executive processes needed to perform an executive task such as a memory task. Thus Wagstaff et al.'s theoretical stance is similar to that put forward by interference-by-process theory. Wagstaff et al. also suggest that as an additional effect, performance on tasks which require only non-executive processes will benefit in social presence because executive processes are engaged elsewhere in evaluating the presence for threat and are thus not freely available to intervene or supervise non-executive systems such as the fight or flight response. Thus, non-executive tasks may be responded to automatically without hindrance from the executive processes.

However, one issue with the predictions that social facilitation theory make comes from the gaze aversion literature. For example, both Glenberg et al. (1998) and Doherty-Sneddon and Phelps (2005), as discussed in section 1.3.1.1, demonstrated that social presence during performance on a long-term memory retrieval task does not fully explain the effect of distraction because the effect was more driven by task difficulty than social presence. Thus while there is little doubt that social presence influences cognition, social facilitation theory does not lend itself to comprehensively explain the distraction effects seen in the earlier literature review.

1.4.4 Mental context reinstatement and mental imagery

Smith's (2001) theoretical account of why ECR benefits memory also proposes that the environment is processed automatically. In terms of memory, the theory suggests that because to-be-remembered details are bound to environmental details during encoding, environmental details act as memorial cues during retrieval. However, in laboratory distraction studies for example, environmental details at retrieval are different to environmental details at encoding. Therefore, the benefit of ECR on memory is lost at retrieval. The theory offers more insight in terms of explaining distraction effects when mental context reinstatement is taken in to account.

Mental context reinstatement has been shown to have beneficial effects on memory retrieval thus implying that mental reinstatement also takes advantage of environmental cues to retrieve memory items. Mental context reinstatement involves using mental imagery during retrieval in order to mentally reinstate the environment in which encoding took place. For example, Wais et al.'s (2010) behavioural study presented earlier showed that visual distraction disrupted recall of visual objects. Alongside this study the authors also report a brain imaging study which reveals that brain areas associated with visual sensory input are activated when participants with eyes closed bring visual details to mind. This implies that mental context reinstatement for visual details at least, relies on visual imagery.

However, mental imagery has been shown to be disrupted by distraction: Wais et al. (2010) also report that brain activation associated with visual sensory input was interrupted when participants watched screens of visual distraction. In addition, Baddeley and Andrade (2000) found visual distraction to reduce reported vividness of visual imagery and auditory distraction to reduce reported vividness auditory imagery. Taken together with findings from mental context reinstatement literature, this implies that distraction disrupts visual and auditory imagery and thus interferes with the ability to mentally reinstate environmental cues with which to recall to-be-remembered details. However, the theory does not make predictions about whether the modality of the distractor also interferes with the modality of details recalled. This is because the theory suggests that the modality of distraction disrupts the ability to recall environmental details of the same modality but does not predict whether to-be-remembered details are bound to environmental details of the same modality or different modality.

1.4.5 Modality-specific effect of distraction

Vredeveldt's (2011) Cognitive Resources Framework puts forward both a general and modality-specific account of eye-closure which is equally useful as an account for the mechanism of distraction. The theory is based on an integration of Glenberg's (1997) finite resource account and of Baddeley and Hitch's (1974) multi-component model of working memory. Not only does Vredeveldt's framework bring together two established theories, it also encompasses some key features covered by the duplex mechanism account of auditory distraction.

Vredeveldt agrees with Glenberg's assertion that automatically monitoring the environment and performing cognitive tasks compete for a finite resource. However, rather than distraction disrupting cognition solely on task difficulty, Vredevldt proposes that disruption is dependent on the modality of the distractor. It is useful to summarise Baddeley and Hitch's (1974) three-component model here. A central attentional executive component is thought to direct attention to all incoming sensory information, a temporary visuospatial store deals specifically with visuospatial information and a temporary store referred to as the phonological loop, deals with auditory information. Vredeveldt suggests that distraction per se, whether visual or auditory, will take up resources from the central executive (or general resource). In addition, visuospatial distraction will take up resources from the visual store and likewise for auditory distraction with the auditory store. The prediction that Vredevldt's framework therefore makes is that visual distraction will show greater interference with cognitive tasks involving visual processes and auditory distraction will show greater interference with cognitive tasks involving auditory processes.

It is worth noting the parallels with auditory distraction's duplex mechanism here. For example Vredeveldt's (2011) proposal that Baddeley and Hitch's (1974) attentional central executive acts as a general resource and is depleted regardless of distraction modality is similar to the proposal that auditory distraction disrupts cognition through attentional capture. In addition, Vredeveldt's (2011) proposal that for example, visual distraction specifically disrupts the visual resource and not the auditory resource suggests an interference-by-process mechanism.

Research supporting Vredeveldt's framework comes mainly from the eyewitness testimony literature which has tested the effect on long term memory retrieval of suppressing visual distraction through eye-closure or increasing visual distraction through asking participants to watch visually distracting screens. However, overall there is only a limited amount of work which has tested and compared the effect of visual and auditory distraction on memory for visual and verbal details and so not surprisingly, as yet results are mixed.

For example, both Perfect et al. (2008; Experiment 4 & 5) and Vredeveldt and Penrod (2013; free recall) found removing visual distraction through eye-closure benefitted recall of both visual and verbal details rather than just visual details. however, Perfect et al. (2008; Experiment 2), Vredeveldt et al. (2012) and Vredeveldt and Penrod (2013, cued recall) found eye-closure benefitted recall of only visual details. Vredeveldt et al. (2011) found low compared to high distraction conditions to improve recall in general and that visual and auditory distraction selectively impaired memory for visual and verbal details, respectively. Thus suggesting both a general load and modality specific hypothesis.

However, Mastroberardino and Vredeveldt (2014) examined the effect of distraction on cued recall accuracy of both visual and verbal details and found no support for either the general cognitive load or modality-specific hypothesis. Participants in a minimal distraction condition gave more accurate responses about visual details than participants in visual and auditory distraction conditions. Perfect et al. (2011) found evidence of a general effect but not a modality-specific effect. The authors report that auditory distraction increases erroneous recall of both visual and auditory details of an event but that instructed eye-closure reduces this detrimental effect equally for both visual and verbal details. Perfect et al. (2012) also found support for a general load effect and report visual distraction to reduce recall accuracy of both visual and verbal details.

It is feasible however, that the mechanism of effect predicted by the Cognitive Resource Framework is sensitive to how precisely recall is measured. For example, work by Vredevedlt and Penrod (2013), Vredeveldt and Sauer (2015) and Vredeveldt et al., (2011) exploring fine and coarse grain responses, suggests that reducing distraction through eye-closure improves the precision (fine grain) of what is recalled but not the general gist (coarse grain) of what is recalled.

The evidence with respect to precision however, is not consistent. Vredeveldt, Tredoux, Kempen, et al. (2015) asked participants to both freely recall details of a witnessed event and identify the perpetrators face from a line up. The authors found instructed eye-closure to benefit free recall of the event but had no effect on recognition recall of the face. More specifically, eye-closure led to an increase in correctly recalled fine-grain verbal and visual details about the event but had no effect on recall of visual details of a face. Their findings support a general load effect but not a modality-specific effect.

1.4.6 Summary of theoretical accounts

Common to all the theories presented above is the assertion that internal cognitive processes are automatically engaged in monitoring the environment. Some theories suggest the level of this engagement depends on whether factors in the environment capture attention and attention may be captured because of the arrival of unpredicted or unfamiliar information. How and when this level of increased engagement affects other internal cognitive processes is debatable because empirical work supporting the different theories predict different mechanisms. These mechanisms can be broadly thought of having a general-effect or an interference-by-process effect or, as hypothesised by Vredeveldt's (2011) Cognitive Resource Framework, as having both a general and interference-by-process effect.

The general effect theoretical stance suggests that detrimental distraction effects on cognitive task performance are seen when a threshold is crossed whereby resources which fuel processes engaged in both monitoring the environment and performing the task are depleted. In distraction studies where the opportunity to control attention through eye-closure or gaze aversion is blocked, this cognitive resource overload manifests as poorer performance on a cognitive task. Glenberg (1997) asserts that the threshold is reached for moderately difficult tasks. However, the author gives no definition with which to operationalise 'moderately difficult' aside inference that by default, some tasks are easier and some are more difficult.

In contrast, an interference-by-process account asserts that the content of distraction and cognitive task are both critical in predicting a distraction effect. With regards to retrieval, Vredeveldt (2011) for example suggests that modality is key and that when distraction is of the same modality as details being retrieved, retrieval is further disrupted in addition to a general effect of distraction.

These theoretical stand points provide a framework from which to further investigate distraction effects because there is evidence to support and query both accounts. However, it should be noted that evidence of an attentional capture mechanism does not rule out interference-by-process as an explanation of distraction effects because the latter depends on the content of both distractor and task but the former does not.

1.5 Inspiration and rationale for the thesis

While there is little doubt that distraction disrupts cognition, the mechanism of effect is not yet fully understood. Therefore, the overarching rationale of the current thesis is based on furthering understanding of distraction. There are a plethora of places to start this work. However, the focus here is on visual distraction and long-term memory.

As indicated in the opening paragraph of the thesis, inspiration for choosing to investigate the effect of visual distraction on memory comes from work in the field of eyewitness testimony (reviewed in detail in Chapter 3). Of particular fascination to the current author was the finding that visual distraction often did not simply lead eye-witness participants to report less information or to pass on a memory question and say ‘I don’t know’: visual distraction led to poorer accuracy. That is, depending on whether participants’ memory was tested through cued or free recall, the quality or quantity of what was reported was often poorer under visual distraction. This is worth pausing on and both generalising and relating to real-life because this finding suggests that a witness interviewed in an unfamiliar or busy environment (both replete with visual distractors) may report a detailed account of a witnessed event but, the quality of the account may be compromised by the simple presence of visual distraction. This clearly has potentially serious practical implications. Alongside this, the current author's interest for this work also lies in theoretical accounts explaining the mechanism of distraction.

This interest in understanding the theoretical mechanism of distraction inspired research work for a Master's degree, (Rae, 2011). The work was designed to investigate distraction effects on recall of word-lists with the aim to establish a simple paradigm which could be easily controlled and manipulated and potentially used as a method with which to explore associated brain activity using neuroimaging techniques. However, despite many attempts and manipulations, no evidence of a distraction effect on word-list recall was found. Therefore, the logical starting place for work presented here was to explore reasons why no distraction effect on word-list recall was found when, for example, Glenberg et al. (1998) reported clear effects on word recall. The next Chapter presents the first set of this thesis' Experiments. The chapter begins with an in depth review of Glenberg et al. (1998) and Rae's (2011) word-list methodology.

Chapter 2: The Effect of Visual Distraction on Memory for Word-Lists

2.1 Introduction to Experiments 1 to 3

As discussed in Chapter 1, the majority of studies demonstrating consistent and robust effects of distraction on retrieval of long-term memory involve participants recalling details of live staged-events or video-clips. It is somewhat surprising, given both the consistent robustness of the distraction effect and the ubiquity of studies on verbal memory, that only one published[1] study (Glenberg, Schroeder and Robertson, 1998) has reported distraction effects on recall of word-lists. Glenberg et al. found that recall of words from the middle positions of word-lists was detrimentally affected by visual distraction but recall of words from other positions within the lists was not. In the same paper, the authors gather together findings from four additional memory studies and argue an interpretation of the distraction effect based on Glenberg's (1997) widely cited resource-limited embodied cognition theory of memory. Central to the theory is the prediction that distraction interferes with recall only when recall requires a moderate amount of effort and not when recall requires greater or less effort (explained in more detail later). Whilst Glenberg et al.'s findings at first appear to support this claim, a close inspection of their selective method of data analysis brings their argument, and the theory, into question. Furthermore, in contrast to their mid-list distraction finding and the prediction that distraction only affects moderately difficult recall, earlier work carried out by the author of the current thesis (Rae, 2011) found no evidence of a distraction effect on word-list recall and no selective effect on recall of words with varying levels of recall-difficulty. Both Glenberg et al. and Rae

[1] Word-list Experiments 1 to 3 presented here, have since been published (Rae and Perfect, 2014)

are discussed in detail below. The discussion naturally leads to the rationale for the first three experiments of the thesis.

Glenberg et al. (1998) report a series of five studies on gaze-aversion, eye-closure and distraction effects on word-list recall. Participants in the first three gaze-aversion studies were unaware that experimenters were observing gaze-aversion.

2.1.1 Glenberg et al., Experiment 1

In Experiment 1, participants were asked to recall autobiographical memories from 9 different memory-domains and three different retention-intervals. For example, participants (all students) were asked to 'name a current professor' (short retention- interval), 'name a professor from last term' (intermediate retention-interval) and 'name a professor from two terms ago' (long retention-interval). Questions were typed on cards and presented in a randomised order. Cards were held up by the experimenter such that the experimenter could not see the question and was thus blind to both the domain and retention-interval of each question. Each of the 27 question-cards (9 domains by 3 intervals) were held up for 10 seconds, after which, participants were signalled to give their answer or say, 'I don't know'. Experimenters recorded whether participants averted their gaze away from the question-card (including closing their eyes) or not, during the 10 second period. This fixed period is important to note because it means that gaze aversion was observed for the same amount of time for each question regardless of how quickly (or slowly) participants were able to recall the relevant detail. To expand further, experimenters would have had less time to observe whether participants averted their gaze when recall was quick and more time for observation when recall was slow. In which case, it would not be possible to determine whether any differences in the frequency of gaze aversion reflected the question's retention-interval or the observation's duration.

Glenberg et al. found that the proportion of times participants averted their gaze increased across short to long retention-interval questions. There was a significant difference between intermediate and long, and between short and long retention-intervals however, there was no significant difference between short and intermediate. Despite the lack of significance between short and intermediate, the overall pattern of gaze aversion suggests that it is more likely during recall of memory from further back in time than from close to the present time. Glenberg et al. also reported that the proportion of ‘don’t know’ answers numerically increased across short to long retention-interval questions. The authors maintain that the proportion of ‘don’t know’ answers is a measure of task-difficulty where higher proportions of ‘don’t know’ answers reflect greater difficulty. Thus, they claim that gaze aversion increases with increased task-difficulty. Given the centrality of task difficulty to their argument, it is curious that they do not strengthen their assertion by either reporting statistical analysis of these data or, reporting effect sizes. In addition, ‘task-difficulty’ could also be construed and measured in terms of the proportion of correct and incorrect answers across interval-retention questions. Should short compared to long retention-interval questions be associated with more correct and/or fewer incorrect answers (as well as the fewer ‘don’t know’ answers reported) the argument for the authors categorising short interval-retention questions as easy and long interval-retention questions as difficult, would be more robust. However, it is understandable why the authors did not measure this: it would have been very challenging (or impossible) to identify an answer as correct/incorrect given the autobiographical nature of the recall task.

2.1.2 Glenberg et al., Experiment 2

In Experiment 2, the authors observed participants' gaze aversion during recall of general knowledge items. Surprisingly, although the use of general knowledge questions provides an opportunity to now measure correct and incorrect answers as well as don't know answers, the authors report only correct answers.

General knowledge (GK) questions were selected from Nelson and Narens' (1980) pool of three-hundred. Nelson and Narens presented 270 university students with 300 GK questions and created 'norms' for each question based on how many participants correctly answered (proportion correct score) the question. The pool provides an opportunity to use proportion-correct scores to create sets of questions that differ in their normative level of difficulty-to-answer. They created 3 sets of experimental questions using the pool's highest- (.80 to 1.00), mid- (.40 to .60) and, lowest- (.00 to .20) proportion correct scores. This 3-level categorisation of task difficulty is frequently referred to throughout Glenberg et al.'s paper. However, for this study, Glenberg et al. selected 30 GK questions with proportion-correct scores between .70 and 1.00 but did not go on to categorise the questions. Their explanation here is that Experiment 2 is concerned with investigating the effect of increases in cognitive-activity on gaze aversion rather than increases in question-difficulty on gaze aversion. They argue that participants may not even attempt to answer questions that are too difficult and in such cases, cognitive activity will be low despite question difficulty being high. However, the authors give no justification for why they used a lower cut-off of .70 and not, for example, .60 or .80. It is certainly feasible that participants may not attempt to answer questions with low proportion correct scores however, without inclusion of these questions it is a speculative argument. Also, because response latency is not measured (due to the fixed retrieval period) it is not possible to tell whether a correct answer was retrieved by a participant almost immediately (low cognitive effort) or after deliberation (higher cognitive effort). The authors' focus on cognitive activity is also at odds with Experiment 1's conclusion that increased question-difficulty is associated with increased gaze aversion. This conclusion was reached using 'don't know' as an index of question-difficulty but some autobiographical questions may have been too difficult to attempt to answer and thus some don't know responses could have in fact involved low cognitive activity. Thus the authors are concerned with task difficulty in Experiment 1 and with cognitive effort in Experiment 2 but, do not address both in either experiment.

In Experiment 2, participants were presented with the 30 GK questions in the same way as for Experiment 1 and again, experimenters observed whether gaze was averted away from the question card during a fixed 10s retrieval period. The first three questions presented served as practice trials and were excluded from analysis. Excluding these questions comes as no surprise because it is common for one or two participants to seek clarification on experimental instructions during the first trial(s) of a study. This could disrupt the fixed retrieval period and, interfere with observations of gaze aversion if participants avert their gaze to question the experimenter rather than as part of a retrieval process. What does come as a surprise however, is the authors' decision to exclude a further 18 questions because too few participants answered them correctly. Pausing on this point for a moment, this means that data associated with just 9 of the original 30 questions is included in the final analysis: only 30% of collected data is reported. Questions were excluded where the proportion of participants giving correct responses fell below.70, in other words, where fewer than 13 of their 18 participants gave a correct answer. The authors do not report what the proportions were thus there could have been a flooring effect where no-one correctly answered the question or, there could have been 12 of the 18 participants correctly answering each excluded question. The authors explain that they did not want to include questions with lower proportion correct scores because these questions may be so difficult to answer that participants do not try to answer. This means that participants would not engage in cognitive activity with difficult questions other than deciding that they cannot answer the question. Whichever way, it is curious that they omit data from questions that were more difficult to answer because ‘difficulty’ is a central theme of their theoretical stance.

A correlational analysis on the 9 included questions shows a strong negative (r= -.83) association between the proportion of answers correct and proportion of instances of gaze aversion. As the number of participants correctly answering a question increased, the number of participants averting their gaze decreased. The authors claim that this correlation confirms gaze aversion is related to question difficulty. This claim is made despite having selectively omitted a large number of questions from analysis that were more difficult to answer. The claim is based on a small sub-sample of responses yet generalised to difficulty per se. In addition, the claim is made despite including and excluding questions based on cognitive activity and *not* on question difficulty. Finally, a foot note at the end of the paper’s reference list reveals a non-significant correlation (r= - 0.25, p=.23) when all items are included in the analysis. In sum, the generalisability of the association found in Experiment 2 is highly questionable.

2.1.3 Glenberg et al., Experiment 3

In Experiment 3, Glenberg et al. address the issue of so few questions being included in the previous analysis by increasing their GK question pool to 40. Twenty-seven additional questions were selected from Nelson and Narens and added to the 13 questions with the highest proportion-correct scores from Experiment 2. Although these included the three practice trial questions and the 9 analysed questions (which gives a total of 12 questions), it does not explain why an additional question from Experiment 2 was added here when it had previously been excluded from analysis for having a proportion-correct score below .70. The authors piloted all 40 questions and retained 30 which had proportion-correct scores of .60 or above. The shift in lowering the cut-off to .60 is without explanation.

The authors also sought to explore whether the same pattern of gaze aversion and question difficulty would be seen when the experimenter was absent from the laboratory. For example, other lines of research suggest that gaze aversion serves a social function – such as turn taking in verbal communication or alleviating social embarrassment (for example, see Argyle & Kendon, 1967). Thus, participants in Experiment 3 sat alone in a laboratory and were presented with questions via a computer screen. Answers were typed after the 10s fixed retrieval period and gaze aversion was observed and recorded via a hidden video-camera. There was no social contact with an experimenter during the trials. Gaze aversion was later independently rated by two experimenters, with 95% agreement.

One participant's data was excluded from analysis because they answered only 8 of the 30 questions correctly which was almost three (2.94) standard deviations below the group mean of 24. It is not unusual to eliminate outliers such as this however, there is a growing body of scholars who strongly argue against using means and standard deviations to identify and justify omitting such data (for example, see Leys, Ley, Klein, Bernard & Licata, 2013). What is curious about the analysis here, is not the exclusion of one outlier but, the decision to exclude data for 6 questions with proportion-correct scores below .70 when a pilot was carried out on the questions to establish a set with a proportion-correct of .60 and above. There is no explanation as to why there is a discrepancy in cut-offs between the pilot and the actual experiment. Employing a cut-off of .70 is in line with Experiment 2 and in that respect, is understandable. However, this means that the authors once again exclude a substantial amount of information: almost a quarter of the collected data (23.3%).

A correlational analysis between proportion-correct and proportion of gaze aversion reveals a significant but weaker than previously seen, association between the two ($r = -.55$). Interestingly, a footnote at the close of the paper shows that when analysis is carried out on the same select 9 questions analysed in Experiment 2, there is a non-significant association. The results suggest that gaze aversion is spontaneously used by participants during cognitive tasks in the absence of social interaction but, due to the exclusion of more difficult questions, the generalisability of the association is again unclear.

Experiments 1 to 3 appear to demonstrate that gaze aversion is spontaneously employed during retrieval processes. It is possible that participants averted their gaze because they retrieved their answers quickly and were absently looking away from the question card but it is perhaps unlikely given the short period within which they had to read and respond to the question card. However, the claim that gaze aversion is associated specifically with question difficulty is based on analyses of subsets of data selected from specific groups of participants. Although the authors are ‘confident’ (p654) about the association between gaze aversion and question difficulty, they provide no detail or analysis of excluded data for comparison and, an unconvincing argument for excluding the data in the first place. In addition, ‘don’t know’ and ‘correct’ responses are not measured across *all* three experiments and, there is no measure whatsoever of ‘incorrect’ responses despite it being straightforward in the latter two studies to record.

2.1.4 Glenberg et al., Experiment 4

Experiment 4 tests recall under two experimental conditions: participants are either instructed to close their eyes or, to continually look at the experimenter’s nose. Participants were asked to answer both GK questions and solve sums.

The same 30 GK questions (selected from the pilot study of 40 questions) used in Experiment 3 were included in the materials however this time, a level of question difficulty was assigned to each question (‘easy’, ’medium’ and ‘difficult’). Surprisingly, these categories were assigned based on the results of an additional experiment (not reported or published) rather than on the results of Experiment 3 but, no information about proportion-correct scores or how the categories were derived, are given. Thirty sums with difficulty levels categorised as ‘easy’ (three-addend additions, x + y +z), ‘moderate’ (divisions, x/y) and ‘difficult’ (multiplications, x*y) were also included. Two sets of 30 questions were created and counterbalanced across the two experimental conditions. Participants were asked to respond to the 30 questions in a mixed order of difficulty and question-type: 15 GK questions (5 easy, 5 medium and 5 difficult) and 15 sums (5 easy, 5 moderate and 5 difficult). Questions and sums were presented on cards and there was again a fixed 10s period before participants gave their answers. Participants either closed their eyes during the 10s period or looked at the experimenter’s nose. The authors predicted that participants would answer more questions correctly under eyes closed than eyes open but, only for ‘moderate’ difficulty items. No explanation is offered as to why they do not expect to see an effect for easy or difficult questions.

Their analysis of data took into account participants’ ‘dramatically’ different mathematical skills. Instead of retaining the same difficulty categories outlined at the outset, the authors calculated a new set of ‘moderate’ difficulty questions not just for sums but also for GK questions. This means that categorisation of difficulty level of GK questions, prior to final analysis, was changed twice prior to the experiment and once after the experiment was run. In order to re-categorise difficulty, correct responses to GK and sum questions were separated and collapsed under eyes closed and eyes open conditions. Questions were then rank ordered in terms of the mean number of correct responses given. The middle 10 means of the ordered list of 30 (one list for GK questions and one for sums) were then categorised as ‘medium’ difficulty items. This methodology of collapsing correct responses across both experimental conditions is unusual because the authors had earlier predicted that eyes-closed would lead to more correct responses than the ‘look’ condition. A more cautious method would be to re-categorise questions based on responses under one condition only.

As with the previous experiments, analysis is reported on selected data only: the newly categorised ‘medium’ difficulty GK questions and sums. They found an overall effect of eyes-closed where more correct responses were given for medium difficult GK questions and sums when eyes were closed compared to looking at the experimenter’s nose. However, there is no mention in the main body of the paper of whether this effect is seen, or not, for items whose mean correct scores had been rank ordered at the top and bottom of the list. Instead, a short footnote at the end of the paper states that differences between eyes-closed and look were ‘generally’ small and non-significant for easy and difficult questions. The authors give the mean differences but, they only report one p value. What is not clear is whether their use of the word ‘generally’ means that at least one of the mean differences was in fact, significant.

2.1.5 Glenberg et al., Experiment 5

The final experiment reported in Glenberg et al.’s paper explored the effect of manipulating the level of distraction in the external environment on memory for word-lists.

The authors selected 150 words from the Toronto Word Pool (Friendly, Franklin, Hoffman, Rubin, & Carolina, 1982) to create 10 lists of 15 words. Although the Toronto Word Pool provides norms for these words, such as indices of imagery, concreteness and noun-usage, Glenberg et al. do not report using *any* of these norms to create categories of word-recall difficulty. For example, words that are easily imagined in the mind’s eye are more likely to be correctly recalled than low imagery words (for example, Paivio, 1969). Thus, the ‘easy’ recall-difficulty word group could consist of words with high-imagery norms. Instead, it appears that whilst the Toronto Word Pool was the source for their word-lists, the associated norms were completely ignored.

Participants were visually presented with a list of words, one word at a time. This was followed by a filler task of 10 three-addend addition sums. Filler tasks are a common design in long-term memory studies and serve to address primacy and recency effects in recall (for example, see Ratcliff Murdock, 1976). After the filler tasks, participants were given a fixed 30s period in which to recall words out aloud from the presented list, in the presence of an experimenter. During this period, participants either looked at a picture of a sunset (static distraction condition) or, looked at a Charlie-Chaplin silent movie-clip (dynamic distraction condition). This was repeated for all 10 lists with half recalled under static and half under dynamic distraction in a counterbalanced and non-blocked design. Participants were presented with the same sunset picture in the static condition but presented with five different 30s clips of the movie in the dynamic condition.

The authors predicted that the dynamic condition would be more distracting and thus more difficult to suppress than the static condition. Therefore, participants would recall fewer correct words under the dynamic than static condition.

Similar to Experiments 1 to 4, the authors exclude a large set of data from the analysis. Despite including a filler task to address primacy and recency effects, they exclude the first and last 5 words from each list because, they explain, of primacy and recency effects. Therefore, analysis was only carried out on correctly recalled words presented in the middle 5 positions of the lists. Overall, a marginally higher proportion of correct words were recalled under static (.28) than under dynamic (.23) distraction.The authors also report that there was no effect of list or interaction of list and condition. However, no other reference to 'list' is made so it is not clear how this analysis was carried out.

In summary, Glenberg et al. present a distraction-effect account based on highly selective data. They conclude that distraction impairs performance of moderately difficult recall tasks. However, in contrast to Glenberg et al.'s reported findings Rae (2011), reported below, found no distraction effect on word-list recall regardless of varying levels of difficulty.

2.1.6 Rae, 2011, Experiment 1

As part of a wider research project for a Master's degree, Rae (2011) explored the effect of distraction on cue-target word pair recall. Mental imagery and semantic properties of word-pairs were manipulated such that pairs could be easily pictured in the mind's eye or not, and easily semantically associated with each other, or not. Manipulating these two properties resulted in three distinct categories of word-recall difficulty (as indexed by correct recall under control conditions): easy, moderate and difficult. Final analysis showed no effect of visual distraction on recall of mid-list words or on recall of moderately difficult words.

A set of 32 cue-target word pairs was created based on imagery norms provided by Clark and Paivio (2004) and semantic association norms provided by the Edinburgh Associative Thesaurus (EAT). Pairs were categorised in one of four ways: high imagery pairs with high or low semantic associations and, low imagery pairs with high or low semantic association (please see Appendix I for examples). Word-pairs were presented to participants in one continuous list of 32. Thus, unlike Glenberg et al.'s (1998) multiple-list method, this experiment used a single-list design. The order of pairs was randomised for each participant and the list was presented twice, back to back. Word-pairs were all presented visually for 3s or, all presented verbally[2] for a similar amount of time. Participants were told that the cue word would always be on the left side of the screen or be spoken first and that they were to try to remember which target word was presented with the cue because they would later be presented with the cue only and asked to recall the target. In order to

[2] No significant differences between modality of word-pair presentation were found therefore, data was collapsed across the two

reduce recency effects, participants were asked to answer 10 two-addend sums immediately after the last presentation of the word-pair list.

A retrieval phrase followed where participants were presented with one cue word at a time in the centre of a screen and were asked to say which target word had previously been presented with the cue. The distraction condition was created with a screen of black and white squares which appeared to flicker and move (explained in more detail later) and the control condition was created with a static version of the same screen. Thus unlike Glenberg et al.'s (1998) semantic distraction conditions, the ones here were semantically neutral. The cue word appeared in a white box in the centre of the distraction or control screen. The screen remained until participants gave a response, including the option to say, 'don't know'. The length of time for which the distraction or control screen was shown was not recorded.

Analysis of correct responses under the control static condition revealed three distinct levels of performance. Cued recall of target words from high-imagery and high-association pairs had the highest mean correct score (2.9 out of a maximum of 4) whereas recall of target words from low-imagery and low-association pairs had the lowest mean correct score (0.7 out of a maximum of 4). The two groups of word-pairs with mixed levels of imagery and association elicited similar levels of performance and had an overall mean of 1.8. Statistical analysis showed that means across the three groups were significantly different. Therefore, proceeding analyses included recall-difficulty (as indexed by mean correct recall): easy, moderate and difficult.

Analysis of distraction showed no main effect of distraction condition on correct recall and no interaction between distraction and recall-difficulty. Numerically, there was no consistent pattern of a distraction effect: correct recall was marginally *higher* under dynamic than static distraction for easy words (DVN *M* = 3.1, static *M* = 2.9) but numerically lower for moderate (DVN *M* = 1.7, static *M* = 1.82) and difficult (DVN *M* = 0.6, static *M* = 0.7). The three categories of recall difficulty also held when incorrect responses under static distraction were analysed where, easy words had the lowest mean incorrect (*M* = 0.3) followed by moderate (*M* = 0.7) and difficult (*M* = 0.9). However, there was no significant interaction between distraction and recall difficulty. Numerically, there was again no consistent pattern of dynamic distraction: mean incorrect of easy was minimally lower under dynamic distraction than static (DVN *M* = 0.2, static *M* = 0.3), mean incorrect of moderate was the same (*M's both* = 0.7) and difficult was lower (DVN *M* = 0.8, static *M* = 0.9).

Thus, Rae found no evidence of a distraction effect on word-list recall and despite successfully manipulating recall difficulty, found no selective effect of distraction on words defined as moderately difficult to recall.

2.1.7 Methodological differences between Glenberg et al. (1998) and Rae (2011)

In summary, Glenberg et al. (1998) found a distraction effect on word-list recall but Rae (2011) did not. There may be multiple reasons why findings from the two studies do not agree but two key differences in methodology stand out and thus are discussed in detail below.

2.1.7.1 Visual distractor

Glenberg et al. (1998) and Rae (2011) both asked their participants to recall word-lists under static and dynamic distraction, but whilst Glenberg et al. used a semantic-rich distractor, Rae did not. It is not possible to tell whether an idiosyncratic semantic aspect of Glenberg et al.'s movie-clips was responsible for the resulting distraction effect. That is, Glenberg et al.'s reported effect may be specific to recalling words whilst watching a silent Charlie Chaplin movie versus looking at a sunset picture rather than a more generalisable explanation that visual distraction disrupts memory. Participants were asked to watch a 30s silent movie clip during recall of one word list. Recall of the next word list was accompanied by a different 30s clip from the same movie. It is therefore feasible that this continuation of movie clip created a distraction rich with semantic content but specific to the movie. This is because a series of 30s movie clips, from the same movie, are perhaps semantically associated to each other in a way that, for example, a series of moving coloured boxes are not. The Charlie Chaplin movie clips have rich visual scenes, each consisting of numerous visual details that can be semantically linked back to (by a participant) from the next movie clip presented in the next distraction condition. In contrast to Glenberg et al.'s semantic-rich distractor, Rae presented Dynamic Visual Noise (DVN) which is a semantically-neutral visual distractor developed by Quinn and McConnell (1996). Based on optimal parameters determined through memory tests run by the developers, Rae's DVN consisted of a 700 x 700 pixel field of black and white squares (10 x 10 pixels per square) which changed from black to white to black at a rate of 291 per second. The black and white colour change gives an effect similar to white noise on a television screen. Recall under DVN can be contrasted to that under Static Visual Noise (SVN). SVN is a freeze frame of DVN, Figure 1 provides an example SVN image.

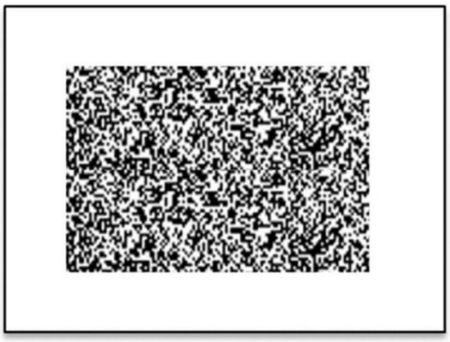

Figure 1: A screen of Static Visual Noise (SVN)

DVN has been widely tested and shown to have negative effects on cognitive processes, including memory. For example, Anderson et al. (2017) investigated the role of visual imagery and executive processes on recall of autobiographical memories. Participants were presented with an on-screen cue word surrounded by a field of DVN, or not, and asked to describe an autobiographical memory associated with the word. The DVN screen remained throughout the retrieval and reporting period. Participants in the control condition were presented with the cue word on a blank white screen. Reponses to the cue words were recorded and coded (a random sub-sample showed high inter-rater reliability). Memories were coded as ‘specific’ (a single specific event), ‘erroneous’ (for example, non-specific repeated events) or ‘omitted’ (no memory was recalled). DVN, compared to blank screen, significantly decreased the number of specific memories, significantly increased the number of erroneous memories and, had no effect on omissions. This pattern of distraction effect is similar to that discussed in Chapter 1 (for example, as reported by Perfect et al. 2012 when distraction was in the form of moving coloured boxes). DVN has been reported to disrupt a range of cognitive processes including recognition memory

(Santana et al., 2013), food cravings (Kemps & Tiggemann, 2013), digit-sequence recall (St Clair-Thompson & Allen, 2013), memory of a peg-word mnemonic (Andrade et al., 2002), identifying visual changes in patterns (Dean et al., 2008), high imagery words (Parker & Dagnall, 2009) and when comparing performance under DVN to SVN (McConnell & Quinn, 2000; Quinn & McConnell, 2006). Throughout the thesis, the term DVN is used specifically as a reference to Quinn and McConnell's (1996) black and white flickering squares.

In summary, there is clear evidence that DVN compared to blank screen or to SVN interferes with retrieval processes. In contrast and not surprisingly, distraction effects based on Glenberg et al.'s (1997) unique dynamic and static material have not been reported elsewhere in the literature.

2.1.7.2 Multiple word-lists and list order

Glenberg et al. presented participants with multiple word-lists (10 15-word word-lists) whereas Rae presented one single list (36 word-pairs). Participants studying and recalling multiple lists may be more vulnerable to proactive interference (PI, for a review, see Anderson and Neely, 1996). Proactive interference describes a phenomenon whereby previously studied information can interfere with the recall of recently studied information. For example, participants studying and recalling words from the 10th list in Glenberg et al.'s study had previously studied 9 other lists consisting of a total of 135 words. Speculatively, it would be surprising if those 135 words had *not* in some way interfered with recall of words from the 10th list. In contrast, recall of their 2nd presented list would have had interference from only one previous list of 15 words.

One theory as to why PI builds up across multiple lists is that participants become unable to distinguish whether a recalled word came from the most recent target list or, from an earlier list (for example, Bennett, 1975; Wixted & Rohrer, 1993). This is at most a minimal possibility with Rae's single list study because during the half-hour experimental slot, participants were not asked to study any other material prior to studying the single list. Whilst Glenberg et al. briefly note that there was no list effect or interaction with list and distraction, it is not clear how they analysed these data. If analysis was based on mid-list recall alone they may have missed a PI effect because they did not take recall of the full lists in to account. If PI causes memory to be vulnerable to distraction, a distraction effect would be more likely for the last lists than the first lists. However, Glenberg et al.'s method of presenting the distraction conditions was to randomly assort them across the 10 lists (within the boundary of 5 lists per condition), thus the first list under one condition is not necessarily the very first list presented to participants. At best, it can be concluded that the first two lists recalled under the static control condition will have had fewer preceding lists than the last two lists recalled under the same condition.

Furthermore, Glenberg et al.'s study included 33 participants but the number of permutations of fully randomising the presentation of 10 lists under two conditions is 252. The authors provide no details of the randomisation of lists thus there is no way of knowing whether this was successful.

2.2 Rationale for Experiment 1

Two key differences in methodology between Glenberg et al. and Rae are the way in which the distraction condition was created and the number of word-lists participants were asked to recall. Therefore, a rational approach to further investigating the discord between the two studies is to replicate the study which did find an effect, Glenberg et al., but with a more controlled method and a non-semantic distraction condition which has been shown to disrupt cognitive processes elsewhere in the literature. The replication therefore will include Glenberg et al.'s multiple list method but will test memory under a DVN condition compared to SVN rather than a dynamic movie-clip compared to a static sunset. In addition, several issues with data analysis were identified in the previous review of Glenberg et al.'s study and these will also be addressed in the replication. These are discussed below

2.2.1 Analysis by word-position

Glenberg et al. report only mid-list recall because they delegated the first and last groups of words in the list as buffers. It is well established in free recall studies of word-lists that words presented first and last in word-lists are correctly recalled more frequently than words presented in the middle of lists (for example, Ward 2002). These patterns of recall are referred to as primacy and recency effects. Last words in the list are thought to be recalled more easily (recency effect) because they are more accessible and easier to bring to mind than words presented earlier (Glanzer & Cunitz, 1966; Bernback, 1975). Words from the beginning of the lists benefit from more frequent rehearsals which increases their associative strength and are thus also more accessible than mid-list words (primacy effect, for example Rundus, 1971). A typical graph plotting correct free-recall of words against the list positions they were originally presented in has a U-shape curve. Glenberg et al.'s word-lists may show a distraction effect because mid-list words are more difficult to recall than other words in the list and memory is more vulnerable to distraction when the task is relatively difficult. However, the authors did not report data for other words in the list and so it is not possible to know what the recall pattern was. Therefore, Experiment 1 will include an analysis of distraction on word-position. In keeping with Glenberg et al.'s 5-word mid-list category of 10-word word-lists, word-position in the replication will be separated in to the first 5-words, mid 5-words and last 5-words per list.

2.2.2 Analysis of correct and incorrect recall

Glenberg et al. found distraction decreased correct recall however, Chapter 1 saw that one distraction study found an effect on incorrect but not correct recall (Perfect et al., 2011). Glenberg et al.'s analysis was restricted to mid-list items, therefore they did not look at incorrectly recalled words because these could not be attributed to mid-list positions. Their reported effect could have been due, in part, to distraction decreasing willingness to report (i.e. a criterion shift) rather than poorer memory. Such a criterion shift would be identifiable by a concurrent decrease in incorrect recall. However, incorrect recall cannot be analysed by word-position, so analysis of incorrect recall will be carried out for full lists.

2.2.3 Analysis by list order

Glenberg et al.'s analysis did not include analysis of correct and incorrect recall of full lists by list-order. As discussed earlier multiple-list recall may be vulnerable to a build-up of PI where fewer correct and more incorrect responses are given for later lists due to source monitoring errors. If memory for later lists is more vulnerable per se, it is feasible that it will also be more vulnerable to distraction. Therefore the replication will include analysis of recall by list order. However, to avoid reducing statistical power by introducing a 5-level factor, recall of the 5 lists under each recall condition will be explored though comparing recall of the first, mid (third) and last (fifth) list presented. Data for lists 2 and 3 will be omitted for convenience.

2.2.4 Aim of Experiment 1

The aim of Experiment 1 is to replicate of Glenberg et al.'s (1998; Experiment 5) multiple word-list study methodology with a more closely controlled manipulation of distraction (DVN, SVN)[3] and an extended analysis of data.

2.3 Experiment 1

2.3.1 Method

2.3.1.1 Power calculation

2.3.1.1.1 *Power throughout the thesis*

Various effect sizes for both the effect of eye-closure and visual distraction on memory have been reported (please see Chapter 3 section 3.2 for an in-depth review). As classified by Cohen (1992), the magnitude of these sizes range from medium to very large (*d*'s for example between 0.50 and 1.20). Power calculations for Experiments 1 through to 8 were therefore based on detecting medium to large main effects of distraction (d = 0.80 or, f = 0.40) with a minimum power of .80. At times, a lower power value of .80, rather than a higher value of .95, was used as a practicality. This was to encompass periods of time throughout the year when it is notoriously challenging to recruit participants but when it remains crucial in the time-limited scheme of the thesis work to continue to collect data (such as end of term and academic holiday periods).

A priori power calculations were carried out using G*Power version 3.1.9.4 (Faul, Erdfelder, Lang, & Buchner, 2007) and are reported separately for each experiment throughout the thesis.

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[3] A third recall condition of eye-closure was also included however, post-test inspection revealed a coding error in the program: the condition had not been randomised. As eye-closure was not used elsewhere in the thesis, these data were therefore dropped from analysis.

2.3.1.1.2 *Experiment 1 power*

Experiment 1 explored the main effect on recall of DVN compared to SVN. The distraction condition was presented as a within variable. Power analysis to examine the difference between two dependent means with an effect size of *d* = 0.8 and power 0.95 indicated the need for 23 participants in the total sample.

2.3.1.2 Participants

Thirty-nine participants (24 females), average age 25.9 years (*SD*= 9.33) took part for course credit or as a paid volunteer. All participants had normal or corrected to normal vision and were fluent English speakers. All participants were made aware that the study involved being exposed to onscreen flickering; anyone concerned about this effect or with a history of seizures or migraines was asked not to sign-up. One participant's data (male, aged 28 years) was excluded from analysis due to failure to comply with procedural instructions (consistently looking away from the visual distractor when prompted) and another (female, aged 20 years) was incomplete due to being interrupted by a fire-alarm. Therefore, data were analysed from thirty-seven participants.

2.3.1.3 Design and Materials

The central design of Experiment 1 followed 2 (Distraction: DVN, SVN) repeated measures structure. Extended analysis, including all additional variables, followed a 2 (Distraction: DVN, SVN) X 3 (list order: first, mid, last list) X 3 (Word Position: recall of first 5, mid 5, last 5 words in each list) repeated measures structure.

2.3.1.4 Word-lists

The same material source as Glenberg et al. was used and 150 words were randomly selected from the 1,080-word Toronto Word Pool (Friendly et al., 1982).

This selection was used to randomly generate (without replacement) a unique set of 10 lists of 15 words for each participant. The order in which words were randomly presented for each list was digitally recorded so that post-test, each correctly recalled word could be coded as having originally been presented in the first 5, middle 5 or last 5 position of the list.

2.3.1.5 Filler task

To address recency effects in a similar way to Glenberg et al.’s design**,** a pool of 100 two-addend addition sums (e.g. 24 + 3 =) was created from which 10 sets of ten sums were randomly selected without replacement, for each participant.

2.3.1.6 Distraction conditions

Static (SVN) and dynamic visual noise (DVN) were presented on a computer screen using parameters set out by Quinn and McConnell (2006): each field measured 700 x 700 pixels and consisted of a random pattern of ten x ten pixel blocks of black and white squares. This field was static during the SVN condition but appeared to flicker during the DVN condition as random pixel blocks changed colour from black to white to black at a rate of 291 per second. The surrounding background screen was white. The order in which SVN and DVN were presented was randomised across the 10 word-lists.

2.3.1.7 Procedure

Participants were told they would be shown several lists of words, one list at a time and one word at a time and later be asked to recall the words one list at a time. To comply with the school of Psychology’s ethics committee’s approval for this series of experiments, participants were also reassured that the study had been designed to make it difficult to recall all of the words on the lists so not to worry if they could not remember many.

Participants studied 10 lists of individual words, each word presented visually for 2s, with an inter-stimulus blank screen interval of 150ms. Words were centred in the middle of the screen and appeared in black capital Arial-font, size 18. A filler task of a series of 10 sums immediately followed the presentation of each word-list; each sum was shown centre screen for 2s at a time with a 200ms inter-stimulus interval between sums. Participants were asked to call out the solution to each sum as it appeared on the screen: all participants answered all sums. Participants were also told that their answers to the sums were not being recorded so not to worry if their answers were incorrect. Following the last sum an onscreen instruction reminded participants to keep looking at the screen. This was followed by a fixed 30-second recall period. During the fixed recall period, participants verbally recalled words from the word-list they had just seen whilst looking at a screen which displayed SVN or DVN for the entire 30 seconds. Each participant recalled five word lists under DVN and five under SVN, the order of DVN and SVN was randomised within the boundaries of there being 10 lists and participants were not aware which recall condition would be presented with each list. The experimenter was seated adjacent to participants such that participants were unable to make eye-contact (without moving their head) with the experimenter during encoding or retrieval phases. This also enabled the experimenter to make sure participants were watching the screen throughout the retrieval phase.

Word-lists were randomised and because the experimenter could not clearly see the experiment screen, the experimenter was not aware of which words had been presented in which list. The experimenter wrote down words as the participant called them out; there was no issue with matching speed of writing with calling out because although participants typically called out the first few words quickly, subsequent words were slow to follow.

The coding of participants' word-recall took place after the experiment was completed. The experiment's programme automatically recorded which words were presented in which serial order for each list and for each participant. Distraction condition of each list was also recorded. Words were coded as correct if they had been presented in the target list and incorrect if they had not.

Across all participants, four words were recalled outside the 30-second recall period and these were therefore excluded from analysis.

2.3.2 Results and Discussion

An alpha level of .05 is used throughout all experiments in the current thesis, unless otherwise stated and explained.

The first analysis uses Glenberg et al.'s method of examining distraction effects on correct recall of mid-list words collapsed across all word-lists. The second analysis extends this by exploring distraction effects on correct recall of words from first, mid and last list positions. The next analysis contrasts correct recall between the first two and last two presented lists whilst also taking in to account word-list position. In addition, incorrect recall is also analysed.

2.3.2.1 Normality and data transformations throughout the thesis

Statistical analysis of data throughout the thesis was carried out mainly using parametric tests. A central assumption of parametric testing is that data follow a normal distribution; the accuracy of parametric tests can be weakened when carried out on non-normally distributed data. Prior to statistical testing, data within each to-be-analysed condition (or subgroup) within each experiment were checked for normality through calculating skew and kurtosis z-scores from SPSS (version 25, 2017) descriptive statistics of data distributions. There are alternative methods of checking for normality, such as the Kolmogorov-Smirnov K-S test, however, such tests can be overly sensitive in detecting small deviations from normality and it is therefore useful to examine skew and kurtosis parameters (Field, 2009).

Standardised skew and kurtosis scores of a data distribution are referred to as z- scores. Skew and kurtosis z-scores of a normally distributed set of data are ‘0’. If a data set has a skew z-score greater in magnitude than 0, it reflects that data scores tend to cluster around one end of the distribution or the other, rather than clustering centrally as seen in classic bell-shaped normal distributions. If a data set has a kurtosis z-score greater in magnitude than 0, it reflects that the peak of the distribution of data scores is more, or less, pointed than that of a normal distribution, with tails heavier or lighter than usually seen in normal distributions. Deviations of z-scores from ‘0’, up to the value of 1.96, are accepted as parameters of a normal distribution. Skew and kurtosis z-scores which exceed a magnitude of 1.96 have a 5% probability of belonging to a normally distributed set of data. Therefore, z-scores with a magnitude greater than 1.96 are interpreted as implying data are not normally distributed. In general, where the majority of subgroups within a data-set have z-scores greater than 1.96, data are either transformed through a $\log_{10}$ function prior to analysis with parametric tests or, data are analysed with non-parametric tests.

Where the majority of subgroups within each experiments’ data set have skew and kurtosis z-scores lower than 1.96 in magnitude, data transformation will not be carried out. That is, some data sets showed some subgroups to have z-scores greater than 1.96 but because the majority of subgroups did not have magnitudes this great, none of the data set was transformed. This is for two reasons. One is because data transformations, which for example, are intended to reduce skew, can have detrimental effects on kurtosis. Thus one parameter may be bought under normal distribution boundaries at the cost of another. The second reason is because all subgroups within a data set must be treated the same therefore, they must either all be transformed or not transformed. That is, it is not possible to transform select subgroups with large z-scores and not subgroups with smaller z-scores. Therefore, if the majority of subgroups within a data set have skew and kurtosis parameters within normal distribution boundaries of 1.96, it is prudent to not transform the data-set at all because transformation can lead to another parameter deviating from the normal distribution.

Logarithmic transformations of data such as Log_{10}, are a generally accepted method for transforming the distribution of a data-set into a normal distribution (for example, see Field, 2009). However, log transformations cannot be carried out on scores of ‘0’ because the log of 0 is undefined. Therefore, because it is possible for participants to score 0 in the experiments presented herein, Log_{10} (score+1) transformations are carried out where data are transformed. The results section for each experiment throughout the thesis includes a summary table of skew and kurtosis z-scores and a statement of whether data was transformed. Skew and kurtosis before and after z-scores are given for transformed data. For ease of visual identification, skew and kurtosis parameters with a magnitude greater than 1.96 are highlighted with a * symbol within the tables.

Parametric testing is carried out where transformations have lowered z-scores to within the expected boundaries of a normal distribution. Non-parametric testing is carried out where skew and kurtosis z-scores are double the magnitude of 1.96. This is because in such cases, data transformations failed to reduce the majority of skew and kurtosis z-scores to below 1.96.

All descriptive data of means, standard deviations and effect sizes, including data presented in graphs, are of non-transformed data.

2.3.2.2 Correct recall

2.3.2.2.1 *Normality testing on Experiment 1 correct recall data*

Table 1 below shows test statistics and significance levels for normality tests on Experiment 1 data grouped by correct recall of first, mid and last words across all lists under each distraction condition. Initial testing showed the distribution of data within the majority of to-be-analysed conditions was significantly different to a normal distribution. Therefore, a Log_{10} (score+1) transformation was carried out. Post transformation analysis of normality shows both skew and kurtosis parameters falling below 1.96. Therefore analyses of Experiment 1 correct recall data were carried out on Log_{10}(score+1) transformed data.

Table 1: Experiment 1 normality testing of correct recall data pre and post data-transformation

Distraction Condition	Word position	Skew z-score		Kurtosis z-score	
		Non-transformed	Log_{10} (score+1) transformed	Non-transformed	Log_{10} (score+1) transformed
SVN	First 5	2.22*	0.77	0.11	-1.21
	Mid 5	2.68*	1.15	0.75	-0.24
	Last 5	3.52*	1.23	3.34*	0.29
DVN	First 5	1.88	0.20	-0.16	-0.86
	Mid 5	2.49*	0.52	1.96*	-0.20
	Last 5	3.55*	1.51	3.37*	0.80

* *significantly different from a normal distribution, alpha .05*

2.3.2.2.2 *Analysis of mid-list correct recall only*

A paired t-test showed that Glenberg et al.'s finding of a distraction effect on mid-list correct recall, collapsed across all lists, was replicated. Correct recall of mid-list words was significantly reduced under DVN compared to SVN, $t(36) = 2.89$, $p=.007$. Where participants recalled a mean of 1.03 words ($SD = 0.56$) out of 5 mid-list words under DVN but a mean of 1.31 words ($SD = 0.67$) out of 5 mid-list words under SVN.

2.3.2.2.3 *Extended analysis of correct recall*

Correct recall of first-, mid- and last-words

When correct recall of words from all list positions are included in the analysis, a 2 (Distraction: DVN, SVN) X 3 (Word Position: recall of first 5, middle 5, last 5 words in each list) repeated measures ANOVA across all lists shows no main effect of distraction, $F(1,36) = 2.04$, $MSe = 0.01$ $p = .162$, partial $\eta^2 = .05$, thus showing that distraction does not affect correct recall of full word-lists. There is a main effect of word position, $F(2,72) = 5.93$, $MSe = 0.01$, $p = .004$, partial $\eta^2 = .14$ but no interaction between distraction and word position, $F(2,72) = 2.75$, $MSe = 0.007$, $p = .070$, partial $\eta^2 = .071$. Analysis of the simple effects of distraction shows the significant decrease in mid-word correct recall under DVN versus SVN, $F(1,36) = 8.35$, $p = .007$, partial $\eta^2 = .19$ but no effect on first-word or last-word recall, $F(1,36) = 0.31$, $p = .861$, partial $\eta^2 = .001$, $F(1,36) = 0.17$, $p = .682$, partial $\eta^2 = .005$ respectively. Please see Figure 2 for mean scores and standard errors.

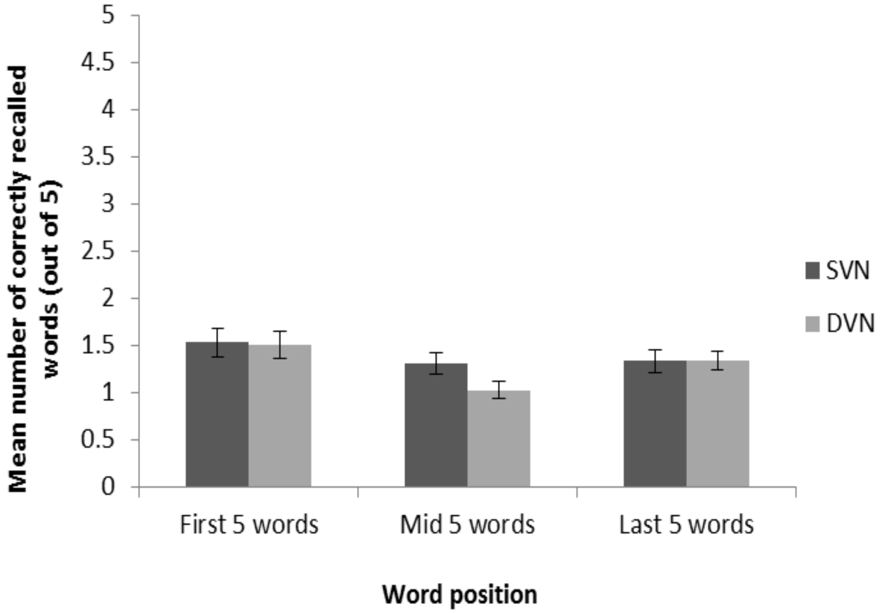

Figure 2: The mean number of correctly recalled words, by distraction condition and word position. Bars represent standard error of the mean

Index of recall difficulty by word position and correct recall

Because Glenberg et al. (1998) defined task difficulty in terms of correct recall, pairwise comparisons of correct recall under the control condition SVN were examined to identify any significant differences between words recalled from first, mid and last word-list positions. The expectation was that there would be fewer SVN correct mid-words than SVN first or last- words. However, analysis showed there was no statistical difference in correct recall between first, mid and last-words under

SVN, $F(2,72) = 1.71$, $MSe = 0.009$, $p = .305$. thus there is no statistical evidence with which to categorise recall of words from the three word positions as having distinctly different levels of difficulty. At best, mid-words are numerically more difficult to recall than first words but no different to last words. If recall difficulty (as indexed by correct recall) is a determinant of a distraction effect the effect seen for mid-list words should also be evident (at least numerically) for last- words because last words have the same level of difficulty as mid words. However, the effect is only seen for mid words.

Correct recall of lists 1, 3 and 5

The next analysis excludes recall of words from the second and fourth presented lists and compares correct recall between the average of the first, third (mid) and fifth (last) lists presented. Figure 3 below shows means and standard errors of a 2 (Distraction: DVN, SVN) X 3 (list order: first, mid, last list) X 3 (Word Position: recall of first 5, mid 5, last 5 words in each list) repeated measures ANOVA on correct recall. There is no main effect of distraction, $F(1,36) = 0.26$, $MSe = 0.05$, $p = .614$, partial $\eta^2 = .007$. However, there is a weak (as evidenced by partial eta-squared) main effect of list order, $F(2,72) = 3.89$, $MSe = 0.05$, $p = .025$, partial $\eta^2 = .09$ and a weak main effect of word position, $F(2,72) = 3.31$, $MSe = 0.04$, $p = .042$, partial $\eta^2 = .08$.

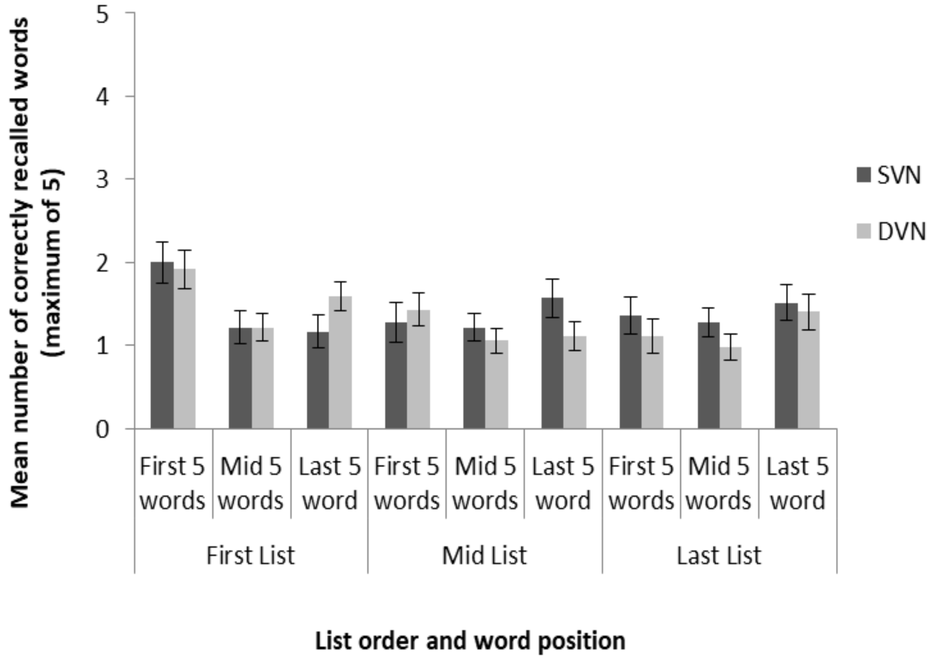

Figure 3: Mean number of correctly recalled words for first, mid and last presented lists under SVN and DVN

There is no significant interaction between distraction and list order, *F*(2,72) = 1.70, *MSe* = 0.05, *p* = .190, partial η^2 = .045 or between distraction and word position, *F*(2,72) = 0.34, *MSe* = 0.04, *p* = .716, partial η^2 = .01, or There is an interaction between list order and word position, *F*(4,144) = 2.68, *MSe* = 0.04, *p* = .034, partial η^2 = .07 but no three-way interaction between distraction, word position and list order, *F*(4,144) = 1.29, *MSe* = 0.05, *p* = .276, partial η^2 = .04.

Analysis of the simple effects of list order shows a list order effect on word order, *F*(2, 35) = 8.77, *p* = .001, partial η^2 = 0.33. Pairwise comparisons between word positions in the first presented list show significantly more words from the first-5-word-positions than the mid-5 (*p* = .008) or last-5 positions (*p* = .009) were recalled. However, this pattern was not repeated for words recalled from the mid or last presented lists. There was no significant difference in the number of words recalled between each of the three word-positions for either the mid presented list (first-5 words compared to mid-5 words, $p = .625$; first-5 words compared to last-5 words, $p = .223$) or the last presented list, (first-5 words compared to mide-5 words, p.885; first-5 words compared to last-5 words, $p = .419$). This implies an overall primacy effect whereby participants were most likely to correctly recall words presented early on in the experimental trial than in the middle or at the end of the trial regardless of distraction condition

Index of recall difficulty by word position, list order and correct recall

Correct recall under the control condition SVN was again examined but this time both word position and list order were taken into account.

There was no main effect of list order, $F(2, 72) = 0.216$, $MSE = 0.05$, $p = .806$, partial $\eta^2 = 0.006$ or word position, $F(2, 72) = 0.859$, $MSE = 0.42$, $p = .428$, partial $\eta^2 = 0.023$. However, there was an interaction between list order and word position, $F(4, 144) = 2.481$, $p = .046$, partial $\eta^2 = 0.64$. Participants recalled more words from the first-5 word positions than mid-5 or last-5 positions for the first presented list $F(2, 35) = 5.82$, $p = .007$, partial $\eta^2 = 0.25$. In contrast, there was no significant difference in correct recall between word positions for the mid $F(2, 35) = 0.746$, $p = .481$, partial $\eta^2 = 0.041$ or last presented list, $F(2, 35) = 0.518$, $p = .600$, partial $\eta^2 = 0.29$. Thus in terms of indexing difficulty, there was no evidence to suggest that recall of words from mid-5 presented words of either first, mid or last presented lists were any more difficult to recall than words from other word positions.

Therefore, when recall difficulty in Experiment 1 is indexed by correct recall, there is little support for Glenberg's (1997) theory that task difficulty drives the effect pattern of distraction. This is because the index of task difficulty in these data suggests that participants found recall of both the mid-5 and last-5 words of the first presented list more difficult to recall than words from the first-5 word positions. If difficulty drives the distraction effect, correct recall of mid-5 and last-5 words of the first list should be relatively impaired by distraction compared to recall of first-5 words, but, this is not the case. In addition, there was no evidence to suggest that under control conditions, participants found mid-5 words overall were any more difficult to recall than first-5 or last-5 yet, recall under distraction clearly showed that correct recall for mid-5 words across all lists was impaired. If the task difficulty of correctly recalling the mid-5 words of word-lists presented in this experiment was not difficult enough for a distraction effect then no detrimental effect of distraction on correct recall would have been detected. If the task difficulty of recalling mid-5 words in this experiment was too difficult for a distraction effect, again no detrimental effect of distraction would have been detected.

2.3.2.3 Incorrect recall

Incorrect recall of words cannot be attributed to a particular word position within a list and so analysis of incorrect recall does not include word-position as a factor. Table 2 shows that the distribution of incorrect data does not follow a normal distribution and although attempts to normalise the incorrect distribution using Log_{10} (score+1) was generally successful in terms of skew and kurtosis, the distribution was still significantly different to that of a normal distribution when analysed with the K-S test. Therefore, as a matter of caution non-transformed data was analysed using non-parametric testing.

2.3.2.3.1 *Normality testing on Experiment 1 incorrect recall data*

Table 2 shows the result of normality testing on data for incorrect recall before and after data transformation. Transformation reduced skew and kurtosis parameters to below 1.96 for the majority of sub-groups therefore, parametric testing was carried out on transformed data

Table 2: Experiment 1 normality testing of incorrect recall data

Distraction Condition	List Order	Skew z-score		Kurtosis z-score	
		Non-transformed	Log_{10} (score+1) transformed	Non-transformed	Log_{10} (score+1) transformed
SVN	1	3.08*	1.01	2.46*	-1.34
	2	2.88*	1.88	0.18	-1.46
	3	4.42*	1.82	4.56*	-0.64
	4	2.38*	1.70	-0.21	-1.77
	5	3.75*	3.04*	1.07	-0.34
DVN	1	2.61*	1.70	-0.06	-1.59
	2	4.05*	0.76	1.96*	-0.51
	3	3.99*	1.51	1.16	-1.34
	4	3.03*	1.78	0.53	-1.39
	5	5.56*	2.26*	8.03*	-0.10

**significantly different from a normal distribution, alpha .05*

2.3.2.3.2 *Analysis of overall incorrect recall*

Numerically, more words were incorrectly recalled under DVN (*M*=0.71, *SD*=0.58) than SVN (*M*=0.54, *SD*=0.43) however, Wilcoxon-signed ranks shows this difference does not reach significance, z = - 1.705, *p* = .088.

2.3.2.3.3 *Analysis of incorrect recall of lists 1, 3 and 5*

A 2 (Distraction: DVN, SVN) X 3 (list order: first two lists; last two lists) repeated measures design was analysed using Friedman's ANOVA with exact significance and showed no effect of either distraction or list order on incorrect recall,

$\chi^2(5) = 8.831$, $p = .164$. Figure 4 shows the mean number of incorrectly recalled words across lists.

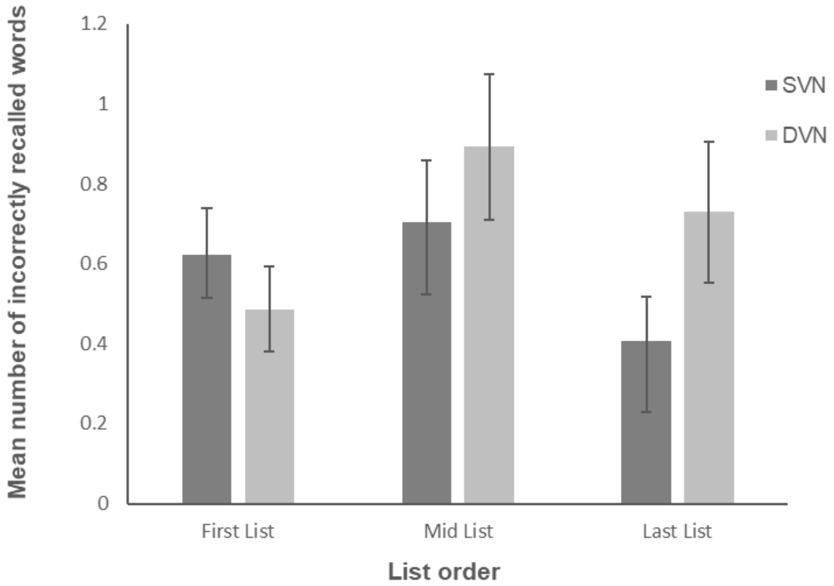

Figure 4: Mean number of incorrectly recalled words from first, mid and last lists. Error bars denote standard error of the mean

Index of recall difficulty by list order and incorrect recall

Numerically, incorrect recall under the control condition SVN is higher for the first and mid list than for the last list. However, analysis of incorrect recall across first, mid and last lists using Friedman's ANOVA shows no significant difference between the lists, $\chi^2(2) = 3.095$, p =.213. Therefore, difficulty cannot be indexed by incorrect recall.

In summary, Experiment 1 replicates the distraction effect on correct recall of mid-list words reported by Glenberg et al using a semantically neutral distraction.

However, there is no evidence of an effect on correct recall across the full list and no evidence of an effect based on recall difficulty as indexed by correct recall; this raises theoretical questions and opens avenues for further investigation.

At first glance, these data appear to support the theoretical position advocated by Glenberg et al. and outlined in the introduction, that distraction impairs moderately difficult recall. This is because recall of mid-words is commonly reported to be poorer than recall of words from other positions within the list and it is therefore tempting to assume that Experiment 1's mid-lists words were more difficult to recall than other words. However, analyses of the different thirds of the list (first, mid and last 5 words) suggest that difficulty as indexed by mean correct recall in the SVN condition, does not predict the likelihood of detecting a distraction effect. Across all lists, mid words were no more difficult to recall than first or last words under SVN. Thus, the first and final list items were as hard to recall as the mid-list items (the latter being consistent with the use of a post-list filler task to remove recency effects) but showed no distraction effect. This is at odds with Glenberg et al.'s theoretical stance on the distraction effect: should task difficulty be the central explanation for the effect, there would be an effect on all tasks of the *same* difficulty. First and last words were as difficult as mid words. If the task was not difficult enough, there should be no effect on mid list recall. If the task was difficult enough to elicit an effect, it should be detected not just for mid recall but,for first and last as well. However, this was not the case.

Whilst Experiment 1 was able to replicate the pattern reported by Glenberg et al (1998), the overall pattern of findings is not consistent with the idea that visual distraction produces general memory impairment, or even an impairment that particularly affects difficult-to-recall items. Although the effect might be related to the build-up of interference over multiple lists, this was not demonstrated here. However, the lack of evidence from these data does not give a compelling argument against a build-up of interference explanation, because of the within-subject manipulation of distraction type, which meant that the first list of a particular condition was not necessarily the first list studied. For instance, a participant may have recalled the first list under EC instructions, the second under DVN, and the third under SVN. Each of these would be the first list in each condition, but the amount of interference would not be equal. Consequently, Experiments 2 and 3 explored two potential reasons why mid-list items might be susceptible to distraction in a multiple-list paradigm.

2.4 Experiment 2

Whilst the lack of a difference between the mid- and final-list items suggests that the difficulty of retrieval was not key to the distraction effect observed, this is not definitive because the argument rests upon a null effect. Consequently, this experiment explored difficulty using a different manipulation. An alternate method for reducing the quality of memories to be retrieved is to impair their encoding. Thus, Experiment 2 included a manipulation of the presentation rate of word-list items. Participants either had 2s per item (as in Experiment 1), or 0.5s per item, with the clear expectation from findings that these items would be harder to recall, and so more susceptible to distraction. Previous researchers report that short versus longer presentation durations of list-items, leads to poorer memory. Stones (1973) verbally presented participants with lists of words grouped in threes. Each word within the triplet was presented for 2s each, but Stones manipulated the time between each triplet presentation to be either 1s or 3s. Participants recalled significantly fewer words under the faster 1s rate. Ratcliff and Murdock (Experiment 2, 1976) tested the effect of presentation duration on recognition accuracy. Participants studied a list of 15 2-syllable common nouns presented for fast (0.6s) medium (0.9s) and slow rates (1.5s) Participants were later asked which words they recognised from the target list from a test list of 15 old and 15 new words. Recognition accuracy was highest for slow presentations and lowest for fast presentations.

The second potential explanation for the effects of distraction on mid-list items stems from the observation that the effect was stronger for later lists. The standard explanation for poorer recall with multiple lists is that there is a build-up of pro-active interference (Keppell & Underwood, 1962), such that the later lists become increasingly difficult to distinguish from previous lists. Thus, a possible modification of the vulnerable memory hypothesis is that distraction impairs the ability to distinguish between competing memories: distraction does not impair recall when there is little competition, but it does so as the trials progress. In order to explore this idea, greater control of the order of presentation of lists in each condition was needed. Consequently a between-subjects manipulation of distraction was designed, so that performance on the first list under each distraction condition could be analysed, free from any potential interference from a previous list recalled under a different condition.

A secondary prediction that derives from an account based upon interference is that the distraction effects across lists should be removed if the interference is reduced by a change of list structure. Consequently, Experiment 2 used the release from proactive-interference paradigm (Loess, 1968; Wickens, Born, & Allen, 1963), in which the first four successive lists all contained items from the same semantic categories, but the fifth list consisted of items from different categories. Thus, the interference account would predict increasing effects of distraction across the first four lists, but less distraction for the fifth list. Of course if list order per se (rather than interference) was key to the effect previously seen in Experiment 1, perhaps as a result of fatigue or loss of motivation as the study progressed, then the distraction effect would be expected to grow for list five, not reduce.

The EC manipulation was not included in this study because the research question here is not whether eye-closure improves memory but, whether distraction impairs memory under conditions of retrieval-difficulty.

2.4.1 Method

2.4.1.1 Power

Experiment 2 explored the main effect on word recall of DVN compared to SVN, in addition to exploring interactions with word presentation rate, word position within a list and order of word-list. The distraction condition was presented as a between variable. Power analysis to examine the main effect and interactions of distraction, with an effect size of f = 0.4 and power 0.80, indicated a total sample size of 54.

2.4.1.2 Participants.

Sixty-four participants (38 females), average age 24.6 years (*SD*= 10.02) took part for course credit or as a paid volunteer.

Design and Materials. This experiment followed a 2 (Presentation rate: 0.5s vs 2s) x 3 (Word Position: first, mid, last items) x 5 (List Order: one to five) x 2 (Distraction: DVN vs SVN) mixed design with repeated measures on all but the distraction conditions. For this experiment and throughout the thesis, participants were randomly assigned to conditions presented as between factors.

In order to counterbalance the lists, it was necessary to move from 15- to 16-item word lists. Ten 16-word high-structured word-lists were created for this experiment from exemplars from 16 categories from Van Overschelde, Rawson and Dunlosky's (2004) semantic association norms. These were used to create two sets of five lists, both consisting of four interference lists (lists 1-4) and a release from interference list (list 5). A Proactive Interference design involves presenting multiple lists of semantically associated words with the last presented list consisting of words *not* semantically associated with those in the earlier lists (for example, see Keppel & Mallory,1968). Each interference list consisted of four exemplars from four different semantic categories (e.g. four professions, four fruits, four kinds of furniture, four animals). The fifth list consisted of four exemplars each from a different set of four categories. Please see Appendix III for an example. This process was repeated to create a second set of five lists, using different categories. For each participant, allocation of categories and items to list were randomly selected without replacement from the set of 16 categories. Mid-list items were defined as the middle six items, rather than five, with scores adjusted (by 5/6) when compared across list portions.

2.4.1.3 Procedure.

The same basic procedure to Experiment 1 was followed, with participants studying and verbally recalling 10 successive lists, with the same filler task between study and test and participants unable to see the experimenter's face throughout encoding and recall. Unlike Experiment 1, participants always received the same distraction condition during the retrieval period, either SVN or DVN. Additionally there was a manipulation of presentation rate. Participants studied five consecutive word-lists with words presented for 0.5s each (fast presentation) and five word-lists with words presented for 2s (slow presentation), counterbalanced for order across participants.

2.4.2 Results and Discussion

Experiment 2 was designed to explore two possible explanations for why DVN in Experiment 1 led to impaired mid-list recall of multiply presented lists: mid-list words are poorly encoded relative to the rest of the word-list; mid-list words are more susceptible to list interference than words in the rest of the list and either or both of these issues render mid-list recall vulnerable to distraction. In order to investigate these possibilities, word presentation rate and list interference were manipulated. It was anticipated that presentation rates of 0.5 seconds versus two seconds per word would lead to poorer encoding and therefore poorer recall and that repeatedly presenting same semantic category words across lists one to four (with a change in category for list five) would lead to a build-up of inter-list interference. In order to test the success of these manipulations, analysis first looked at the effect of presentation rate and list position (1 to 5) on overall correct recall.

2.4.2.1 Correct recall

2.4.2.1.1 Normality testing on Experiment 2 correct recall data

Experiment 2 and collection of correct recall data followed a 2 (Presentation rate: 0.5s vs 2s) x 3 (Word Position: first, mid, last items) x 5 (List Order: one to five) x 2 (Distraction: DVN vs SVN) design with repeated measures on all but the last factor. Tables 3 and 4 show the results of normality testing on correct recall data collected under SVN and DVN conditions. Skew and kurtosis z-scores showed that these parameters are within the boundaries of a normal distribution for 51 of 60 subgroups therefore parametric testing was carried out without performing data transformation.

Table 3: Experiment 2 normality testing of correct recall data under SVN

Distraction Condition	Presentation speed	List order	Word position	Skew z-score	Kurtosis z-score
SVN	Fast	1	First	1.35	-0.06
			Mid	-0.12	-1.2
			Last	-0.35	-1.04
		2	First	0.89	-0.76
			Mid	2.72*	1.01
			Last	1.32	-0.19
		3	First	1.18	-1.36
			Mid	0.49	-1.54
			Last	2.01*	1.40
		4	First	2.15*	1.05
			Mid	1.82	-0.40
			Last	2.50*	1.00
		5	First	2.30*	1.30
			Mid	1.16	-1.01
			Last	1.06	-0.35
SVN	Slow	1	First	-0.32	-0.82
			Mid	1.53	0.20
			Last	0.59	-0.59
		2	First	1.38	0.09
			Mid	0.53	-1.55
			Last	1.46	-0.30
		3	First	0.59	-1.22
			Mid	0.81	-1.11
			Last	2.01*	0.38
		4	First	0.23	-1.24
			Mid	1.10	1.36
			Last	1.01	-0.72
		5	First	0.37	-1.57
			Mid	-0.23	-1.37
			Last	1.17	-1.13

Table 4: Experiment 2 normality testing of correct recall data under DVN

Distraction Condition	Presentation speed	List order	Word position	Skew z-score	Kurtosis z-score
DVN	Fast	1	First	-0.37	-0.94
			Mid	2.70*	2.06*
			Last	1.27	-0.10
		2	First	1.21	-1.08
			Mid	1.58	0.13
			Last	0.41	-0.77
		3	First	1.13	-0.51
			Mid	1.62	-0.41
			Last	1.65	-0.09
		4	First	3.06*	2.00*
			Mid	2.89*	0.98
			Last	1.57	-0.69
		5	First	0.97	1.20
			Mid	1.06	-0.35
			Last	0.84	-0.61
DVN	Slow	1	First	0.26	-0.10
			Mid	1.27	0.01
			Last	-0.03	-0.36
		2	First	1.66	-0.23
			Mid	0.87	-0.27
			Last	0.68	-1.21
		3	First	0.55	-0.66
			Mid	0.59	-0.92
			Last	1.39	0.38
		4	First	0.66	-1.19
			Mid	-0.19	0.52
			Last	0.18	0.50
		5	First	-0.027	-1.29
			Mid	1.14	0.38
			Last	0.34	-0.67

2.4.2.1.2 Analysis of correct recall

Correct recall means and standard errors are reported below in Table 5. A 2 (Presentation rate: 0.5s vs 2s) x 3 (Word Position: first, mid, last items) x 5 (List Order: one to five) x 2 (Distraction: DVN vs SVN) mixed ANOVA was carried out with repeated measures on all but the last factor.

Table 5: Experiment 2, the mean number of correctly recalled words under SVN and DVN per list for fast and slow presentations. Standard error of the mean in italics.

		SVN						DVN					
		First	*SE*	Mid	*SE*	Last	*SE*	First	*SE*	Mid	*SE*	Last	*SE*
Fast Presentation	List 1	1.31	*0.20*	1.17	*0.17*	1.47	*0.18*	2.00	*0.20*	1.30	*0.17*	1.69	*0.18*
	List 2	1.19	*0.20*	0.78	*0.17*	1.22	*0.17*	1.44	*0.20*	1.25	*0.17*	1.22	*0.17*
	List 3	1.19	*0.20*	1.07	*0.15*	0.81	*0.15*	1.22	*0.20*	0.78	*0.15*	1.06	*0.15*
	List 4	0.97	*0.18*	1.02	*0.17*	0.94	*0.18*	1.09	*0.18*	0.73	*0.17*	1.00	*0.18*
	List 5	1.16	*0.19*	0.83	*0.16*	1.28	*0.18*	1.44	*0.19*	1.17	*0.16*	1.34	*0.18*
Slow Presentation	List 1	2.56	*0.24*	2.06	*0.17*	2.38	*0.23*	2.50	*0.24*	2.37	*0.17*	2.31	*0.23*
	List 2	1.97	*0.20*	1.72	*0.19*	1.66	*0.22*	2.25	*0.20*	1.80	*0.19*	1.88	*0.22*
	List 3	1.88	*0.23*	1.38	*0.18*	1.59	*0.22*	1.59	*0.23*	1.46	*0.18*	1.75	*0.22*
	List 4	1.72	*0.23*	1.25	*0.18*	1.25	*0.17*	1.50	*0.23*	1.51	*0.18*	1.69	*0.17*
	List 5	2.00	*0.25*	1.74	*0.20*	1.84	*0.23*	2.16	*0.25*	2.16	*0.20*	2.31	*0.23*

There was a weak main effect of distraction on correct recall where overall, more correct words were recalled under DVN than SVN $F(1,62) = 4.14$, $MSe = 0.09$, $p = .046$, partial $\eta^2 = .06$. This unexpected finding is considered in the discussion section. In addition, there was a strong main effect of presentation rate where overall, recall was better for slower presentation rates, $F(1,62) = 194.2$, $MSe = 1.22$, $p<.001$, partial $\eta^2 = .76$. There was a main effect of word position, $F(2,124) = 8.41$, $MSe = 1.49$, $p < .001$, partial $\eta^2 = .12$ and a main effect of list order, $F(4,248) = 32.48$, $MSe = 29.41$, $p < .001$, partial $\eta^2 = .34$.

There was no interaction between distraction and presentation rate, $F(1,62) = .004$, $MSe = 0.01$, $p = .95$, partial $\eta^2 < .001$, no interaction between distraction and word position, $F(2,124) = 0.09$, $MSe = 1.49$, $p = .92$, partial $\eta^2 < .001$ and no interaction between distraction and list order, $F(4,248) = 1.56$, $MSe = 0.91$, $p = .19$, partial $\eta^2 = .025$.

There were no interactions between presentation rate and word position, $F(2,124) = 0.16$, $MSe = 1.40$, $p = .86$, partial $\eta^2 = .002$ or between presentation rate and list order, $F(4,248) = 2.01$, $MSe = 1.49$, $p = .094$, partial $\eta^2 = .0.03$.

There was no three-way interaction between presentation rate, word position and list order, $F(8,496) = 0.34$, $MSe = 1.18$, $p = .704$, partial $\eta^2 = .011$. There were no three-way interactions between distraction, presentation rate and list order, $F(4,248) = 0.75$, $MSe = 1.07$, $p = .56$, partial $\eta^2 = .012$; distraction, presentation rate and word position, $F(2,124) = 1.86$, $MSe = 1.40$, $p = .160$, partial $\eta^2 = .029$ or, distraction, word position and list order, $F(8,496) = 0.60$, $MSe = 1.14$, $p = .780$, partial $\eta^2 = .010$.

Finally, there was no four-way interaction between the factors, $F(8,496) = 0.69$, $MSe = 1.18$, $p = .70$, partial $\eta^2 = .011$.

Post-hoc pairwise analysis of word position shows fewer correct mid-words were recalled than first ($p = .001$) but, shows no significant difference between mid-words and last words ($p = .050$) or between first and last words ($p = .228$). The multivariate effect of word position within each level combination of other factors in the analysis, based on pairwise comparisons is significant, $F(2,61) = 28.5$, $p = .001$, partial $\eta^2 = .19$.

Post hoc pairwise analysis of list order shows a linear drop in correct recall across lists one to four but an increase for list 5 where correct recall of list 5 is lower than that for list 1 ($p < .001$), no different from that for list 2 ($p > .99$) but greater than that for lists 3 ($p = .001$) and 4 ($p < .001$). The multivariate effect of list order based on pairwise comparisons is significant, $F(4,59) = 28.5$, $p < .001$, partial $\eta^2 = .66$. The linear drop in recall across lists one to four, with an increase in list five, reflects the process of proactive interference. Each of lists one to four consists of repeated exemplars from the same semantic category but list five consists of exemplars from different semantic categories. The pattern of recall from lists one to four suggests that participants found it increasingly difficult to recall whether an exemplar had been presented in the target list or in an earlier list. Thus reflecting a build-up of list interference, that is, a build-up of PI. However, the relatively improved recall of list five, which had no exemplars from previous semantic categories, suggests participants no longer suffered from the same interference. Thus, list five shows release from PI.

Given that the manipulations produced the expected effects on recall, such as showing a typical pattern of release from PI, the effect of distraction was unexpected. Furthermore, distraction did not reliably interact with any of the other factors in any combination and nor were there any other interactions.

2.4.2.2. Incorrect recall

2.4.2.2.1 Normality testing on Experiment 2 incorrect recall data

Experiment 2 and collection of incorrect recall data followed a 2 (Presentation rate: 0.5s vs 2s) x 5 (List Order: one to five) x 2 (Distraction: DVN vs SVN) mixed design with repeated measures on all but the last factor. Skew and kurtosis z-scores reported below in Table 6 suggest that the distributions of incorrect recall data are non-normal. Skew and kurtosis parameters were so far removed from a normal distribution that no attempt was made to transform the data and instead, non-parametric analysis was carried out.

Table 6: Experiment 2 normality testing of incorrect data recall

Distraction Condition	Presentation speed	List order	Skew z-score	Kurtosis z-score
SVN	Fast	1	4.06*	1.08
		2	2.38*	0.06
		3	3.20*	0.71
		4	4.22*	3.64*
		5	3.45*	0.05
	Slow	1	8.75*	16.71*
		2	2.92*	-0.70
		3	2.46*	-0.06
		4	6.68*	10.19*
		5	13.65*	39.54*
DVN	Fast	1	5.44*	5.26*
		2	3.73*	2.31*
		3	3.62*	2.76*
		4	3.00*	2.15*
		5	3.44*	1.39
	Slow	1	4.64*	3.05*
		2	5.29*	6.99*
		3	2.90*	0.61
		4	4.13*	3.77*
		5	4.33*	2.90*

2.4.2.2.2 Analysis of incorrect recall

A 2 (Presentation rate: 0.5s vs 2s) x 5 (List Order: one to five) x 2 (Distraction: DVN vs SVN) mixed design experiment with repeated measures on all but the last factor was analysed, the means are reported below in Table 7.

Table 7: Experiment 2, the mean number of incorrectly recalled words under SVN and DVN per list for fast and slow presentations. Standard error of the mean in italics.

		SVN		DVN	
		Mean	*SE*	Mean	*SE*
Fast Presentation	List 1	0.19	*0.09*	0.25	*0.09*
	List 2	0.47	*0.13*	0.59	*0.13*
	List 3	0.56	*0.17*	0.84	*0.17*
	List 4	0.47	*0.16*	0.91	*0.16*
	List 5	0.22	*0.09*	0.38	*0.09*
Slow Presentation	List 1	0.13	*0.1*	0.31	*0.1*
	List 2	0.25	*0.13*	0.53	*0.13*
	List 3	0.5	*0.14*	0.69	*0.14*
	List 4	0.44	*0.19*	0.81	*0.19*
	List 5	0.06	*0.09*	0.31	*0.09*

The first analysis examined the effect of distraction condition, as a between factor, on incorrect recall. A Man-Whitney test showed a main effect of distraction where overall, more errors were produced under DVN than SVN, $U = 336.50$, $z = -2.358$, $p = .018$, $r = .295$.

The next analysis examined the effect of distraction condition on incorrect recall of fast versus slow presented words. A Wilcoxon signed ranks test suggested distraction condition did not have a selective effect on presentation rate. Under DVN, there was no significant difference between the number of incorrectly recalled fast (*Mdn* = 0.6) and slow (*Mdn* = 0.4) presented words, $z = -0.625$, $p = .532$. Under SVN, there was no significant difference between the number of incorrectly recalled fast (*Mdn* = 0.4) and slow (*Mdn* = 0.2) presented words, $z = -1.643$, $p = .100$.

Finally, an analysis examined the effect of distraction condition on incorrect recall across lists 1 to 5. A Friedman's ANOVA suggested that the pattern of incorrect recall building across lists 1 to 4 and reducing for list 5, as seen in Table 7, was significant under both DVN, $X^2(4) = 26.972$, $p < .001$ and SVN, $X^2(4) = 19.542$, $p = .001$, recall conditions. Four follow-up analyses using a Bonferroni corrected alpha of (.05/4) .0125, confirmed that the number of incorrectly recalled words from list 3 was greater than the number from both List 1 and from List 5: under DVN List 1 versus 3, $z = 3.382$, $p = .001$ and List 3 versus 5, $z = 3.861$, $p < .001$; under SVN List 1 versus 3, $z = 2.814$, $p = .005$ and List 3 versus 5, $z = 3.331$, $p = .001$.

Overall, distraction increased overall incorrect recall compared to control condition but, this increase did not appear to be driven by word-presentation rate or by a build-up of list interference.

2.4.2.3 Type of error

Because more errors were made under DVN than SVN but there were no interactions of distraction with other factors, a follow-up analysis examined the type of error made. Errors were coded as 'previous list' errors of they had been presented in any earlier list and as 'other' if they had not. A total of 267 errors were recorded across participants and lists. Twenty-eight percent of these errors (75) were 'other' errors. Whilst an initial attempt was made to categorise other errors in terms of semantic relatedness to the target list, this method was abandoned due to the overwhelming subjectivity of the task. For example, should a participant have been presented with the category of fruit and an exemplar included 'Strawberry', an error may include the word 'raspberry' which is clearly semantically related to the word category however, errors such as 'shortcake' that at first appear to be unrelated, may in fact be related because the participant was reminded of a popular child's character named 'Strawberry shortcake'. Figure 5 shows the proportion of each type of error under each distraction condition. A chi-squared test showed no significant association between error-type and distraction condition, $\chi^2(1) = 1.70$, $p = .21$, Cramer's V = .08.

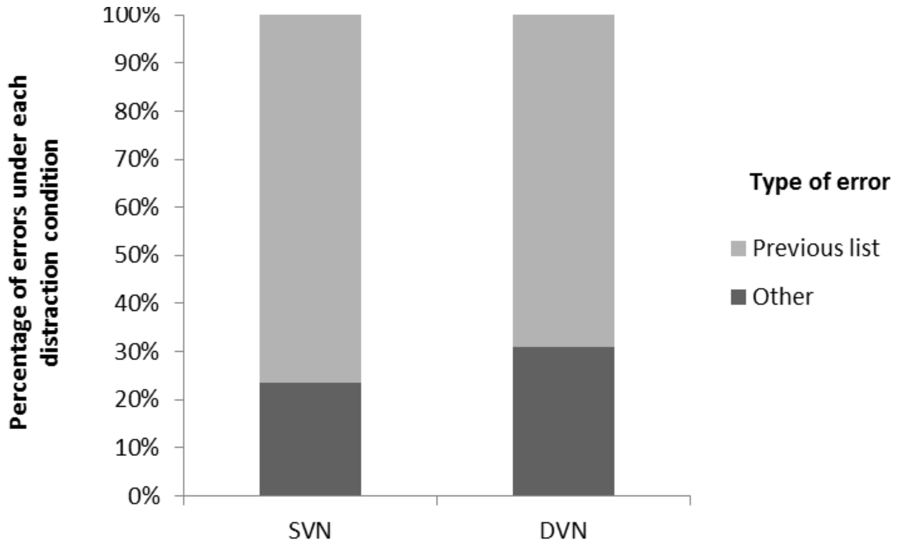

Figure 5: Percentage of error-type under each distraction condition

In summary, although Experiment 2's manipulations of presentation rate and list interference manipulations were successful in moderating recall performance, they did not interact with the effects of distraction. Moreover, the main effects of distraction did not replicate that found in Experiment 1. Whilst distraction once again increased errors, it also increased correct recall. In fact, it appeared that the magnitude of the effects on correct and incorrect recall was approximately the same, with an increase of Cohen's *d* = 0.54 in correct recall, and Cohen's *d* = 0.63 for errors. Thus, despite the increase in errors, there is little evidence to support the idea that DVN causes impairment of memory, but rather that it shifts willingness to report an answer that comes to mind. That is, participants seemed more likely to give an answer per se under DVN, regardless of whether the answer was correct or incorrect. These patterns were not moderated by position of the words in the list. Thus these data do not appear to be consistent with inter-list interference and poor encoding as explanations for the distraction effect seen for mid-list items in Experiment 1 and seen in Glenberg et al.'s(1998) study.

One difference between the studies that showed an impairment of recall from distraction, and Experiment 2 is that the previous studies used entirely unstructured lists containing unrelated items both within- and across-lists. In contrast, Experiment 2 used list structure as a means of manipulating interference, and consequently used a restricted set of items. One possibility is that participants utilised this structure in their retrieval strategies and were able to overcome any environmental distraction. Slightly under a third of errors were categorised as 'other' and not as previous list errors. Although speculative, it is possible that these errors were semantically related to the list structure through participants' idiosyncratic strategies of encoding/retrieval. Consequently, Experiment 3 addressed the role of list structure, whilst controlling for item effects.

2.5 Experiment 3

In Experiment 2, interference came from inter-list repeated categories. However, each list had a high degree of structure because several exemplars from the same semantic category were presented. That is, for a particular participant, each of the first 4 lists contained multiple exemplars from the same categories. So, although participants were clearly affected by the build-up of list interference (correct recall decreased across each set of lists 1 to 4 and incorrect recall increased), they may have adopted a recall strategy that used their knowledge of the list structure (i.e. the semantic categories contained in each list) which made them less susceptible to the negative effects of distraction. Therefore, Experiment 3 manipulated the degree of list structure (and cross-list similarity) whilst controlling for item effects by repeatedly sampling the same pool of 16 items from 16 categories. In the high structure condition, participants saw four exemplars from four categories successively for four lists, repeating this (with different categories) four times overall. In contrast, the low structure condition saw one exemplar from each of the 16 categories for 16 trials. An example of high and low list structure is given in Appendix IV. Thus, across all lists, both conditions were matched for the items studied. However, the high-structure condition resembled the structure used in Experiment 2, with the expectation that a build-up of proactive interference would be observed across the sets of four lists (with release from interference between sets). In contrast, the low structure condition resembled Experiment 1, in that the lists were as unstructured as they could be, given the constraint that the same set of items was used. If structure is the key difference between the first two studies, there should be a greater distraction effect for the unstructured condition than for the structured condition.

2.5.1 Method

2.5.1.1 Power calculation

Experiment 3 explored the main effect on word recall of DVN compared to SVN, in addition to exploring interactions with list structure, word position within a list and order of word-list. The distraction condition was presented as a within variable and power analysis was carried out based on detecting a main effect of distraction, with d = .08 and power = 0.95. Analysis indicated a total sample size of 23. As an oversight, power analysis was not extended to include interactions. This potential limitation is discussed later in Chapter 5 alongside the meta-analysis of Experiment 1 to 8's effect sizes.

2.5.1.2 Participants

Thirty-six participants (23 females), average age 22.6 years (*SD*= 8.86) took part for course credit or as a paid volunteer.

2.5.1.3 Design and Materials

A 2 (List structure: low vs high) x 3 (Word Position: first, mid, last items) x 5 (List Order 1-4) x 2 (Distraction: DVN vs SVN) ANOVA with repeated measures on all but the first factor was the design for this Experiment.

The same 16 category word-lists used in Experiment 2 were used to create a set of 16 high and 16 low structured word-lists, each consisting of 16 words. High structured lists were created in the same way as experimental lists one to four in Experiment 2, and thus constituted lists for which interference was expected to build up over the four lists. Low structured lists were created by randomly selecting, without replacement, one word from each of the 16 category word-lists.

2.5.1.4 Procedure

Participants studied and then recalled either 16 high or 16 low structured-lists, under the same conditions as Experiment 1. The nature of the distraction was held constant for blocks of four lists, and then switched, with this repeated until all 16 lists had been tested, with participants recalling eight lists under DVN and eight under SVN, with order counterbalanced across participants. Otherwise, the experimental conditions replicated Experiment 2.

2.5.2 Results and Discussion

2.5.2.1 Correct recall

2.5.2.1.1 Normality testing on Experiment 3 correct recall data

Experiment 3 and collection of correct recall data followed a 2 (List structure: low vs high) x 3 (Word Position: first, mid, last items) x 4 (List Order 1-4) x 2 (Distraction: DVN vs SVN) ANOVA deign with repeated measures on all but the first factor. Tables 8 and 9 show the results of normality testing on correct recall under SVN and DVN conditions respectively. The large majority of data subgroups (43 out of 48) showed non-significant deviations from normal distributions therefore, data was not transformed and statistical analysis was carried out using parametric tests, but with caution.

Table 8: Experiment 3 normality testing of correct recall data, SVN condition

List Structure	List order	Word position	Skew z-score	Kurtosis z-score
High	1	First	1.20	0.87
		Mid	-0.53	0.02
		Last	0.41	-0.68
	2	First	-0.13	-0.54
		Mid	0.49	-0.93
		Last	0.26	-0.17
	3	First	0.72	-0.36
		Mid	0.65	-0.07
		Last	-0.90	-0.52
	4	First	1.25	0.58
		Mid	2.47*	1.94
		Last	0.87	-0.55
Low	1	First	-0.05	-0.96
		Mid	1.20	0.87
		Last	0.54	-0.04
	2	First	0.04	-1.4
		Mid	1.31	0.40
		Last	0.50	-0.81
	3	First	-0.44	-0.90
		Mid	1.35	0.02
		Last	0.49	-0.71
	4	First	2.23*	0.79
		Mid	1.41	-0.18
		Last	0.83	-0.58

Table 9: Experiment 3 normality testing of correct recall data, DVN condition

List Structure	List order	Word position	Skew z-score	Kurtosis z-score
High	1	First	-0.69	-0.91
		Mid	-2.32*	-1.30
		Last	-0.81	-1.35
	2	First	-1.28	-0.08
		Mid	-0.42	-0.86
		Last	1.54	0.82
	3	First	1.03	-0.90
		Mid	2.43*	2.03*
		Last	1.41	0.61
	4	First	-0.04	-0.78
		Mid	0.39	-0.38
		Last	-0.52	-0.55
Low	1	First	1.56	0.69
		Mid	2.06*	0.78
		Last	0.29	-0.36
	2	First	0.49	-1.27
		Mid	0.71	-0.55
		Last	0.67	-0.32
	3	First	0.69	-1.36
		Mid	1.14	-0.71
		Last	0.12	-1.00
	4	First	0.94	-0.30
		Mid	1.21	-0.47
		Last	0.16	-1.03

2.5.2.1.2 Analysis of correct recall

Experiment 3 manipulated inter- and intra- list structure: it was anticipated that high-structured lists would build-up inter-and intra-list interference and impair recall (as was found in Experiment 2) to a progressively greater degree across lists one to four than low-structured lists.

The first analysis looked at correct recall, and the means are reported in Table 10. A 2 (List structure: low vs high) x 3 (Word Position: first, mid, last items) x 4 (List

Order 1-4) x 2 (Distraction: DVN vs SVN) ANOVA was carried out with repeated measures on all but the first factor.

Table 10: Experiment 3, means and standard errors of correctly recalled words across lists 1 to 4 for high and low structures under SVN and DVN

		SVN						DVN					
		First	*SE*	Mid	*SE*	Last	*SE*	First	*SE*	Mid	*SE*	Last	*SE*
High structured	List 1	2.75	*0.27*	1.83	*0.21*	2.08	*0.22*	2.08	*0.30*	2.01	*0.21*	2.28	*0.23*
	List 2	2.11	*0.27*	2.00	*0.22*	1.75	*0.24*	2.39	*0.27*	2.09	*0.23*	1.89	*0.21*
	List 3	1.72	*0.21*	1.44	*0.19*	1.81	*0.23*	2.14	*0.32*	1.53	*0.22*	1.75	*0.26*
	List 4	1.75	*0.27*	1.67	*0.25*	1.81	*0.25*	1.56	*0.27*	1.30	*0.19*	1.83	*0.24*
Low structured	List 1	2.03	*0.27*	1.46	*0.21*	1.94	*0.22*	1.78	*0.30*	1.60	*0.21*	1.86	*0.23*
	List 2	1.92	*0.27*	1.30	*0.22*	1.61	*0.24*	1.78	*0.27*	1.48	*0.23*	1.56	*0.21*
	List 3	1.94	*0.21*	1.48	*0.19*	1.50	*0.23*	1.81	*0.32*	1.27	*0.22*	1.69	*0.26*
	List 4	1.44	*0.27*	1.20	*0.25*	1.75	*0.25*	2.00	*0.27*	1.20	*0.19*	1.89	*0.24*

Main effects showed that overall, low-structured lists were recalled no differently than high-structured lists, $F(1,34) = 1.64$, $MSe = 0.70$, $p=.210$, partial $\eta^2=.046$. There was a main effect of list order, $F(3,93.12) = 10.02$, $MSe = .53$, $p<.001$, partial $\eta^2=.23$ and a main effect of word position, $F(2,57.16) = 10.55$, $MSe = 1.11$, $p<.001$, partial $\eta^2=.23$. Overall, correct recall of words from lists 1 to 4 steadily decreased, where the mean correct recall for list 1 ($M = 1.98$) was higher than for list 2 ($M = 1.82$, $p = .023$), than for list 3 ($M = 1.67$, $p < .001$) and than for list 4, ($M = 1.62$, $p <.001$).

However, there was no significant main effect of distraction, $F(1,34) = .084$, $MSe = 1.00$, $p=.77$, partial $\eta^2=.002$.

There was no significant interaction between list structure and list word position, $F(2,68) = .58$, $MSe = 1.11$, $p=.56$, partial $\eta^2=.02$, no significant interaction between word position and list order, *F*(6,204) = .1.47, *MSe* = 0.71, *p*=.19, partial η^2=.04 but, there was a weak interaction between list structure and list order, *F*(3,102) = 3.38, *MSe* = 1.11, *p*=.021, partial η^2=.09. Pairwise comparisons show that participants correctly recalled more words from the first presented high structured list than from the third (*p* <.001) or fourth (*p* < .001) presented high structured list but there was no significant difference in the number recalled between the first and second list (*p* = .145) or between low structured lists (differences between low structured list 1 and 2, *p* =.068; lists 1 and 3, *p* = .121; lists 1 and 4, *p* = .102). The overall pattern for correct recall from high structured lists resembled that seen in Experiment 2 where the series of lists appeared to show a build-up of list interference. As expected, this pattern was not evident for low structured lists. Thus, the main effect of list order was driven by the recall pattern of high structured lists.

In addition, there were no two-way interactions of distraction with list structure, *F*(1,34) = .02, *MSe* = 1.00, *p*=.90, partial η^2<.001 or with word position, *F*(2,68) = 1.38, *MSe* = 0.98, *p*=.871, partial η^2=.004 or, with list order, *F*(3,102) = .58, *MSe* = 0.47, *p*=.63, partial η^2=.017.

There was no three-way interaction between list structure, word position and list order, *F*(6,204) = .50, *MSe* = 0.71, *p*=.81, partial η^2=.015. Furthermore, there were no three-way interactions between distraction, list structure and word position, *F*(2,68) = .03, *MSe* = 0.84, *p*=.97, partial η^2=.001; distraction, list structure and list order, *F*(3,102) = 2.29, *MSe* = 0.47, *p*=.083, partial η^2=.063 or between distraction, list order and word position, *F*(6,204) = .1.109, *MSe* = 0.82, *p*=.36, partial η^2=.032.

Finally, there was no interaction between all four factors, *F*(6,204) = .84, *MSe* = 0.82, *p*=.54, partial η^2=.024.

2.5.2.2 Incorrect recall

2.5.2.2.1 Normality testing on Experiment 3 incorrect recall data

Experiment 3 and collection of incorrect recall data followed a 2 (List structure: low vs high) x 4 (List Order 1-4) x 2 (Distraction: DVN vs SVN) design with repeated measures on all but the first factor. Normality tests showed numerous distributions to be positively skewed and so $Log_{10(score+1)}$ transformations were carried out prior to analysis using parametric tests. Data transformations bought the majority of each subgroup's skew and kurtosis parameters within accepted boundaries of normal distributions thus analysis proceeded with parametric tests but, with caution.

Table 11: Experiment 3 normality testing of incorrect recall data, SVN and DVN conditions

Distraction condition	List structure	List order	Skew z-score		Kurtosis z-score	
			Original	$Log10_{(score+1)}$	Original	$Log10_{(score+1)}$
SVN	High	1	3.57*	2.52*	2.80*	0.63
		2	-1.53	-0.63	2.61*	-1.53
		3	0.99	-0.23	-0.38	-1.26
		4	-0.12	-1.32	-0.55	-1.03
	Low	1	4.62*	0.89	7.88*	0.73
		2	2.68*	1.72	1.29	-0.61
		3	3.08*	2.09*	1.62	-0.12
		4	4.01*	1.71	4.36*	0.69
DVN	High	1	1.92*	1.43	-0.43	-1.16
		2	0.86	-0.50	-0.58	-1.06
		3	0.51	-0.21	-1.22	-1.70
		4	1.26	-0.14	-0.47	-0.97
	Low	1	2.56*	1.54	0.79	-0.78
		2	3.06*	1.71	2.11*	-0.24
		3	2.70*	1.01	1.81*	-0.56
		4	3.18*	1.40	2.37*	-0.23

2.5.2.2.2 Analysis of incorrect recall

A 2 (List structure: low vs high) x 4 (List Order 1-4) x 2 (Distraction: DVN vs SVN) mixed ANOVA was carried out on intrusion errors with repeated measure on all but the first factor, and the means are reported in Table 12.

Table 12: Experiment 3, means and standard errors of incorrectly recalled words across lists 1 to 4 for high and low structure under SVN and DVN conditions

		SVN		DVN	
		Mean	*SE*	Mean	*SE*
High structured	List 1	0.25	*0.14*	0.25	*0.12*
	List 2	0.47	*0.12*	0.61	*0.11*
	List 3	0.56	*0.13*	0.58	*0.12*
	List 4	0.86	*0.16*	0.56	*0.14*
Low structured	List 1	0.69	*0.14*	0.36	*0.12*
	List 2	0.42	*0.12*	0.33	*0.11*
	List 3	0.39	*0.13*	0.44	*0.12*
	List 4	0.61	*0.16*	0.53	*0.14*

Overall, there was a main effect of list order, $F(3,102) = 3.34$, $MSe = .027$, $p = .022$, partial $\eta^2 = .089$ with contrasts showing a significant linear relationship where progressively more incorrect words were recalled across lists one to four, $F(1,34) = 9.39$, $MSe = .046$, $p = .004$, partial $\eta^2 = .22$. However, simple effects of list order show that the linear relationship was driven by progressively poorer recall of high structured lists, $F(3,32) = 9.75$, $p < .001$, partial $\eta^2 = .48$ and not low structured lists, $F(3,32) = 9.39$, $p = .122$, partial $\eta^2 = .16$.

There was no main effect of distraction, $F(1,34) = 0.195$, $MSe = 0.042$, $p = .662$, partial $\eta^2 = .006$ and there were no interactions between distraction and structure, $F(1,34) = 0.023$, $MSe = .042$, $p = .880$, partial $\eta^2 = .001$ or between distraction and list order, $F(3,102) = 0.49$, $MSe = .042$, $p = .669$, partial $\eta^2 = .014$. Finally, there was no three-way interaction between distraction, structure and list order, $F(3,102) = 0.514$, $MSe = .043$, $p = .673$, partial $\eta^2 = .015$

In summary, this study found no reliable effects of distraction at all, despite once again demonstrating list position effects, and interference effects. Therefore the absence of a distraction effect in Experiment 2 does not appear to be a result of the high level of structure used in that Experiment. This does not rule out the possibility that the absence of evidence of a distraction effect (and the presence of the effect in previous studies) reflects some unknown attributes of the items, because Experiment 3 used the same pool of items as Experiment 2, which was different from the set used for Experiment 1. However, whilst this possibility cannot be ruled out, it does leave the theoretical explanation of the effect with little explanatory power, because any account would require that the negative effects of environmental distraction appears to occur only for particular items, studied as mid-list items of multiple lists.

2.6 General Discussion

The work in Chapter 2 began with a partial replication of Glenberg et al.'s (1998) multiple-list method but with a semantically neutral established method of creating the distraction and control conditions. The main purpose of Experiment 1 was to investigate whether Glenberg et al.'s findings (Experiment 5, 1998) could be replicated, that is, whether visual distraction impairs recall of word-lists. Experiment 1 found a moderately sized distraction effect for recall of the mid-list items. However, although Glenberg et al. conclude that the effect is driven by retrieval task difficulty, this did not appear to be the case in Experiment 1. This is because when task difficulty was indexed by variations in correct recall of words under control conditions for both word-position and list-position, expected concurrent detrimental effect patterns of distraction were not found. Furthermore, Experiment 1's detrimental distraction effect on midlist recall was not replicated in either Experiment 2 or Experiment 3. Looking at data from the full word-lists presents a consistent negative picture. When analysing memory for all the items in the list, there was no evidence of distraction impairing correct recall, whilst Experiment 2 showed that DVN *increased* full-list correct recall, albeit with a concomitant increase in errors. Results for incorrect recall were less consistent. Distraction had no significant effect on incorrect recall in Experiment 1 or Experiment 3 but increased errors for multiple lists in Experiment 2.

The results of Experiments 2 and 3 clearly show effects of word presentation rate, interference and word position on recall. Experiment 2 data show that varying word presentation rate differentiates the difficulty of the retrieval task because fewer correct words are recalled under control conditions for words presented at faster rates. However, there is no evidence of a differential distraction effect. Experiment 3 data show that increasing levels of proactive interference differentiates the difficulty of the retrieval task because as the task became more demanding participants recalled fewer correct words and made more errors. Approximately one third of words were recalled from each word-list which suggests that there were no obvious floor or ceiling effects restricting the ability to detect an effect of distraction. If participants were able to recall only one word out of 16 from each list or, could recall 15 words out of 16 from each list, this would imply that there were floor or ceiling effects, respectively, with regards to word-list recall. A flooring effect would for example, limit the number of words recalled to include in an analysis and may therefore make it difficult to detect any changes in recall between distraction conditions. Therefore, if visual noise competes with demanding retrieval processes for finite resources the expectation is that an effect is seen on one of the tasks presented but there was not.

Glenberg's (1997) embodied cognition account of distraction predicts that performance on moderately difficult retrieval tasks will suffer under distraction conditions. Glenberg et al. (1998) demonstrate this with data on correct recall of mid-list words and claim that the retrieval of words from midlist positions of word-lists is moderately difficult. However, the authors do not report analysis for full list recall or for incorrect recall. When these data are taken in to account in Experiments 1 to 3, there is little support for Glenberg's theoretical stance. When task difficulty in Experiments 1 to 3 is indexed by correct recall, there is no support for Glenberg's theoretical stance.

Figure 6 illustrates the overall pattern for the studies reported here, both for recall of mid-list items, and for recall of all items. This plots mean effect size and 95% confidence intervals around those effect sizes for each study. Glenberg, Schroeder and Robertson's mean effect size is included for comparison, but no confidence intervals for their data are available. This illustrates that five out of six potential effect sizes are compatible with their being no effect. The more optimistic reading of these data is that all studies are compatible with a very small effect: the confidence intervals calculated for each study all include the range d = 0.12 to d = 0.15. Thus, the appropriate conclusion to be drawn from the current series of studies is that there is either no impact of distraction upon recall from word lists, or very little effect, irrespective of the difficulty of the memory materials.

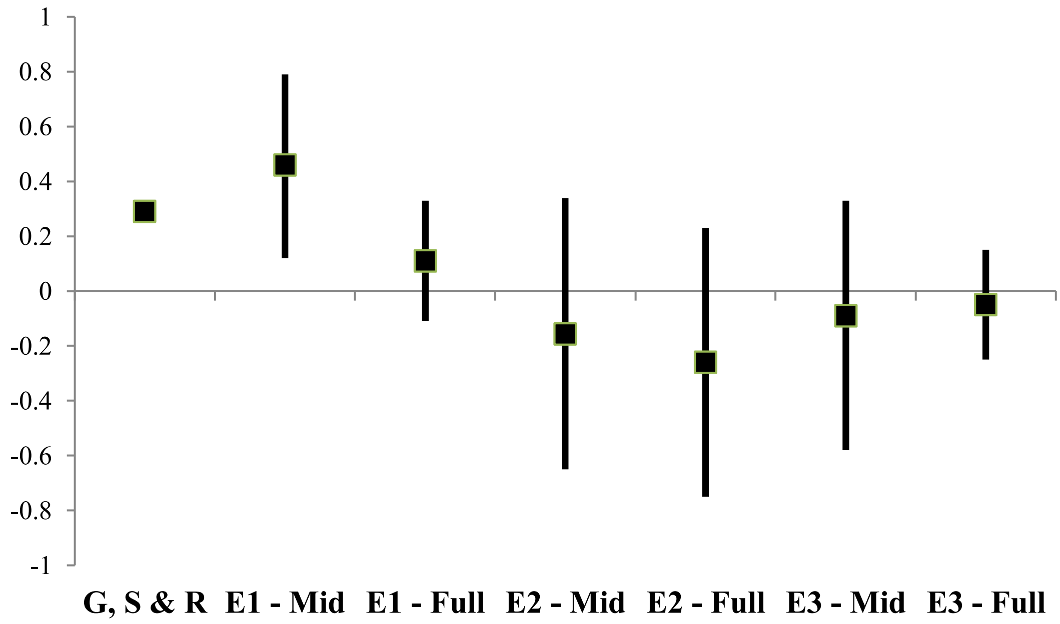

Figure 6: Mean effect size with 95% confidence intervals for Glenberg et al. (GS & R) and Experiments 1 to 3

Overall, these data patterns do not support the claim that detrimental effects of distraction are driven by task difficulty. While distraction has been shown to disrupt memory, the effect is not inevitable. That is, numerous studies report distraction effects on memory. Therefore, the argument that distraction can disrupt memory is one that is not disputed because, it *can* disrupt memory because it has been shown to disrupt memory. What is interesting however, is that distraction does not always appear to disrupt memory.

The question therefore is not whether environmental visual distraction does or does not produce an impairment of recall, because both have been shown here, instead, the question is under what conditions does environmental visual distraction impair recall. What needs explanation is why the studies of event memory presented in Chapter 1's literature review report moderate to large effect sizes for the negative effects of distraction and the positive effects of eye-closure to reduce distraction, but the studies using memory for lists appear to show little, if any effect.

Chapter 3 presents experimental work designed to search for answers to this research question. The chapter begins with an in-depth review of methods used by the studies which tested visual distraction and eye-closure conditions on event memory and reported robust and consistent effects.

Chapter 3: The Effect of Visual Distraction on Memory for Events

3.1 Introduction to Chapter 3

The lack of evidence for a consistent distraction effect from Chapter 2's long-term memory word-list studies was unexpected for two reasons. Firstly, Glenberg's (1997) widely cited cognitive-load theory predicts that distraction will impair long-term memory and secondly, prior research using eyewitness methods support this prediction by demonstrating consistent and robust effects of distraction on long-term event memory. Thus, despite a clear theoretical rationale and good evidence from eyewitness distraction methods, the word-list studies in Chapter 2 show at best an inconsistent effect on long-term memory for word-lists. The question is, why do eyewitness studies demonstrate robust distraction effects but word-list studies do not?

One way to search for an answer is to start with an exploration of key differences between eyewitness and word-list methods. Chapter 3 therefore begins with an in-depth review of eyewitness distraction studies. The review takes into account the type of material participants were asked to study for later recall, how distraction conditions were manipulated, how memory was tested (free or cued recall), which features of memory were measured (memory for visual or verbal details, number of correctly recalled details, accuracy of recalled details and so on) and what pattern of distraction effect was found.

3.2 Review of eye-witness distraction studies

Police officers interview eyewitnesses in order to gather as much accurate information about a witnessed event as possible. In order to help witnesses remember an event, police interviewers may use a set of memory-aid techniques collectively known as The Cognitive Interview (CI, Fisher, Geiselman & Amador, 1989). The efficacy of these techniques have been demonstrated through both laboratory and field research (for a review see Memon, Meissner & Fraser, 2010). However, the CI takes much longer than a standard interview (Clarke & Milne, 2001) and many police officers do not use the CI because of time constraints (Dando, Wilcock, & Milne, 2009) . It is not surprising therefore, that one strand of eye-witness research has focussed on ways of reducing the time to conduct the CI and in particular, has explored the effect on recall of the simple technique of instructing witnesses to close their eyes while remembering. Instructed eye-closure has been found to improve both the number of details reported and the accuracy of what is reported. Researchers are interested in recall accuracy (the number of correct details recalled out of all details reported) because in terms of the judicial system, accuracy of a witness statement is crucial to legal proceedings. Some researchers have also looked at the precision of recall (fine or precise recall versus coarse or imprecise recall). In addition, other researchers have extended eye-closure work by manipulating the level of distraction in the environment. Eye-closure and distraction studies will be referred to collectively as eyewitness distraction studies.

A typical eyewitness distraction study involves testing participants' long term memory for visual and verbal details of a witnessed event under varying conditions of distraction during retrieval. Distraction levels during recall are typically manipulated in one of two ways: participants are either presented with a task-irrelevant visual/auditory stimulus or, participants are instructed to close their eyes/ wear noise-cancelling headphones. An eye-closure condition removes incidental environmental visual distraction and can be thought of as the converse of the task-irrelevant visual stimulus condition (visual distraction). Similarly, a noise-cancelling condition (or ‘ear closure’) can be thought of as the converse of auditory distraction. Recall under distraction conditions is compared to recall under control conditions; for instructed eye-closure the control condition is usually a no-instruction condition and for visual/auditory distraction conditions this is usually a blank screen or an auditory quiet condition. Participants may be asked a fixed set of questions (cued-recall) or asked to recall as much as they can in as much detail as they can (free-recall), or both. In both cases, instructions typically ask participants not to guess.

The review includes studies carried out with adult and not child participants. While there is work exploring distraction effects on child witness testimony it is thought that due to developmental processes younger participants are more vulnerable to attentional issues and may at times benefit from instructed eye-closure under different circumstances to adults (for example, see Mastroberadino and Vredveldt, 2014). In addition, experimental work carried out for the thesis was designed to explore distraction effects among adult and not child participants.

In order to address the issue of differential power across the studies a standard measure of distraction effect size, Cohen’s *d* (Cohen, 1992) is reported where distraction was a between-participant factor and where published data are available. The review is broadly in two sections with the first section focussed on eye-closure methods and the second section focussed more on visual/auditory stimulus methods. Inevitably however, there is some overlap.

3.2.1 Eye-closure methods

Wagstaff et al. (2004, Experiment 2) instructed participants to close their eyes, or not, while recalling details of a prominent event witnessed five years earlier:

the televised funeral of Princess Diana. Memory for the event was tested using both cued and free recall but there was no measure of whether the details were visual or verbal in nature. Participants who closed their eyes freely recalled more correct details (d = 0.57) than those who did not, but there was no difference in the number of incorrect details given (data were not provided in the paper). The lack of a concurrent increase in incorrectly recalled details suggests that eye-closure does not simply increase willingness to report all details that come to mind, thus the key finding here is that removing incidental visual distraction through eye-closure appears to improve recall accuracy. However, this was demonstrated with free recall only because there was no statistical evidence of a distraction effect on cued recall (no data were given).

As a note on recall accuracy, care needs to be taken over interpreting the pattern of eye closure or distraction conditions, on correct and incorrect recall. For example, Vredeveldlt and Penrod (2013) and Perfect et al. (2008, Experiment 5) found a significant increase in correct free recall under eyes-closed, which was not concurrent with a significant increase in incorrect recall. However, this did not lead to an increase in recall accuracy. The increase in incorrect recall, while not significant, was numerical and this increase influenced the accuracy scores whereby eye closure was not seen to improve accuracy.

Perfect et al. (2008) conducted five experiments testing the effect of instructed eye-closure on memory for a video-clip or live-staged interaction. The authors measured both cued recall, with a 'don't know' option so that recall accuracy could also be measured, (Experiments 1, 2, & 4) and free recall (Experiments 3 and 5). Questions for cued recall were asked in the order in which the details appeared in the clip/live interaction. Experiment 1 presented a crime-scene video-clip for study.

Recall of visual and verbal details was not examined separately. Eye-closure led to an increase in correct recall (*d* = 1.66), a decrease incorrect recall (*d* = -1.02) and taken together, led to an increase in recall accuracy (*d* = 1.28). Experiment 2 measured cued recall of visual and verbal details of a news bulletin video-clip. Eye-closure increased the number of correctly recalled visual details (*d* = 0.56) but decreased the number of correctly recalled verbal details (*d* = -0.61). There was no overall significant effect on incorrect recall, but eye-closure increased visual accuracy (*d* = 0.60) and decreased verbal accuracy (*d* = -0.64). Experiment 4 measured cued recall of visual and verbal details of a live-staged event. Eye-closure had slightly larger beneficial effects on correct recall of verbal details (*d* = 0.98) compared to visual (*d* = 0.71) and on incorrect recall of verbal details (*d* = -1.16) compared to visual (*d* = -0.88). Overall, eye-closure improved recall accuracy of verbal details (*d* = 1.25) to a greater extent than visual (*d* = 0.72).

Experiment 3 and 5 measured free recall. Experiment 3 presented a TV drama video-clip and found eye-closure led to an increase in overall correct recall (*d* = 1.45) with marginally greater benefit for recall of visual details (*d* = 1.27) than verbal (*d* = 1.14). However, eye-closure also led to an increase in incorrect recall of verbal details (*d* = 0.90) and a decrease in incorrect recall of visual details (*d* = -0.49) which implies that eye-closure led to a report criterion shift for verbal details only. Overall, eye-closure led to an increase in recall accuracy of visual details (*d* = 0.76) but a decrease in recall accuracy of verbal details (*d* = -0.62). Experiment 5 measured free recall of a live-staged event. The authors developed a set of visual and verbal pre-determined target details from a pilot study and only these details from free recall reports were analysed. The purpose of using this method was to enable a comparison of free recall of the same details under eye-closed and under no-instruction. Eye-closure led to an overall increase in the number of correct target details with marginally greater benefit on correct recall of verbal details (*d* = 0.55) than visual (*d* = 0.39). However, there was no effect on incorrect recall or on accuracy either overall or for each modality of detail.

In summary, Perfect et al.'s (2008) work clearly demonstrates that eye-closure consistently increases correct cued and free recall. There was generally an increase in correct visual details and regular increases in recall accuracy of visual details. The effect on recall of verbal details was less consistent and so the implication for how visual distraction, the converse of eye-closure, will affect memory is not clear. That is, there is evidence to imply that visual distraction will consistently disrupt memory for visual details but, it may or may not disrupt memory for spoken verbal details.

Vredeveldt, Baddeley and Hitch (2012) investigated the effect of eye and 'ear'-closure on cued-recall of visual and verbal details of a violent TV video-clip. Eye-closure led to more correct fine-grain[4] visual details (*d* = 0.38) but fewer correct fine-grain verbal details (*d* = -0.38) and had a greater effect on recall of correct verbal coarse-grain (*d* = 0.76) than correct visual coarse-grain details (*d* = 0.38). Ear-closure led to a stronger increase in correct fine-grain visual details (*d* = 0.30) than correct fine-grain verbal details (*d* = 0.19) and an increase in correct coarse-grain verbal (*d* = 0.38) but a decrease in visual coarse-grain details (*d* = -0.34). Thus is appears that both eye- and ear-closure benefit correct recall of fine-grain visual but coarse-grain verbal, details. Eye-closure decreased incorrect recall of visual details (*d* = -0.84) but increased the incorrect recall of verbal details (*d* = 0.47). However,

[4] For example, in response to the question, 'Where on his body did the man get shot?' a fine-grain/precise response would be 'on his left upper arm' and a coarse-grain/imprecise response would be 'on his arm' (Vredeveldt and Sauer, 2015; Vredeveldt, 2011)

ear-closure showed negligible increases in the number of incorrect visual (*d*=0.05) and verbal (*d* = 0.04) details.

Vredeveldt, Baddeley and Hitch (2014) measured eye-closure on free and cued recall of a video-clip immediately after viewing and one week later. Eye-closure had no significant benefit for immediate free recall however, it improved free recall one week later where it showed greater benefit to correct recall of visual (*d* = 0.82) than verbal details (*d* = 0.36) but similar benefits to recall accuracy of visual (*d* = 0.30) and verbal details (*d* = 0.21). Eye-closure was also beneficial to cued recall one week later however, the effect appears to be modality-specific because there were strong benefits for recall accuracy of visual details (*d* = 1.00) but none for recall accuracy of verbal details (*d* = 0.00).

Vredeveldt, Tredoux, Kempen, et al. (2015) measured free and cued recall of a video-clip. Overall, eye-closure had only marginal beneficial effects on improving free correct recall of visual (*d* = 0.16) and verbal details (*d* = 0.21). However, when the precision of the responses were taken in to account eye-closure was shown to have a stronger effect on correct fine-grain visual details (*d* = 0.66) than on fine-grain verbal details (*d* = 0.33).

In a field study, Vredeveldt, Tredoux, Nortje, et al. (2015) measured free recall of real life serious crimes. More details about the perpetrator were reported by witnesses with eyes closed than those given no instruction (*d* = 0.43). Furthermore, a police expert rated the details given by witnesses with eyes closed as being significantly more forensically relevant than witnesses with no instruction (*d* = 0.43)

3.2.2 Visual/Auditory stimulus methods

Vredeveldt et al. (2011) tested the effect of visual and auditory distraction and eye-closure on cued-recall of visual and verbal details of a violent video-clip. The visual distraction condition was created with Hebrew-script letters appearing and disappearing in random locations every second. The auditory distraction condition was created with a spoken stream of the same Hebrew letters. Overall, distraction (visual and auditory) compared to blank screen and eye-closure led to fewer correctly recalled details (d = -0.48) and more incorrectly recalled details (d = 0.40). However, a more focussed analysis on fine-grain recall between the two distraction conditions showed that visual distraction compared to auditory distraction had a detrimental effect on correct recall of visual details (d = -0.75) and auditory distraction compared to visual distraction had a detrimental effect on recall of verbal details (d = -0.40). A similar analysis on incorrect details also revealed a modality-specific effect where visual distraction compared to auditory distraction increased incorrect recall of visual details (d = 0.88) and auditory distraction compared to visual distraction increased incorrect recall of verbal details (d = 0.20). Although Vredeveldt et al. (2011) found no significant difference between blank screen and eye-closure conditions and thus collapsed the two groups for follow up comparisons with the distraction conditions, it is of particular interest here to tease out the pattern of eye-closure, visual distraction and auditory distraction versus blank screen. Eye-closure compared to blank screen was more beneficial to correct recall of visual details (d = 0.40) than verbal details (d = 0.21) and was more beneficial in reducing incorrect recall of visual details (d = -0.50) than verbal details (d = -0.25). Visual distraction compared to blank screen was more detrimental to correct recall of visual details (d = -0.76) than verbal details (d = -0.43) and detrimental to incorrect recall of visual details (*d* = 0.85) with negligible effect on incorrect recall of verbal details (*d* = -0.02). Auditory distraction compared to blank screen was more detrimental to correct recall of verbal details (*d* = -0.50) than visual details (*d* = -0.37) and more detrimental to incorrect recall of verbal details (*d*=0.34) than visual details (*d* = 0.14). In summary, the pattern of Vredeveldt et al.'s (2011) data suggests a beneficial effect of eye-closure and a detrimental effect of distraction on recall. Their data also suggest that distraction may be modality-specific.

Perfect et al. (2011) investigated whether eye-closure reduces the detrimental effect of auditory distraction on cued-recall of visual and verbal details of a live-staged interaction. Recall under auditory distraction (bursts of white noise) was compared to recall under a quiet condition. In addition, participants were either instructed to close their eyes or were given no instruction. Eye-closure compared to no-instruction had negligible to weak detrimental effects on correct recall under quiet conditions (correct visual *d* = -0.05; correct verbal *d* = -0.19) and negligible beneficial effects on correct recall under auditory distraction (correct visual *d* = 0.07; correct verbal *d*=0.03). In addition eye-closure had negligible benefits on incorrect recall under quiet conditions (incorrect visual *d* = -0.06; incorrect verbal *d* = -0.09) but marked benefits on incorrect recall under auditory distraction (incorrect visual *d* = -0.80; incorrect verbal *d* = -1.08). In summary, eye-closure had the most beneficial effect on recall when recall took place in a distracting rather than quiet condition with greater benefit on reducing incorrect recall of verbal details than visual.

Perfect, Andrade and Syrett (2012) investigated whether the amount and predictability of a visual distractor differentially affects cued recall of visual and verbal details of a news-bulletin. A simple visual distraction condition was created by presenting a single red box on screen and a complex visual condition was created by presenting one red and one blue box on screen. In both conditions boxes moved from one corner of the screen to another in either a predictable and fixed clockwise movement or, in a quasi-random movement. Effect sizes show that the complex versus simple condition was more detrimental to correct recall of visual (d = -1.54) than verbal details (d = -0.60), more detrimental to incorrect recall of visual (d = 1.26) than verbal details (d = 0.68) and more detrimental to recall accuracy of visual details (d = -1.64) than verbal details (d = -0.82).

Vredeveldt and Penrod (2013) explored the interaction between eye-closure and context reinstatement on free and cued recall of a live staged altercation on a busy New York street corner. Half of the participants were interviewed at the side of a busy street and half indoors in a quiet area and were either instructed to close their eyes or given no instruction. Eye-closure versus eyes-open was more beneficial to correct free recall of visual details when participants were interviewed inside (d = 1.02) than outside (d = 0.14) and slightly less beneficial to correct free recall of verbal details when interviewed inside (d = 0.05) than outside (d = 0.58). For cued-recall responses, eye-closure versus open resulted in more correct fine-grain visual details (d = 0.43) but fewer fine-grain verbal details (d = -0.25) with no interaction with interview location. In summary, eye-closure was of greatest benefit to free recall indoors of both visual and verbal details and fine-grain cued-recall of visual details regardless of in or outdoor location.

3.2.3 Summary of review

In summary, eyewitness distraction studies show a fairly consistent pattern of main effects of environmental distraction (or its removal though eye or ear-closure) on memory: increasing the level of distraction in the environment decreases both the quantity and quality of cued and free recall of an event. This is demonstrated repeatedly across the studies discussed here. On the surface this implies a general effect of distraction on recall however, under the surface there is mixed evidence of a modality-specific effect which implies that the mechanism of distraction is not yet fully accounted for. The unweighted mean effect of distraction on incorrect recall of visual details (d = 0.70) is more than double the unweighted mean effect on incorrect recall of verbal details (d = 0.29).

The overarching point to make here however, is that eye-witness studies repeatedly demonstrate robust detrimental effects of distraction on long term memory. This is shown when distraction is removed through instructed eye-closure or amplified through appearing and disappearing Hebrew letters, moving coloured boxes, bursts of white noise and spoken letters. In contrast, the word-list studies of Chapter 2 fail to demonstrate the same robustness or consistency of effect. One of the purposes of the review was thus to explore eyewitness methods. The methodology used in eyewitness show several similarities to that for word-list studies: both test the effect of distraction on long term memory, both present distraction during retrieval, both have measured cued recall (Rae, 2011; Experiment 1) and free recall (Chapter 2) and both have analysed correct and incorrect recall. However, one conspicuous difference in methodology is the type of material participants were asked to recall. The following section therefore discusses how a difference in recall material may account for a difference in findings.

3.3 Cognitive processes involved in event versus word-list retrieval

Eyewitness participants were usually asked to recall details of an event which had been presented in a video-clip or live staged interaction whereas word-list participants were asked to recall details of word-lists presented either verbally or visually in type. Eyewitness events were replete with sights, sounds and movement and this clearly contrasts to the relatively static unimodal appearance of word-lists. One plausible explanation therefore is that distraction disrupts specific retrieval processes rather than retrieval processes in general. In other words, retrieving event details may engage different cognitive processes than retrieving word-lists and distraction may interfere with the former processes but less so with the latter. The aim of the following subsections is therefore to explore how the two types of material, word-lists and events, are different and thus may engage different cognitive processes.

3.3.1 Flowing events versus static lists

One difference between events and word-lists is the amount of movement within each: events have flowing movement but lists are relatively static. One strand of research which has particular relevance to the discussion on flowing events versus static lists relates to Event Segmentation Theory EST (J. M. Zacks & Swallow, 2007). EST proposes that observers process events by automatically chunking the event into manageable segments however, there is evidence to suggest that lists are not necessarily processed in this way. This is because research suggests that segmentation relies on movement of which there is very little in a list. If event details are encoded through a process of segmentation using movement as a key marker it is likely that retrieval of event details involves mentally reconstructing this movement. However, if list details are not encoded using movement as a key marker then retrieval of list details is unlikely to involve mentally reconstructing movement. This distinction is useful because there is evidence to suggest that distraction selectively interferes with processes involved in retrieving moving details and this may therefore explain the apparent differential distraction effect on recall of events and word-lists.

3.3.1.1 Events are processed through segmentation

EST is based on earlier work by Newtson (see Newtson 1976 for a review). More recent research in this field suggests that events are encoded through an automatic cognitive process of parsing the event into a series of smaller meaningful segments (for a brief overview, see Zacks and Swallow, 2007). Information within each segment is bound together. This in effect compresses the amount of event-information stored and at the same time provides distinct potential cues for later retrieval. Participants who are efficient at segmenting events have better memory for the event later on (J. M. Zacks, Speer, Vettel, & Jacoby, 2006) and participants explicitly instructed to use segmentation as a memory strategy show better memory for the event one month later (Flores, Bailey, Eisenberg, & Zacks, 2017). Segments are hierarchical and defined as coarse and fine. For example, encoding the bustling noisy event of a large family dinner may include parsing a coarse segment of 'the main course' which in turn is made up of fine segments of information such as 'roast potatoes', 'blue serving dish', 'Uncle Pete said he had a new job' and so on. These fine segments are bound together within the coarse segment. Information is ordered temporally so that the 'main course' precedes the 'dessert'. Segments have clear boundaries and memory for information presented at the boundaries has been shown to be stronger than for information presented in the middle of the boundaries (for example, Newtson, 1976; Swallow, Zacks, Abrams, 2009). Laboratory experiments have shown there to be consistency across participants of where the boundaries of segments are perceived to be (Zacks, Tversky, & Iyer, 2001) whether for full length feature films (Zacks, Swallow, Speer, & Maley, 2006), animations of geometric shapes (Zacks, Swallow, Vettel, & McAvoy, 2006) or narrative texts (Whitney et al., 2009). Segmentation can be thought of as a tool with which to organise and store information: a useful tool when organising complex information such as ordering the stages of a busy family dinner but perhaps not as useful when organising information which is already highly organised, such as a word-list. Although early research by Miller (1956) suggests that 'chunking' information is useful for memorising organised information such as a series of numbers, this conclusion is based on short-term memory studies. Participants in Miller's short term memory studies were able to continually, sub vocally rehearse a series of numbers. Although participants who used 'chunking' to place the series of numbers into small groups were able to recall more numbers than those who did not, the chunks of numbers were continually sub-vocally rehearsed. Continual sub vocal rehearsal is unlikely to be used as a memory aid in long term memory studies because of the greater volume of material participants are asked to encode. In addition, the inclusion of filler tasks prior to long term memory tests are used to address such potential issues of recency and sub-vocal rehearsal. Therefore, Miller's concept of chunking in short-term memory appears to be a different one to that of segmentation in long term memory.

If segmentation is generally of little benefit to processing highly organised information it is plausible that it is not predominantly involved in processing word-lists.

3.3.1.2 Segmentation relies on movement

The creation of segmentation boundaries is based on making predictions about what will happen next within the event (Zacks, Speer, Swallow, Braver & Reynolds, 2007; Kurby & Zacks, 2008). As an event unfolds observers create an event model of what will happen next based on previous experience of similar events. If an occurrence within the event violates a prediction of the event model, a segment boundary and thus a segment is created and the event model updated. Neuroimaging research suggests that updating event models, making predictions and therefore segments, is dependent on movement (Zacks et al., 2001). For example behavioural studies have demonstrated that segment boundaries are dependant on changing locations (Magliano, Miller, & Zwaan, 2001) (and speed of movement (Zacks, 2004). Other research suggests that segmentation is also dependent on conceptual changes such as changes in social interactions or goals of individuals within the events (Speer & Zacks, 2005).

Although research does not purport that movement is the only key variable involved in the cognitive process of creating coarse segment boundaries it certainly appears to be an important aspect and elsewhere, has also been shown to influence cognitive processing. For example, movement also explains the ‘dynamic superiority effect’ (for example, Goldstein, Chance, Hoisington & Buescher,1982; Matthews, Benjamin & Osborne, 2007) whereby memory for flowing (dynamic) images has been repeatedly shown to be superior to memory for static images. The superiority effect does not appear to be explained by greater attention being paid to flowing than static images. This is because Mathews, Buratto and Lamberts (2010) found that a divided attention task reduced memory for both static and flowing images however memory for flowing images was still superior to that for static. Matthews et al.’s(2007) work however suggests that the superiority effect is driven by movement within the flowing images: when compared to memory for multiple, quickly presented static images, memory for flowing images is still superior. This work was extended by Candan, Cutting, and DeLong (2015) who analysed the amount of visual activity in flowing images containing varying amount of movement and found that movement per se rather the amount of movement, was responsible for the superior recognition of flowing over static images. Thus the key feature of dynamic superiority appears to be based on flowing movement within an image and because memory for flowing images is consistently superior to memory for static images, this suggests that different cognitive processes are involved in retrieving flowing versus static material.

In summary so far, there is evidence to suggest that cognition involved in processing events involves automatically segmenting events using movement as an index with which to create segment boundaries. As there is no movement involved in word-lists albeit the appearance and disappearance of words on a screen it seems unlikely that cognition involved in processing word-lists also relies on movement. Therefore, a key feature which differentiates events from word-lists is movement: events are flowing but word-lists are static. The next subsection thus explores reasons why distraction may interfere with retrieval of flowing material but not static.

3.3.1.3 Distraction disrupts mental reconstruction of movement

Segmentation research suggests there is an association between how events are segmented and how they are retrieved (Ezzyat & Davachi, 2011, Schwan, Garsoffky & Hesse, 2000). Therefore, events which have been encoded through automatic segmentation using movement as an index should rely, at least in part, on reconstructing movement at retrieval. Furthermore, as noted earlier, memory for details at the boundaries of segments is superior to memory for details within segments. This implies that if movement was the key feature by which a segment was created at encoding then memory for that movement will be relatively strong because it was the detail which led to the creation of the segment in the first place and therefore sits at the boundary of the segment. This further supports the assertion that retrieving a segment which was encoded as a movement-indexed segment will involve retrieving details of the movement. Retrieving details of the movement will involve mental reconstruction of the movement. This is important to note because there is evidence that distraction interferes with the ability to mentally reconstruct movement. As discussed in Chapter 1’s literature review, work by Heremans et al. (2008) implies that mental reconstruction of movement involves visual-spatial imagery. Also discussed was research which could be interpreted as suggesting that visual-spatial imagery may be disrupted if eye-movement during imagery is restricted (Markson & Patterson, 2009; Buchanan et al., 2014). Visual distraction may interfere with eye-movement because it may direct eye-movement according to its own features and patterns and thus does not afford completely free eye movement required for visual-spatial processes. This may manifest in inaccurate reconstructions of segment-movement and result in inaccurate representations of coarse segments and the fine segments bound within the coarse segments.

So far, this account has been based on visual movement within an event but it could also be applied to verbal or auditory movement. This relies on an assumption that the auditory track of an event could also be construed as consisting of flowing movement. The verbal and auditory details can be thought of as flowing in terms of how they connect to each other both semantically and temporally. Thus, words in a sentence are connected in that they each hold meaning and also follow grammatical rules and are thus placed in a particular temporal order which gives the whole sentence meaning. Sentences or phrases are connected because the meaning of one sentence may be determined by the meaning of a sentence which was spoken before. There may be short silences but these silences will also hold meaning within the event. When someone switches off a radio, the act of switching off the radio will be accompanied by relative silence. The silence has meaning because it confirms that the radio has been switched off and therefore, the silence has a place in the flow of information. In addition, research suggests that cognition involved in processing verbal information is associated with eye-movement. A body of research exploring eye-movement during encoding and retrieval of verbal flowing information demonstrates an association between eye-movement and temporal elements of verbal information. For example, Martarelli, Mast, and Hartmann (2017) measured spontaneous eye-movement during encoding, free recall and recognition of verbally presented information. Participants listened to a verbal account about a fictitious person. The account included information about things the person had in their apartment or would like to have in the future, activities they enjoyed doing 10 years ago or would like to do in the future, clothing they like to wear now or used to wear and so on. The authors found that eye-movement during retrieval of these verbal details matched earlier eye-movement recorded during encoding of the same details. They also found eye-movement was directed more towards the right during recall of information about the future compared to recall of information about the past. Other researchers have found associations between eye-movement and for example, processing verbal descriptions of rooms in a house (Spivey & Geng, 2001) and counting aloud in a numerical upward sequence (Hartmann, Mast, & Fischer, 2016).

Overall, it thus appears that processing verbal information involves eye-movement and the direction of movement itself is dependent upon the content of the verbal information. When the content of verbal information can be construed as flowing, because it has both a temporal and semantic aspect which creates a flow, eye-movement plays a key role in retrieval processes. This implies that retrieval of verbal flowing information should be vulnerable to restrictions in eye movement in a similar way that retrieval of visual flowing information is vulnerable to these restrictions.

In summary, event segmentation suggests that a useful theoretical and experimental approach to exploring the apparent difference in distraction effect on event versus word-list recall is to view the former as flowing material and the latter as static. In theory, recall of visual and verbal details embedded in a flowing event should be disrupted by distraction but the same details embedded in a static list should not.

3.3.2 Modality of recalled detail: Visual versus Verbal

Vredeveldt's (2011) Cognitive Resources Framework (see Chapter 1 for a description) predicts that visual distraction will have detrimental effects on recall of both visual and verbal details but the relative size of detrimental effect will be greater on recall of visual than verbal details. Effect sizes reported in section 3.1.1's review on eye-witness studies lend support to this stance because for example, the unweighted mean effect on incorrect recall of visual details (d = 0.70) is more than double the unweighted mean effect on incorrect recall of verbal details (d = 0.29). However, while the direction of the distraction effect on incorrect recall of visual details is consistent, the direction of the effect on recall of verbal details is not (ranges from d = -0.90 to d = 1.16). Interestingly, Experiment 1 in Chapter 2 found a moderate distraction effect on incorrect recall of verbal details (d = 0.34) which is comparable to the eye-witness studies' unweighted mean effect on incorrect recall of verbal details. It is interesting because it leads to the question of whether the lack of consistent effect seen in word-lists studies is simply a reflection of the inconsistent effects detected in the eye-witness literature or a reflection that the structural features of lists (such as being static), regardless of verbal or visual content, generally protect memory from detrimental distraction effects or, perhaps both.

Overall, the above discussion lends further support to carrying out an experimental manipulation which compares distraction effects on recall of verbal and visual details. The cognitive resources framework predicts that visual distraction will disrupt recall of both visual and verbal details however, it also predicts a greater detrimental effect on recall of visual than verbal details..

3.3.3 One modality (unimodal) or two (bimodal)

Eye-witness studies tend to present participants with information in two simultaneous modalities: a stream of visual information alongside a stream of verbal information. In contrast, word-list studies present information in one modality at a time: either a series of visually typed words or a series of spoken words (for example, Rae, 2011). That is, eye-witness memory sources are typically bimodal but word-list sources are typically unimodal. Everyday life events are usually perceived through multi-modal streams such as through sights, sounds, tastes, smells and so it is perhaps due to evolutionary processes that we seem more adept at recalling details of a memory which was encoded in more than one modality than a detail of memory encoded in one modality only. For example, in a series of six experiments Meyerhoff and Huff (2016) tested recognition-recall of a series of short film clips which were presented as either bimodal (audio-visual) or unimodal (either audio or visual) and found recognition memory was most accurate for bimodal clips. Semantically congruent audio-visual clips were better recalled than incongruent but interestingly, memory for both remained superior to memory for unimodal clips. This finding implies that memory for details which were embedded in bimodal presentations is superior to memory for details which were embedded in unimodal presentations. Why then would eye-witness studies with bimodal presentations find a consistent distraction effect but word-list studies with unimodal presentations, not? Theoretically, this may be explained by Baddeley's (2001) theorised episodic buffer.

Baddeley(2001) extended Baddeley and Hitch's (1974) multi-component theory of memory and theorised the existence of an episodic buffer (explained in more detail in Chapter 4) which integrates information between two modality-specific subsystems (visuo-spatial sketch-pad and phonological loop) and maintains cross-modality bindings between information in long term memory. Thus one explanation for superior recall of details from bimodal presentations is that bimodal information is stored as a single percept but can be accessed by more than one cue (verbal and visual) and therefore bound details are more readily accessed than details encoded as unimodal. This explains why memory for bimodal presentations is superior to unimodal presentations but it does not explain why distraction might interfere with bimodal presentation. A more in-depth look at the theory is needed.

Another feature of this theoretical account is that bound details are also stored separately as weaker memory traces within the relevant modality-specific subsystem. In addition, Allen, Baddeley, and Hitch (2006) and Baddeley et al. (2011) also explain that while the episodic buffer is thought to temporarily hold and manipulate the bound details, the creation and maintenance of bindings is carried out by the central executive. The central executive relies on attention and so when attention is depleted, the bindings between details are thought to disintegrate. The central executive is also assumed to be the gateway between episodic buffer and long term memory. When bound details are retrieved from long term memory they pass through the central executive. The central executive maintains the binding between the details while placing them in the episodic buffer. However, if attention is disrupted during retrieval (through distraction), the work of the central executive is also disrupted. The bindings it is responsible for maintaining, as they pass from long-term memory to working memory, disintegrate. There are still traces of the details in the relevant modality-specific subsystem but these are weaker and thus potentially more vulnerable to erroneous reporting.

In summary, the episodic buffer account may explain why distraction appears to disrupt memory for bimodal events and not necessarily for unimodal lists and therefore suggests that a useful differentiating factor between events and word-lists is based on bimodal versus unimodal presentation of details. This can be manipulated experimentally by simply separating the visual and audio tracks of a video-clip and comparing distraction effects on recall of each unimodal track to recall of the bimodal presentation.

3.3.4 Summary of differences between lists and events

The above exploration suggests there are three useful key factors which can be used to differentiate events from word- lists and thus used to further investigate the mechanism of distraction effects on memory. Word-lists can be described as static, verbal and unimodal memory sources whereas events can be construed as flowing, verbal and visual, and bimodal memory sources. It is feasible from what has been discussed so far that the three factors of movement (flowing versus static), modality of recalled detail (visual versus verbal) and presentation (unimodal versus bimodal), may moderate distraction effects and therefore provide a theoretical framework with which to further investigate distraction.

3.4 Different methods of manipulating distraction

So far the review has focussed on how eyewitness and word-list methods differ in terms of the type of material participants were asked to recall, however, another methodological consideration is the way in which distraction conditions were created. Therefore, this subsection will explore how each study method typically produced these manipulations.

Eyewitness studies have demonstrated detrimental effects of distraction on memory under conditions of both incidental distraction (eyes/ears open) and irrelevant visual/auditory stimuli. Incidental distraction refers to environmental sights and sounds that are not under experimental control. This might include the sound of distant doors opening and closing or the sight of a poster hanging on the wall. With the exception of Vredeveldt and Penrod (2014), it is fair to assume that most eyewitness studies discussed in the earlier section would have been conducted indoors in research rooms. Therefore, incidental distraction is likely to be minimal in these studies because research rooms or laboratories tend to be quiet and clear of wall displays for the very purpose of minimising incidental distraction. Therefore, the control condition in eye-closure/ear closure studies most likely consisted of quiet. However, the control condition in Chapter 2's wordlist studies involved looking at a screen of SVN which may or may not produce a greater level of distraction than a control condition which has only incidental distraction.

The distraction conditions in eyewitness studies created distractors in a variety of ways. This included appearing and disappearing Hebrew letters in random locations on a screen (Vredeveldt et al., 2011) and moving coloured boxes (Perfect et al., 2012). Interestingly Perfect et al. (2012) found that the predictability of movement of the boxes had no impact on memory however, the complexity of display (two boxes rather than one) was important to eliciting a distraction effect. In Chapter 2's word-lists studies, distraction was created based on DVN and had the appearance of movement through many small squares appearing and disappearing randomly, causing a flickering moving effect. While auditory distraction literature presented in Chapter 1 implies that a changing-state distractor such as flickering squares will continually capture attention, there is a possibility that, for example, the simple but quasi- random movement by Perfect et al.’s (2012) complex coloured boxes demanded more attention from their changing states than the blanket of flickering black and white squares of DVN.

Thus, with respect to the DVN versus SVN conditions used in word-list studies there are two potential issues to consider: DVN may be ineffective as a visual distractor and SVN is itself distracting. Although there are several avenues to pursue in teasing out features of lists versus events which may explain differential distraction effects and thus shed light on the mechanism of distraction, one pressing investigation at this point, is demonstrate that DVN is an effective distractor.

3.5 Aim of Experiment 4

The primary aim of Experiment 4 is therefore to test whether DVN compared to SVN shows similar detrimental effects on memory for details of an event, as reported in the eyewitness literature.

3.6 Experiment 4

3.6.1 Retrieval material

Eyewitness studies have demonstrated consistent and robust distraction effects on recall of details of an event. Therefore, if DVN is an effective distractor it should also show detrimental effects on event recall. DVN has been shown to have a detrimental effect on event memory when the event being recalled is autobiographical (Anderson et al., 2017) however, it has not yet been tested on event memory when the event being recalled was previously presented in a video-clip. Therefore, Experiment 4 will test the effect of DVN on recall of a video-clip.

3.6.2 Distraction conditions

Another way to establish the efficacy of DVN as a distractor is to compare its effect on recall with a visual distractor already shown to have a detrimental effect on event memory. Perfect et al. (2012) tested the effect on memory of a visual distractor consisting of two same sized boxes (measuring 2.38cm x 2.58cm), one coloured blue and one red, appearing simultaneously in one of two corners of the screen. Therefore, Experiment 4 will include a ‘Boxes’ distraction condition based on Perfect et al.’s (2012) reported parameters.

Experiment 4 will also test the possibility that SVN is more distracting than looking at a blank screen. In addition to a DVN and Boxes distraction condition, recall will also be tested under an SVN and a blank screen condition. Thus recall of video-clip details will be tested under one of four distraction conditions, either one of two high-distraction conditions (DVN, Boxes) or one of two low-distraction conditions (SVN, Blank Screen).

3.6.3 Modality of recalled detail

Testing the effect of DVN on event recall presents opportunity to also explore potential modality-specific effects of visual distraction and therefore memory for visual and verbal details will be measured separately. Participants will be asked to recall an equal number of visual and verbal details in the order in which they appeared in the event through being asked set questions about visual and verbal aspects of the video-clip. In addition, participants will be given a ‘Don’t Know’ option, therefore, correct and incorrect recall and recall accuracy will be analysed.

3.6.4 Subjective distraction ratings

Participants will be asked to rate the level of distraction experienced under SVN, DVN and Boxes. This is to explore whether DVN and Boxes are subjectively perceived as more distracting than SVN. Beaman (2005, Experiment 2) asked participants to rate on a 7 point Likert scale, whether they had found an auditory distraction condition ‘not at all disruptive, annoying or uncomfortable’ (rated as 1) through to ‘very disruptive, annoying and uncomfortable’. A similar method will be used here, using a scale of 0 to 10.

3.6.5 Method

3.6.5.1 Power

Experiment 4 explored the effect on word recall of four levels of distraction condition presented between participants. The potential interaction of distraction on recall of visual and verbal details was also examined. A power analysis with $f = .04$ and power = 0.90 indicated a minimum total sample size of 93 was needed.

3.6.5.2 Participants

One hundred and four participants (53 females), average age 28.9 years (SD= 13.74) took part for course credit or as a paid volunteer. All participants had normal or corrected to normal vision and hearing and were fluent English speakers. Potential participants were warned that they may be asked to look at a flickering computer screen; anyone concerned about this effect or with a history of seizures or migraines was asked not to take part in the study. This information was recapitulated when each participant who signed-up attended their study-slot: no participants withdrew from the study.

3.6.5.3 Design and Materials

A 4 (Distraction: Blank Screen, SVN, DVN, Boxes) x 2 (Question modality: visual vs verbal) mixed design was used with repeated measures on the second factor.

New-bulletin video-clip: Because Perfect et al. (2008) tested the effect of Boxes on recall of a news-bulletin, Experiment 4 uses similar retrieval-material and duration. A three-minute continuous clip was taken from a half-hour 'BBC Scotland' news broadcast aired in February 2012. The clip was selected on the basis that it presented a wide range of information (seven different news stories were presented in brief), did not consist of national or international prominent events and was not recent news. This was done to reduce the likelihood that participants would be familiar with the news stories and to provide a rich event to later question participants about. At the end of the experiment, all participants were asked if they had seen the clip before or had any knowledge of the news stories presented: none had.

Questions about the video-clip: Twenty-two questions requiring one-word answers about details of the video-clip were selected from a pilot of forty questions about an equal number of visual and verbal details of the video-clip (pilot N=11). All questions in both the pilot and main experiment were based on video-clip details that had either been presented visually or verbally but, not both. For example, a visual question asked, 'What colour tie was the sport presenter wearing?' and a verbal question asked, 'What was the name of the museum shortlisted for a prize?' Criteria for selecting questions for the main experiment from the pilot study were: questions that were answered correctly by at least two participants (minimum percentage correct=18.2%) and no more than 9 participants (maximum percentage correct=81.8%). This was done to avoid potential floor and ceiling effects. The twenty-two questions used in the main experiment are listed in Appendix V.

Distraction conditions. In a between-design, Participants took part in one of four distraction conditions: Blank screen, SVN, DVN and Boxes. Twenty-six participants took part in each condition.

For the Blank condition the computer screen was set to a blank white background. The SVN and DVN conditions were the same as in Experiments 1 to 3. The Boxes condition was created using parameters set out by Perfect et al. (2012). A looped power-point presentation of twelve slides showed two boxes (one blue, one red) measuring 2.8cm x 2.6cm simultaneously appearing in separate corners of the screen (displaced from each corner horizontally 1cm and vertically 1.5cm). Each slide showed the two boxes in different corners and, was presented for 2 seconds. The sequence of presented slides was ordered such that it was not possible to anticipate the path of the boxes (for example the blue box did not rotate around the corners in a clockwise or anti-clockwise pattern). This fixed but pseudo-random sequence of 12 slides was presented on a continuous loop until the recall phase was completed. Each participant in the Boxes condition saw the same sequence.

3.6.5.4 Procedure

Participants were given all experimental instructions at the outset: they were told that they would twice watch a three-minute news-bulletin video-clip and would later be asked questions about details they saw and heard in the clip and that if they could not answer any of the questions, to just say, ‘don’t know’.

Participants were randomly allocated to one of the four distraction conditions when they signed-up for the experiment. Participants were not told which condition they had been allocated to. After having been given the experimental instructions, and in order to reduce any possible ‘audience’ effects during encoding, the experimenter explained to participants that people sometimes find it easier to concentrate when there is no-one else in the room and for that reason, the experimenter would leave the room whilst they watched the clip through twice. The procedure of watching the clip through twice was based on the methodology used by Perfect et al. (2012) to avoid flooring and ceiling effects on recall. The authors’ video clip was of the same duration as that used here and was presented to participants twice. Perfect et al. also tested participants’ memory with a similar number of questions (20) as used here. Perfect et al. found no obvious flooring or ceiling effects. Participants started the video-clip once the experimenter had left the room, watched it through once and then clicked to start the clip a second time. Whilst no formal recording was made as to how long it took participants to complete both viewings, the audio track of the video was audible from outside of the room and thus it was possible to check that the video had been played twice with only a minimal delay between the viewings. After the second viewing participants called the experimenter back in the room and the recall phase began. Participants were reminded that it was important to keep looking at the screen throughout the recall phase but that in case they forgot to do so, the experimenter would regularly look over at them and give a verbal reminder if needed. However, as an oversight, this was not enforced for the Blank screen condition and thus it is possible that recall under Blank screen may also incorporate instances of eye-closure and gaze-aversion. Therefore, with possible exceptions in the Blank screen condition, participants watched one of the four distraction condition screens whilst verbally answering verbally presented questions about details of the video-clip: answers were written down and later coded, by the experimenter.

In each distraction condition, the experimenter sat near to the participant but was partially hidden by a room-divider out of their field of vision but, at an angle that enabled the experimenter to check that the participants continued to look at the computer screen: there was no eye contact between participant and experimenter during recall. At the close of the experiment, participants were asked to rate how distracting the screen was, ratings were on a scale of 0 to 10 where 0 denotes 'not at all distracting' and 10 denotes 'the most distracting I have ever experienced'.

3.6.6 Results

Analyses on the normality of data distributions and on the effect of distraction condition on correct, incorrect and accuracy of recall are presented below. This is followed by an analysis on participants' subjective ratings of distraction condition (see section 3.1.6) and on duration of presentation of target visual details on correct and incorrect responses (see section 3.1.3).

3.6.6.1 Correct Recall

3.6.6.1.1 Normality testing on Experiment 4 correct recall data

Experiment 4 and collection of correct recall data followed a 4 (Distraction: Blank Screen, SVN, DVN, Boxes) x 2(Modality of detail recalled: visual vs verbal) mixed design with repeated measures on the second factor. Table 13 shows skew and kurtosis parameters were all well within accepted boundaries for normal distributions therefore, data were not transformed prior to analysis.

Table 13: Experiment 4, normality testing on correct recall of visual and verbal details under SVN, Blank screen, DVN and Boxes.

Distraction condition	Modality of detail	Skew z-score	Kurtosis z-score
SVN	Visual	-0.54	-0.92
	Verbal	-0.10	-1.15
Blank	Visual	-0.12	-0.94
	Verbal	-0.43	-0.44
DVN	Visual	0.79	0.23
	Verbal	-0.06	-0.13
Boxes	Visual	-1.22	-0.68
	Verbal	-1.23	0.54

3.6.6.1.2 Analysis of correct recall

Figure 7 shows the mean number of correctly answered questions about visual and verbal details under each distraction condition. A 4 (Distraction: Blank Screen, SVN, DVN, Boxes) x 2 (Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the second factor, found no main effect of distraction condition on correct recall, $F(3,100) = 1.009$, $MSE = 4.4$, $p = .392$, $\eta_{2\ partial} = .03$.

Overall, participants gave more correct answers to questions about verbal details ($M = 5.31$, $SD = 2.15$) than visual details ($M = 4.37$, $SD = 1.72$), $F(1,100) = 14.38$, $MSE = 3.145$, $p < .001$, $\eta_{2\ partial} = .126$. Numerically there were more correct answers to visual questions under SVN and Blank than under DVN and Boxes however, there was no significant interaction between distraction condition and detail mode on correct recall, $F(3,100) = 1.35$, $MSE = 3.145$, $p = .26$, $\eta_{2\ partial} = .039$.

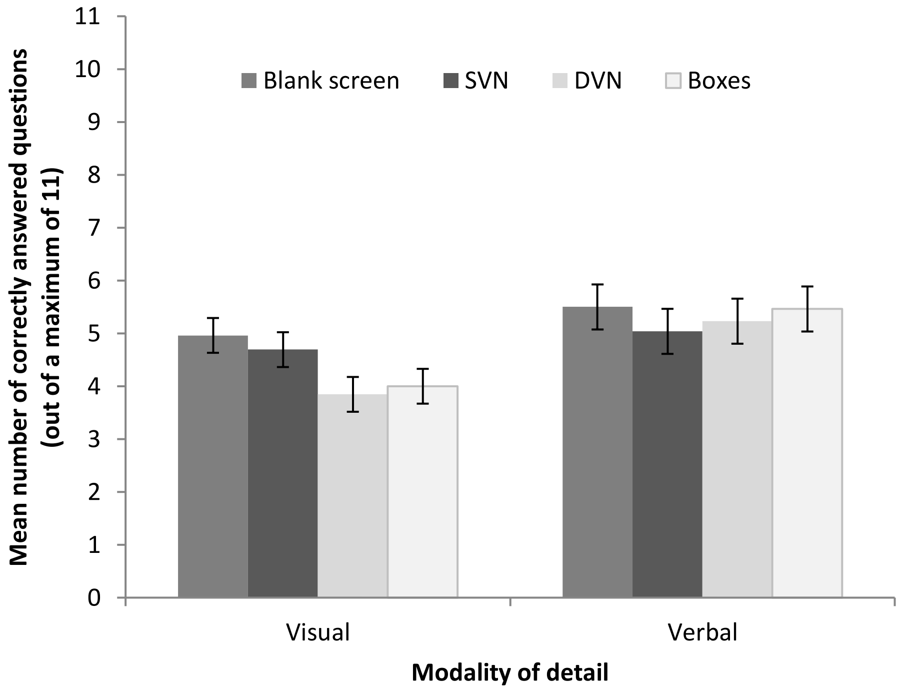

Figure 7: The mean number of correctly answered questions about visual and verbal details under four distraction conditions. Error bars represent standard errors of the mean.

3.6.6.2 Incorrect Recall

3.6.6.2.1 Normality testing on Experiment 4 incorrect recall data

Experiment 4 and collection of incorrect recall data followed a 4 (Distraction: Blank Screen, SVN, DVN, Boxes) x 2(Modality of detail recalled: visual vs verbal) mixed design with repeated measures on the second factor. Table 14 shows, with the exception of the Boxes verbal recall condition, skew and kurtosis parameters were within accepted boundaries for normal distributions therefore, data were not transformed prior to analysis but parametric testing was interpreted with caution.

Table 14: Experiment 4, normality testing of incorrect recall of visual and verbal details under SVN, Blank screen, DVN and Boxes.

Distraction condition	Modality of detail	Skew z-score	Kurtosis z-score
SVN	Visual	1.12	-0.31
	Verbal	1.26	-0.31
Blank	Visual	0.84	0.28
	Verbal	1.32	-0.51
DVN	Visual	1.02	-0.16
	Verbal	0.65	-0.86
Boxes	Visual	0.86	-0.03
	Verbal	2.35*	2.16*

3.6.6.2.2 Analysis of incorrect recall

Figure 8 shows the mean number of incorrectly answered questions about visual and verbal details under each distraction condition.

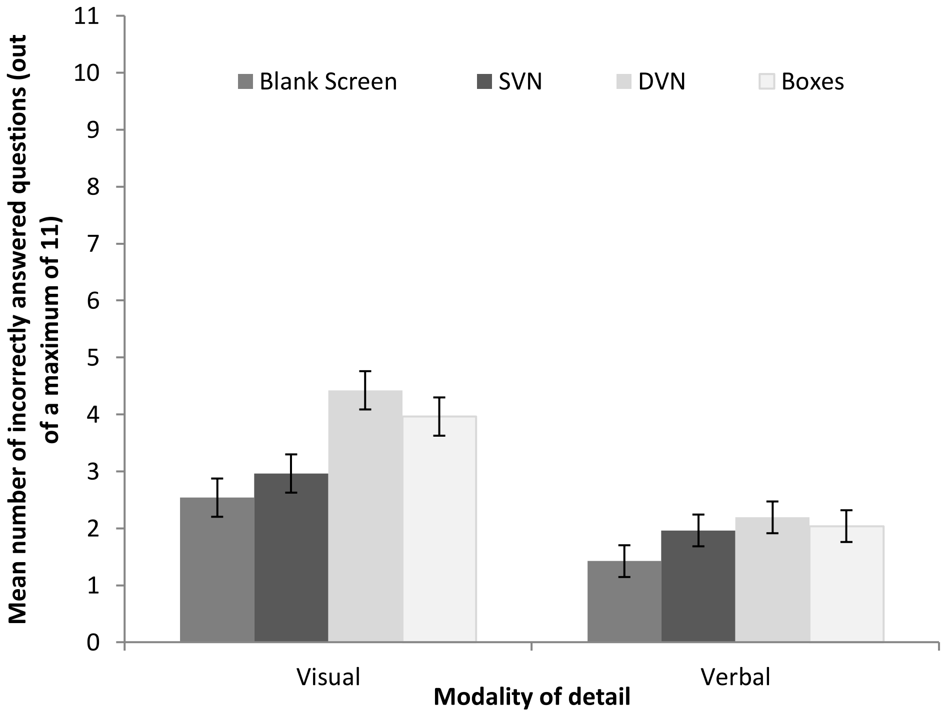

Figure 8: The mean number of incorrectly answered questions about visual and verbal details under each of the four distraction conditions. Error bars represent standard errors of the mean

A 4 (Distraction: Blank Screen, SVN, DVN, Boxes) x 2 (Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the second factor, found a main effect of distraction condition on incorrect recall, $F(3,100) = 5.50$, $MSE = 3.25$, $p = .002$, $\eta_{2\ partial} = .14$. Pairwise comparisons revealed no significant difference in the number of incorrectly recalled details between SVN and Blank Screen conditions ($p > .999$) or between DVN and Boxes conditions ($p > .999$) but a significant difference between Blank Screen and both DVN ($p = .002$) and Boxes conditions ($p = .029$) and between SVN and DVN conditions ($p = .019$). Although numerically fewer incorrect responses were given under SVN than Boxes, the difference was not significant ($p = .131$).

There is a main effect of modality of detail incorrectly recalled: participants gave fewer incorrect answers to questions about verbal details ($M = 1.9$, $SD = 1.43$) than to questions about visual details ($M = 3.47$, $SD = 1.85$), $F(1,100) = 75.35$, $MSE = 1.696$, $p < .001$, $\eta_{2\ partial} = .43$, Cohen's $d = -0.96$.

There is a significant interaction between distraction condition and modality of detail recalled, $F(3,100) = 2.793$, $MSE = 1.696$, $p = .044$, $\eta_{2\ partial} = .077$. Simple effects analyses show that whilst participants gave more incorrect visual details than verbal details overall, the difference was more marked under DVN and Boxes ($p < .001$, $\eta_{2\ partial} = .276$; $p < .001$, $\eta_{2\ partia\ l} = .221$, respectively) than under Blank Screen or SVN ($p = .003$, $\eta_{2\ partial} = .087$; $p = .007$, $\eta_{2\ partial} = .071$, respectively).

A follow-up analysis reveals a significant effect of distraction condition on mean number of incorrect visual details, $F(3,100) = 6.739$, $MSE = 19.73$, $p < .001$ but no effect on incorrect verbal details, $F(3,100) = 1.44$, $MSE = 2.91$, $p = .24$. Post hoc analysis shows that more incorrect visual details were given under DVN and Boxes than Blank Screen (DVN versus Blank screen, *p* < .001; Boxes versus Blank Screen, *p* = .003) or SVN (Boxes versus Blank Screen, *p* = .003; Boxes versus SVN, *p* = .038). There is no significant difference in the number of incorrect responses to visual questions given under Blank Screen compared to SVN (*p* = .375) or given under DVN compared to Boxes (*p*= .333)

3.6.6.3 Accuracy of recall

Participants were given the option of not answering questions and instead responding with, 'Don't know'. Thus, it is possible to calculate the overall accuracy of responses by taking in to account how many answers were correct compared to the total number of answers given. The calculation used for this analysis was:

Accuracy = (number correct/(number correct + number incorrect))x100

3.6.6.3.1 Normality testing on Experiment 4 accuracy data

Table 15 shows normality testing for accuracy data. With the exception of Boxes, subgroups showed parameters within acceptable boundaries of a normal distribution. Data were not transformed prior to analysis, however, parametric testing was carried out with caution.

Table 15: Experiment 4, normality testing of accuracy of recall of visual and verbal details under SVN, Blank, DVN and Boxes distraction conditions

Distraction condition	Modality of detail	Skew z-score	Kurtosis z-score
SVN	Visual	-0.43	-0.97
	Verbal	-1.14	0.02
Blank	Visual	0.61	0.04
	Verbal	1.32	-0.51
DVN	Visual	-0.05	0.59
	Verbal	-0.94	0.54
Boxes	Visual	-2.18*	1.27
	Verbal	3.12*	2.65*

3.6.6.3.2 Analysis of recall accuracy

Figure 9 shows the mean-percentage accuracy scores of answers to questions about visual and verbal details, under each distraction condition.

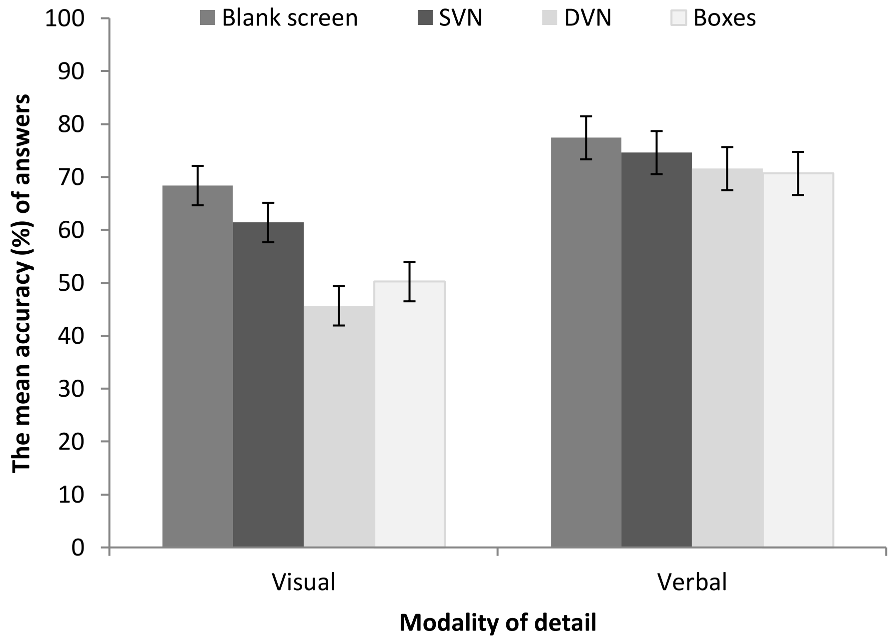

Figure 9: The mean recall accuracy (as a percentage) or visual and verbal details. Error bars represent standard errors of the mean

A 4 (Distraction: Blank Screen, SVN, DVN, Boxes) x 2 (Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the second factor, showed a significant main effect of distraction condition on accuracy, $F(3,100) = 4.43$, $MSE = 519.07$, $p = .006$, $\eta_{2\ partial} = .12$. Pairwise comparisons show that responses were significantly more accurate under Blank Screen than under DVN ($p = .011$) or Boxes ($p = .038$) but no different under Blank Screen compared to SVN ($p > .999$). However, there was also no difference in accuracy under SVN compared to DVN ($p = .229$) or to Boxes ($p = .564$.). There was also a main effect of modality of detail on accuracy, with higher accuracy for verbal details ($M = 73.57\%$, $SD = 20.62$) than visual details ($M = 56.42\%$, $SD = 20.78$), $F(1,100) = 56.12$, $MSE = 15288$, $p < .001$, $\eta_{2\ partial} = .36$.

There was a significant interaction between modality of detail and distraction condition on accuracy, $F(3,100) = 2.67$, $MSE = 733.75$, $p = .05$, $\eta_{2\ partial} = .08$. Follow-up one-way analyses reveal a significant effect of distraction condition on accuracy of visual details, $F(3,100) = 7.73$, $MSE = 2790.70$, $p < .001$ but no effect on accuracy of verbal details, $F(3,100) = 0.57$, $MSE = 244$, $p = .638$. Post hoc analysis shows that visual details were less accurate under DVN and Boxes compared to Blank Screen (DVN versus Blank screen, $p < .001$; Boxes versus Blank Screen, $p = .001$) and SVN (DVN versus SVN, $p = .004$; Boxes versus SVN, $p = .036$). There was no difference in accuracy between Blank Screen and SVN ($p = 0.188$) or between DVN and Boxes ($p = .388$).

3.6.6.3.3 Distraction ratings

Participants in each condition were asked to rate out of 10, how distracting it was to watch the screen during recall. Due to an oversight, participants in the blank screen condition were not asked for this rating. Mean ratings are shown in Figure 10, higher scores reflect greater levels of perceived distraction. The results of a one-way ANOVA showed that participants rated the DVN and Boxes conditions as more distracting than the SVN condition, $F(2,73)=29.648$, $p=.006$. Post hoc analysis shows that ratings given for SVN were lower than for DVN (p=.006) and Boxes (p=.005) and that DVN and Boxes were rated as similarly distracting (p=.951).

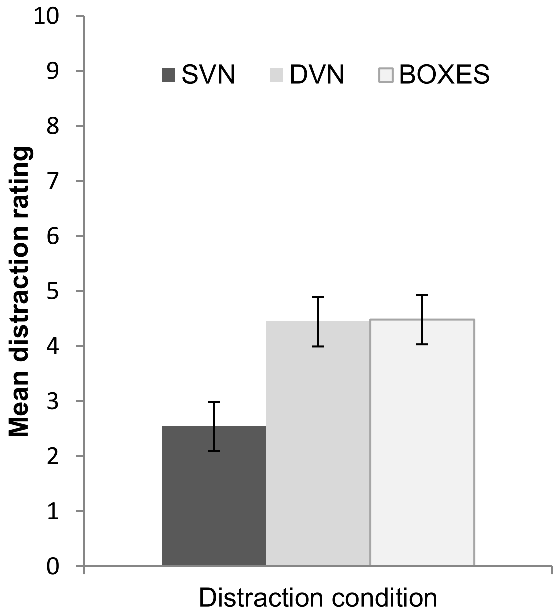

Figure 10: The mean distraction rating (0 to 10) given for each distraction screen. Error bars represent standard errors of the mean.

3.6.6.3.4 Post-Hoc Exploration: Effect of presentation duration on recall accuracy of visual details

The analysis revealed that distraction (DVN, Boxes) led to a reduction in recall accuracy of visual but not verbal details. One possibility is that presentation duration moderated the effect because presentation durations of verbal details were relatively homogenous but presentation durations of visual details were not. For example, the target one-word answer to verbal questions was spoken just once and therefore the length of time the 11 verbal answers were presented for was closely comparable. However, presentation durations of target visual details varied from 2 seconds to 12 seconds. For example, the target visual detail answer to the visual question, ‘How many medieval carved stones did you see lined up on the wall?' was visually presented in the video-clip for 2 seconds whereas the target visual detail to the visual question, 'What colour was the sport's presenter's tie?' was visually presented for 10 seconds. It is feasible that visual information presented for longer periods are more central to attention than details presented for relatively brief periods and it is possible that details presented for longer durations allow opportunity for elaborate rehearsal, and elaborate rehearsal processes are more vulnerable to distraction. Therefore, a post-hoc analysis on presentation duration and recall accuracy was carried out as an exploration.

Method

Target visual detail durations were rank ordered and split in to two groups either side of the median value of 6.5 seconds. This meant that two questions were omitted from the post hoc analysis because the duration of both was 6.5 seconds. Thus four target visual details were split in to the 'short' durations group (*M*=4.25s, *SD*=2.10) and five target visual details in to the 'long' durations group (*M*=9.40s, *SD*=2.30). As there was no difference in recall performance between SVN and Blank screen conditions and DVN and BOXES, these were collapsed in to two recall conditions: low (SVN and Blank screen) and high (DVN and BOXES) distraction. Analysis was carried out on recall accuracy because this takes in to account both correct and incorrect responses.

Results: recall accuracy of visual target detail by presentation duration

A 2 (Distraction: Low versus High) x 3 (Presentation-duration: short, medium, long) mixed ANOVA with repeated measures on the second factor showed a main effect of distraction condition on recall accuracy, $F(1,102) = 8.05$, $MSE = 920.44$, $p = .005$, $\eta_{2\ partial} = .07$ with higher recall accuracy under low distraction (*M* = 56.88, *SD* =

30.52) than high (*M* = 44.94, *SD* = 29.31). There was also a main effect of presentation-duration on recall accuracy, $F(1,102) = 34.31$, $MSE = 987.70$, $p < .001$, $\eta_{2\ partial}$ =. 252, with greater accuracy for visual details presented for longer durations (*M* = 63.67, *SD* = 26.40) than short (*M* = 38.14, *SD* = 35.56).

However, there was no interaction between distraction condition and presentation-duration, $F(1,102) < .001$, $MSE = 1987.70$, p =.985, $\eta_{2\ partial} < .001$.

Discussion

The post hoc exploration offers no evidence to suggest that duration of presentation may have moderated the distraction effect seen for recall accuracy of visual details. While it is not surprising that details presented for longer duration are recalled more accurately than those presented for shorterdurations, there was no evidence that distraction selectively interfered with this.

3.6.7 Discussion

In summary, the Experiment 4 data show that recall of verbal details (indexed by correct, incorrect and accuracy) was not significantly impaired by high levels of distraction (DVN and Boxes). Recall of visual details however, revealed a different pattern: participants under conditions of high distraction gave more incorrect visual details and, were less accurate. In comparison, Perfect et al (2012) found that Boxes demonstrated a general-effect of distraction and led to impaired recall of both visual and verbal details. However, Experiments 4’s modality-specific effect is not unexpected because a similar pattern was previously reported by Vredeveldt et al. (2011) Vredeveldt et al. (2012) and Vredeveldt and Penrod (2013) and is predicted by Vredeveldt’s (2011) cognitive resource framework.

The primary aim of Experiment 4 was to test whether DVN compared to SVN is an effective distractor by testing the effect of the two conditions on recall of an event and comparing the effects to that of Boxes and looking at a blank screen. There were no differential effects between the two high-distraction conditions in any of the analyses on recall therefore suggesting that black and white flickering squares are comparable to two coloured moving boxes in terms of their effect on memory. In addition, participants in the DVN condition, who took part in one condition only and therefore had no opportunity to experience other distraction conditions rated the level of distraction created by DVN the same as participants did for Boxes. Furthermore, participants in the SVN condition gave a significantly lower distraction rating. Thus DVN and Boxes are comparable both objectively and subjectively.

Another aim of Experiment 4 was to compare memory under SVN to a blank screen condition because one explanation for the lack of consistent effect in Chapter 2 was that the control condition of SVN was in itself distracting and thus a poor comparative condition for DVN. There was no significant difference between SVN and blank screen conditions in correct or incorrect recall of visual or verbal details. However, whilst accuracy of recall was no different under SVN to a blank screen, it was poorer under DVN and Boxes compared to a blank screen but there was no significant difference between SVN and DVN or SVN and Boxes. It was only in a follow-up analysis that explored recall of visual details separately that accuracy of recall under SVN was shown to be significantly different to recall under DVN and Boxes. The data also showed that correct, incorrect and accuracy of recall was numerically poorer, but not significantly so, under SVN than under blank screen. This implies that whilst SVN appears adequate in acting as a control condition, it does not provide as low a level of distraction seen with a blank screen.

The post hoc exploration into recall of visual details presented for long versus short durations revealed that participants gave more correct visual details and were more accurate when the target details had been presented for longer rather than shorter durations. However, there were no interactions between duration and distraction condition and, no main effect or interactions on incorrect recall. This suggests that distraction does not selectively impair memory based on length of encoding time and nor is it related to difficulty of recall. This replicates a finding of Experiment 2 where very short word presentations (0.5s compared to 2s) led to poorer recall but did not interact with distraction condition.

In summary, Experiment 4 showed a detrimental DVN effect on event memory: the increase in incorrect recall under DVN was comparable to that under Boxes; there was no difference in recall performance between SVN and Blank screen however, performance under DVN and Boxes was significantly poorer than under SVN and Blank Screen. This implies that DVN is an effective distractor and that SVN was not in itself distracting. Thus analyses presented so far from word-list Experiments 1-3 and from Experiment 4 imply that visual distraction in the form of DVN impairs recall of an event but not consistently so for a word-list. As discussed earlier, one explanation for this apparent selective distraction effect may be that different cognitive processes are involved in event versus word-list memory and these differences may be based on movement, modality of detail recalled, or bimodal presentation. Therefore Experiment 5 was designed to further explore this explanation.

3.7 Aim of Experiment 5

The aim of Experiment 5 is to test the effect of distraction on memory for the same details as Experiment 4 when the details are presented in a static, unimodal format. This in effect is an attempt to turn the news-bulletin into a list based on attributes discussed earlier in the chapter.

3.8 Experiment 5

One way to conceptualise differences between events and lists is in terms of modality, movement (or lack of) and whether details are presented concurrently with details of a different modality (unimodal versus bimodal presentation). Therefore, in order to turn the news-bulletin in to a list of details, information will be presented as unimodal and static. To test distraction effects on modality of recalled detail, the same visual and verbal questions will be asked as in Experiment 4. These manipulations are explained below.

3.8.1 The news bulletin as a static list

Presenting the visual information of the news bulletin as a list of static details is straight forward because scenes can be captured in one static visual image and presented one after the other. However, presenting the verbal track of the news bulletin as a list of static details is not as straight forward because the verbal track cannot truly be static in the same way as the visual. The logical solution would be to present the verbal track as a series of isolated single words similar to word-lists however, unlike the visual static images, single words cannot be placed in a wider context and therefore it would not be clear to participants which verbal detail they were being asked to recall. For example, Experiment 4's target verbal-details included the single word-answers of 'John, Thursday, Midnight, Jackie'. While it is possible to present these single words in a list, participants would not know which word a probe question was referring to. That is, the single word answer to the probe question, 'What is the name of the axed editor?' could equally be Jackie or John. Therefore, instead of presenting verbal details as a list of single words with no context the verbal static list will instead consist of verbal short clips that contain just enough information for participants to relate them to verbal questions during the recall phase.

3.8.2 Unimodal presentation

The verbal and visual static lists will be presented as unimodal in a within-participants design and the order in which the lists are presented will be taken into account in the analysis. The reason for this is that is allows a speculative exploration of whether relatively lower levels of structure are vulnerable to distraction. Participants who see the visual list before having heard the verbal list may find it challenging to mentally structure the incoming visual clips of information. In contrast, participants who hear the verbal list before seeing the visual list may then use their memory of the verbal details to create a structure around the clips of visual details. For example, one of the details in the visual list is an image of three wallabies which may be a confusing and unexpected image for participants who have been told they will see images taken from a Scottish news-bulletin. However, the verbal list includes a verbal clip which refers to three wallabies having escaped from a local zoo. Thus, it is possible that participants hearing the verbal list before seeing the visual list will perceive a greater degree of structure to the visual list. The assumption is that participants who hear the verbal list first, perceive the visual list as having more structure than that perceived by participants who see the visual list first. The prediction therefore, is that distraction will detrimentally effect recall of visual details from the visual list when the visual list is presented first (less perceived structure) but, will have no or less of effect on recall of visual details when the verbal list is presented first.

3.8.3 Distraction conditions

Experiment 4 found that the differential effect of DVN compared to blank screen was stronger than when DVN was compared to SVN. Therefore, Experiment 5 will replace SVN as a control condition and instead, used a blank screen as control.

3.8.4 Method

3.8.4.1 Power

Experiment 5 explored the effect on word recall of two levels of distraction condition presented between participants. The potential interaction of distraction with recall of visual and verbal details and order in which details were studied, was also examined. A power analysis with f = .04 and power = 0.90 indicated a minimum total sample size of 52 was needed.

3.8.4.2 Participants

Fifty-six participants (45 females), average age 27.39 years (*SD*= 11.2) took part for course credit or as a paid volunteer. All participants had normal or corrected to normal vision and hearing and were fluent English speakers. The same recruitment procedure as for Experiment 4 was followed as regards a flickering computer screen warning: no participants withdrew from the study.

3.8.4.3 Design and Materials

This was a 2 (Distraction: DVN, Blank) x 2 (List order: visual list first vs verbal list first) x 2 (Modality of detail: visual vs verbal) mixed design with repeated measures on the last factor design.

News-bulletin Verbal List. A total of 22 short verbal clips were created from the original audio-track. Nine clips contained the 11 one-word answers to the same 11 verbal questions asked in Experiment 4 and 13 clips contained irrelevant information. The length of the clips ranged from 2.4 to 10.75 seconds, with an average length of 5.09 seconds. In order to distinguish between the clips and present information in a list-like format, a set period of 2 seconds silence was presented between each clip. The total length of the full verbal list was 2 minutes and 46 seconds which was slightly shorter than the original three-minute audio-track. The verbal list was presented in the same order as the original audio-track.

News-bulletin Visual List. A total of 24 static images were created from the original visual track. Nine images contained the 11 one-word answers to the same 11 visual questions asked in Experiment 4 and,15 images contained irrelevant information. Each static image was presented on a PowerPoint slide for between 4 and 5 seconds followed by a blank white screen for 3 seconds. The total length of the full visual list was 3 minutes and 9 seconds, slightly longer than the original visual track. Twenty-four images were used to enable the length of the full list to be as close to the original duration of 3 minutes as possible, while at the same time presenting images for similar durations of time.

Questions about the lists: These were the same as for Experiment 4.

3.8.4.4 Procedure

The procedure followed a similar format to Experiment 4 where participants listened to the verbal list twice followed by verbal recall and then watched the visual list twice followed by visual recall. The order and content of the verbal and visual list were fixed so that each participant saw and heard the same information, in the same order. Verbal information was the same as that presented in the sound track of the original video clip. Visual information was the same as that presented in the visual track of the original video. Thus, rather than studying the details from the original video clip, participants heard (twice) verbal clips from the video and then answered questions and saw (twice) visual clips from the original video and then answered visual questions. The order of visual and verbal list presentation was counterbalanced. Participants again had the option of responding ‘I don’t know’ and again, the experimenter was not in the laboratory during the encoding phase.

3.8.5 Results

3.8.5.1 Correct Recall

3.8.5.1.1 Normality testing on Experiment 5 correct recall data

Experiment 5 and collection of correct recall data followed a 2(Distraction: DVN, Blank) x 2 (List order: visual list first vs verbal list first) x 2(Modality of detail recalled: visual vs verbal) design with repeated measures on the last factor. Table 16 shows skew and kurtosis z-scores for each sub-group suggest data are normally distributed therefore, analysis was carried out with parametric tests.

Table 16: Experiment 5, normality testing of correct recall data

Distraction condition	First list	Modality of detail	Skew z-score	Kurtosis z-score
Blank	Verbal	Visual	-0.57	-0.60
		Verbal	-1.07	-0.74
Blank	Visual	Visual	1.20	0.57
		Verbal	-0.46	-0.62
DVN	Verbal	Visual	-0.76	0.57
		Verbal	0.47	0.11
DVN	Visual	Visual	0.86	-0.03
		Verbal	-0.41	-0.92

3.8.5.1.2 Analysis of correct recall

Figure 11 shows the mean number of correctly answered questions about visual and verbal details under DVN and Blank screen.

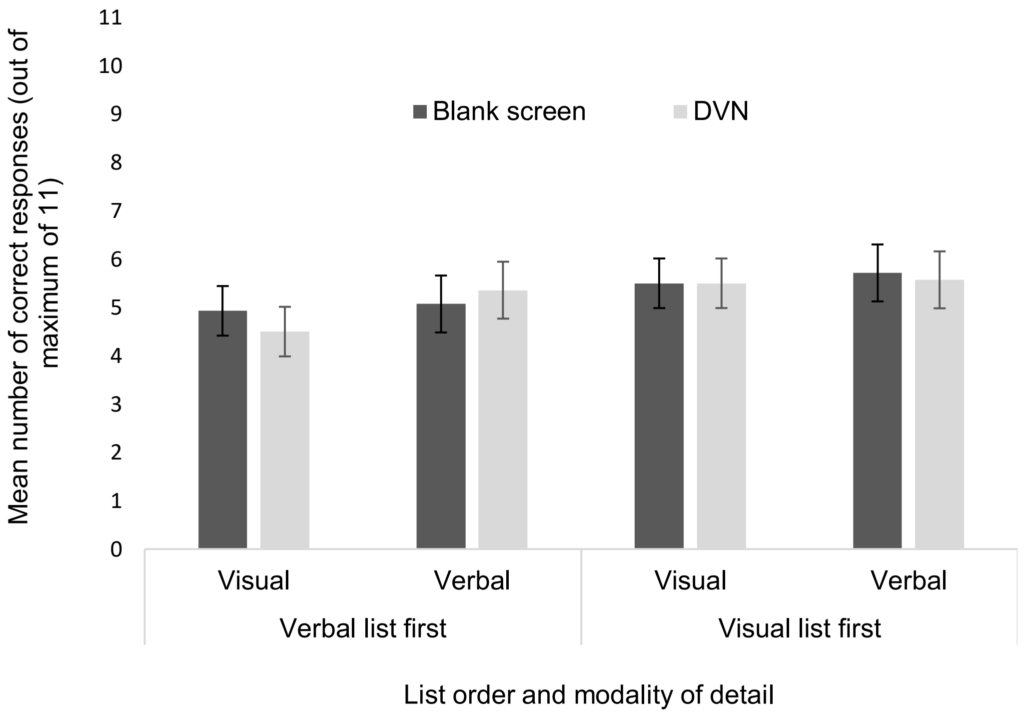

Figure 11: The mean number of correctly answered questions about visual and verbal details under blank screen and DVN. Error bars represent standard errors of the mean

A 2 (Distraction: DVN, Blank) x 2 (List order: visual list first vs verbal list first) x 2(Modality of detail recalled: visual vs verbal) x mixed ANOVA with repeated measures on the last factor, found no main effect of distraction condition on correct recall, $F(1,52) = .026$, $MSE = 5.59$, $p = .874$, $\eta_{2\ partial} < .001$, no main effect of list order $F(1,52) = 1.85$, $MSE = 5.59$, $p = .180$, $\eta_{2\ partial} = .034$ and no main effect of modality of detail recalled on correct recall, $F(1,43) = .98$, $MSE = 2.95$, $p = .327$, $\eta_{2\ partial} = .019$.

There was no interaction between distraction and list order $F(1,52) < .001$, $MSE = 5.59$, $p > .999$, $\eta^2_{partial} < .001$, no interaction between distraction and modality of detail, $F(1,52) = .19$, $MSE = 2.95$, $p = .662$, $\eta^2_{partial} = .004$ and no interaction between list order and modality of detail $F(1,52) = .303$, $MSE = 2.95$, $p = .585$, $\eta^2_{partial} = .006$.

There was no 3-way interaction between distraction, modality of detail and list order, $F(1,52) = .436$, $MSE = 2.949$, $p = .512$, $\eta^2_{partial} = .008$

3.8.5.2 Incorrect Recall

3.8.5.2.1 Normality testing on Experiment 5 incorrect recall data

Experiment 5 collection of incorrect recall data followed a 2(Distraction: DVN, Blank) x 2 (List order: visual list first vs verbal list first) x 2(Modality of detail recalled: visual vs verbal) design with repeated measures on the last factor. The skew and kurtosis z-scores presented in Table 17 suggest that with the exception of incorrect recall of verbal details presented before visual details, data are normally distributed. Thus, analysis was carried out with parametric tests with caution paid to the interpretation of test results.

Table 17: Experiment 5, normality testing of incorrect recall data

Distraction condition	First list	Modality of detail	Skew z-score	Kurtosis z-score
Blank	Verbal	Visual	1.18	-0.08
		Verbal	2.73*	4.61*
Blank	Visual	Visual	1.03	-0.34
		Verbal	0.35	-0.41
DVN	Verbal	Visual	0.76	-1.00
		Verbal	1.15	-0.48
DVN	Visual	Visual	-1.60	-1.60
		Verbal	0.95	1.08

3.8.5.2.2 Analysis of incorrect recall

Figure 12 shows the mean number of incorrectly answered visual and verbal questions under each distraction condition.

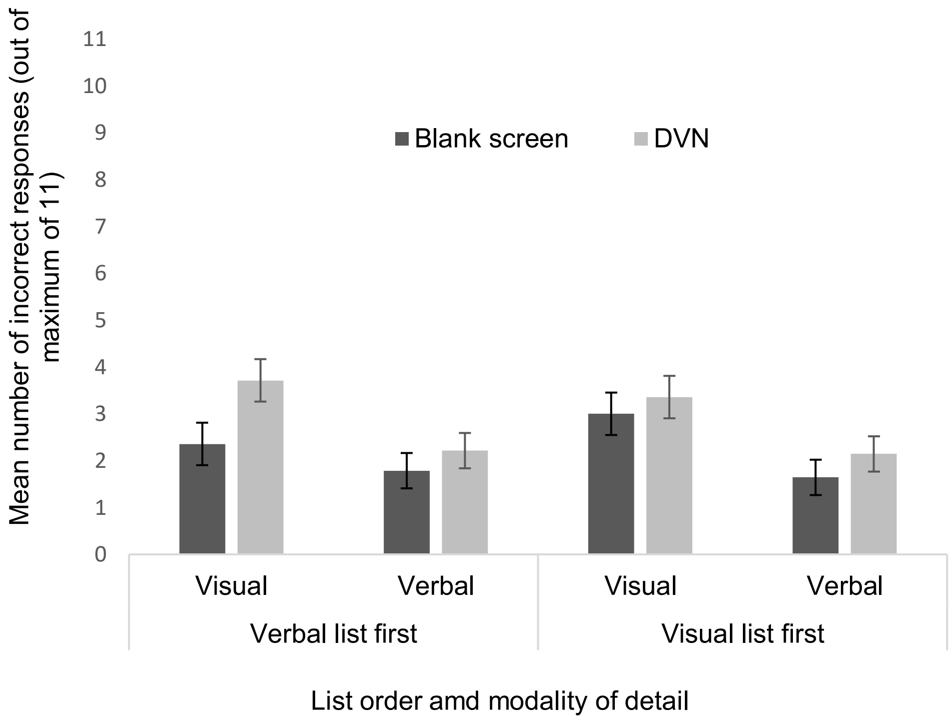

Figure 12: The mean number of incorrectly recalled visual and verbal details under blank screen and DVN

A 2 (Distraction: DVN, Blank) x 2 (List order: visual list first vs verbal list first) x 2 (Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the last factor showed no significant main effect of distraction on incorrect recall $F(1,52) = 3.98$, $MSE = 3.07$, $p = .051$, $\eta^2_{partial} = .071$. Whilst this effect was not significant, there was a numerical pattern where more incorrect details were recalled under DVN than blank screen. There was no main effect of list order on incorrect recall, $F(1,52) = .003$, $MSE = 3.07$, $p = .957$, $\eta^2_{partial} < .001$ but, there was a main effect of modality of detail on incorrect recall where more incorrect visual details than verbal details were recalled, $F(1,52) = 21.04$, $MSE = 1.793$, $p < .001$, $\eta^2_{partial} = .288$. .

There was no interaction between distraction and modality of detail, $F(1,52) = .60$, $MSE = 1.79$, $p = .44$, $\eta^2_{partial} = .011$ or between distraction and list order $F(1,52) = .49$, $MSE = 3.07$, $p = .49$, $\eta^2_{partial} = .009$ and no interaction between modality of detail and list order $F(1,52) = .244$, $MSE = 1.79$, $p = .623$, $\eta^2_{partial} = .005$.

3.8.5.3 Accuracy of recall

3.8.5.3.1 Normality testing on Experiment 5 recall accuracy data

The skew and kurtosis z-scores presented in Table 18 suggest that subgroups within recall accuracy data are normally distributed. Thus, analysis was carried out with parametric tests.

Table 18: Experiment 5, normality testing of recall accuracy data

Distraction condition	First list	Modality of detail	Skew z-score	Kurtosis z-score
Blank	Verbal	Visual	-0.04	-1.10
		Verbal	-1.58	0.68
Blank	Visual	Visual	-0,83	-0.66
		Verbal	-0.66	-0.62
DVN	Verbal	Visual	-0.95	-0.57
		Verbal	-1.28	-0.01
DVN	Visual	Visual	1.20	1.78
		Verbal	-0.78	-0.66

3.8.5.3.2 Analysis of recall accuracy

Figure 13 shows the mean-percentage accuracy scores of answers to questions about visual and verbal details under DVN and Blank screen.

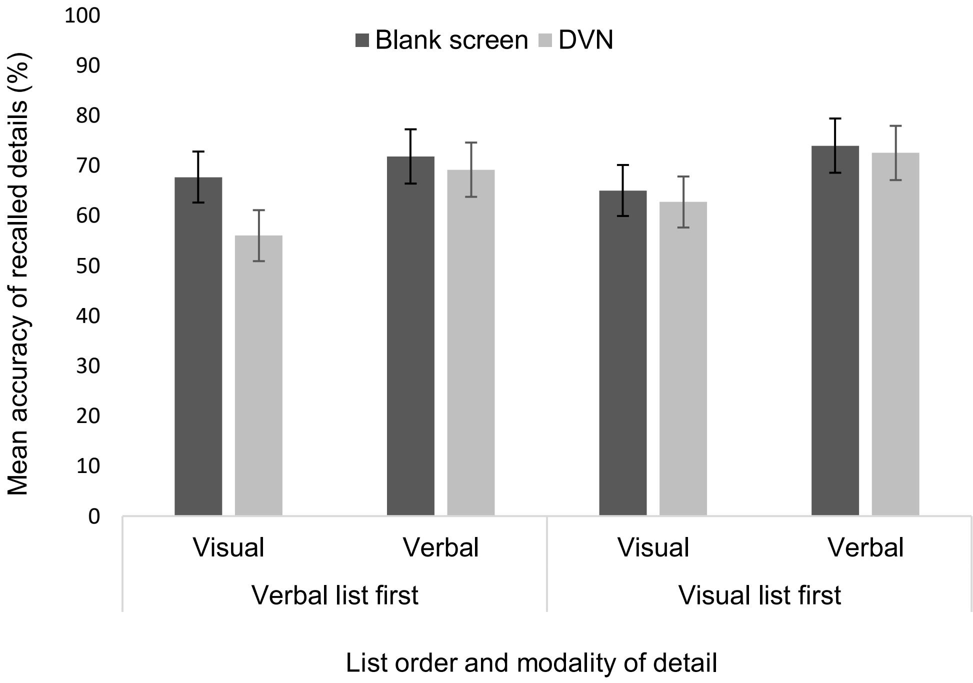

Figure 13: The mean recall accuracy of visual and verbal details (as a percentage). Error bars represent standard errors of the mean.

A 2 (Distraction: DVN, Blank) x 2 (List order: visual list first vs verbal list first) x 2 (Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the last factor, found no main effect of distraction condition on accuracy of recall, $F(1,52) = 1.22$, $MSE = 471.51$, $p = .275$, η^2 *partial* =.023 and no main effect of list order $F(1,52) = 0.39$, $MSE = 471.51$, $p = .564$, η^2 *partial* = .006. However, there was a main effect on accuracy of modality of detail recalled, $F(1,52) = 7.51$, $MSE = 302.57$, $p=.008$, η^2 *partial* =.126 where overall, recall of visual details was less accurate ($M = 62.86\%$, $SD = 19.04$) than that of verbal details ($M = 71.87\%$, $SD = 19.79$).

There was no interaction between distraction and list order $F(1,52) = 0.42$, $MSE = 471.51$, $p = .521$, η^2 *partial* = .008, between distraction and modality of detail,

$F(1,52) = 0.57$, $MSE = 302.57$, $p = .456$, η^2 *partial* = .011 or between list order and modality of detail $F(1,52) = 0.01$, $MSE = 302.57$, $p = .911$, η^2 *partial* < .001.

There was no 3-way interaction between distraction, modality of detail and list order, $F(1,52) = .390$, $MSE = 302.57$, $p = .535$, $\eta_{2\ partial} = .007$.

3.8.6 Discussion

The aim of Experiment 5 was to test the effect of distraction on memory for the news-bulletin visual and verbal details when presented as static (or pseudo static) and unimodal. Similar to Experiment 4's analysis, no significant effect of distraction was found for correct recall of either visual or verbal details. There was a numerical increase in incorrect recall of both visual and verbal details however, this was not significant. There was no distraction effect on recall accuracy. Thus, unlike Experiment 4, Experiment 5 found no significant detrimental effect of distraction on recall. Experiment 5's results seem to lie somewhere between those of the word-list studies and the event study.

The quantity of details recalled in Experiment 4 compared to 5 suggests that studying the visual and verbal details in separate lists is no easier than studying the details concurrently because under control conditions very similar numbers of correct and incorrect verbal and visual details were recalled. Thus, the distraction effect on incorrect recall does not appear to be driven by task difficulty.

In both Experiments 4 and 5 the pattern of distraction effect appears to be more driven by recall of visual than verbal details. However, the effect of distraction on incorrect recall of visual details in Experiment 4 (*d* =1.16) is more than double the effect seen on incorrect recall of visual details in Experiment 5 (*d*=0.51). This suggests that the distraction effect may have been weakened by presenting the visual details as a list of static, unimodal items. However, it also suggests that despite being static and unimodal, distraction still showed a detrimental effect on recall of visual details which implies that distraction is modality-specific. There was no statistical evidence to suggest that the perceived structure of the visual list may moderate the distraction effect because, there was no statistical interaction between distraction and list order.

Speculatively, modality may be just one part of the distraction mechanism because there was a weaker effect of distraction on recall of visual static unimodal details than visual flowing bimodal details. However, these two factors were both manipulated at the same time therefore, it is not yet known whether the weaker effect is due to the visual details being static or unimodal or both. Therefore Experiment 6 will compare distraction effects on recall of both bimodal and unimodal presentations.

3.9 Aim of Experiment 6

The aim of Experiment 6 is to test the effect of distraction on recall of static visual details when presented as unimodal compared to bimodal with verbal details.

3.10 Experiment 6

3.10.1 Bimodal and unimodal presentation of details

So far, distraction has been shown to disrupt recall of bimodal flowing visual details of a video-clip but not bimodal flowing verbal details. When the same visual details are presented as unimodal and static, distraction appears to have a much weaker detrimental effect on recall. There are two possible explanations for this detrimental effect, one is because the visual details are static and the other is because the visual details are unimodal. Experiment 4 presented bimodal flowing visual details but Experiment 5 manipulated both of these qualities at the same time and presented visual details as both unimodal and static. Therefore, Experiment 6 will try to unpick these aspects by retaining the static feature of visual images and testing distraction effects on both unimodal and bimodal presentations of those static images. In order to continue exploring whether the verbal track appears to moderate the pattern of distraction effect on recall of visual details, the unimodal visual track will again be presented either before or after the verbal track.

In addition, Experiment 6 will return to presenting the verbal track as flowing information rather than as a series of pseudo-static details. This will enable a direct comparison of distraction effects between recall of visual static details and recall of visual flowing details when both are encoded from bimodal presentations. That is, distraction effects on recall of visual static details from Experiment 6 can be directly compared to distraction effects on recall of visual flowing details from Experiment 4.

3.10.2 Duration of visual detail presentation

Static images of visual details in Experiment 5 were presented for a fixed duration and each image was separated from the other by a blank white screen.. These fixed durations do not reflect the durations that visual details were presented for in Experiment 4's original video clip . The distraction effect on recall of visual details was weaker in Experiment 5 than in Experiment 4.It is possible that the fixed duration of visual detail presentations in Experiment 5 may have influenced this. For example, some of the static visual images were shown for longer durations than when they had been shown as flowing visual images in the original video clip. Experiment 6 presents an opportunity to reinstate the original presentation durations of visual images. . Therefore, durations of presentation of static visual images in Experiment 6 will be set to match the durations of presentation when the same images were presented as flowing images in the original news-bulletin. For example, if a visual flowing image, holding the answer to a visual question, was presented in the original video in Experiment 4 for 6 seconds, the duration of the same visual image as a static image will be presented in Experiment 6 for 6 seconds. In addition, there will be no white screens in between the static visual images. This is to ensure that the duration of presentation of the visual list does not exceed the duration of the original news-bulletin. This manipulation also serves to remove any artificially inserted distinctiveness to the visual list.

3.10.3 Method

3.10.3.1 Power

Experiment 6 explored the effect on word recall of distraction condition and potential interactions of distraction with recall of visual and verbal details and the way in which details were studied. A power analysis based om the design reported below, with f = .04 and power = 0.95 indicated a minimum total sample size of 100 was needed.

3.10.3.2 Participants

One-hundred and two participants (81 females), average age 22.16 years (*SD*= 7.29) took part for course credit or as a paid volunteer. All participants had normal or corrected to normal vision and hearing and were fluent English speakers. The same recruitment procedure as for Experiment 4 was followed as regards a flickering computer screen warning: no participants withdrew from the study.

3.10.3.3 Design and Materials

Experiment 6 used a 2 (Distraction: DVN, Blank) x 3 (Video Presentation: combined verbal track and visual list, verbal track first, visual list first) x 2 (Modality of detail recalled: visual vs verbal) mixed design with repeated measures on the last factor.

News-bulletin visual list. The same 24 static images from Experiment 5 were used however, the timings were altered to match the length of time the same information was presented for in the original video-clip.

News-bulletin verbal track. The verbal track was presented in its original flowing format.

Questions about the verbal and visual details: These were exactly the same as for Experiments 4 and 5.

Distraction conditions. This between-design experiment has the same two distraction conditions as Experiment 5: DVN and Blank screen.

3.10.3.4 Procedure

Participants either watched the static images at the same time as listening to the verbal-track (combined) or, they watched the images before or after listening to the verbal track (separate): this manipulation was between participants. As with the previous two experiments, participants watched and listened to both verbal and visual aspects twice. Participants who listened to the verbal whilst watching the visual did so twice before calling the experimenter in to the room to start the recall phase. Participants who listened to the verbal separately to the watching the visual either first watched the visual twice and then were asked visual questions or, first listened to the verbal track twice before being asked verbal questions. In this latter case, the order of visual and verbal presentation was counterbalanced. Participants again had the option of responding 'I don't know' and again, the experimenter was not in the laboratory during the encoding phase.

3.10.4 Results

3.10.4.1 Correct Recall

3.10.4.1.1 Normality testing on Experiment 6 correct recall data

Experiment 6 correct recall data followed a 2 (Distraction: DVN, Blank) x 3 (Video Presentation: combined verbal track and visual list, verbal track first, visual list first) x 2(Modality of detail recalled: visual vs verbal) design with repeated measures on the last factor. Skew and kurtosis z-scores presented in Table 19 suggest normally distributed data therefore, analysis was carried out with parametric tests.

Table 19: Experiment 6, normality testing of correct recall data

Distraction condition	Video presentation	Modality of detail	Skew z-score	Kurtosis z-score
Blank	Combined	Visual	0.30	-0.36
		Verbal	-0.23	-0.83
	Verbal first	Visual	0.18	-0.49
		Verbal	-1.82	0.89
	Visual first	Visual	-0.03	0.35
		Verbal	1.05	-0.51
DVN	Combined	Visual	1.31	-0.33
		Verbal	0.18	-0.93
	Verbal first	Visual	-0.50	-0.68
		Verbal	-0.41	-0.83
	Visual first	Visual	-0.03	0.78
		Verbal	1.09	-0.32

3.10.4.1.2 Analysis of correct recall

Figure 14 shows the mean number of correctly answered questions about visual and verbal details under DVN and Blank screen.

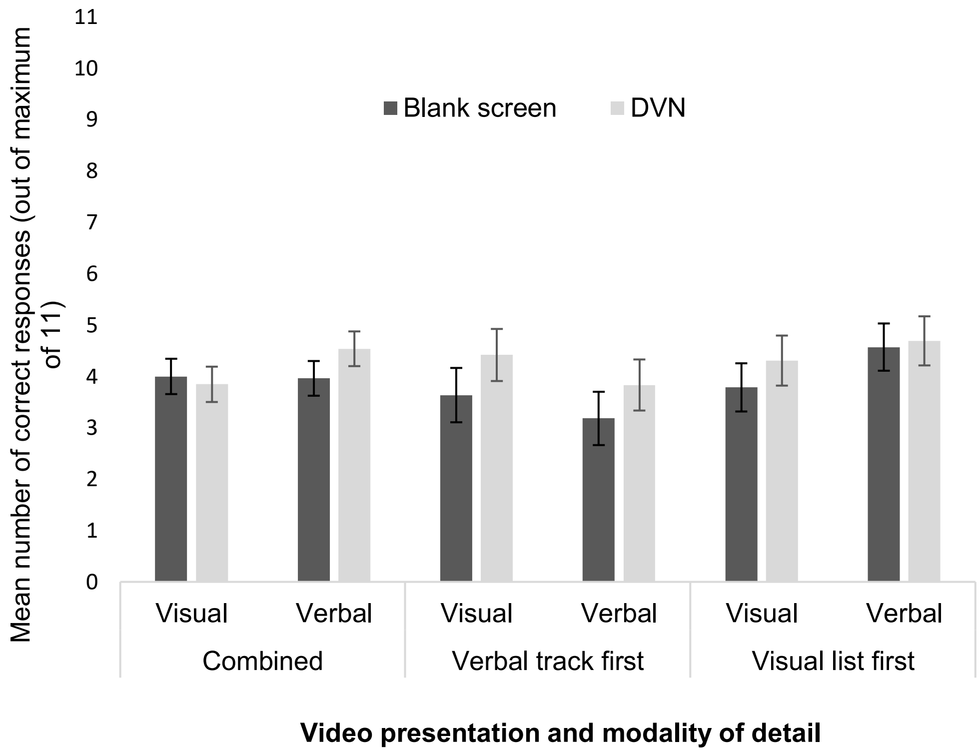

Figure 14: The mean number of correctly answered questions about visual and verbal details under blank screen and DVN. Error bars represent standard errors of the mean.

A 2 (Distraction: DVN, Blank) x 3 (Video Presentation: combined verbal track and visual list, verbal track first, visual list first) x 2 (Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the last factor found no main effect on correct recall of distraction, $F(1,96) = 2.15$, $MSE = 3.64$, $p = .15$, $\eta_{2\ partial} =.022$, video presentation $F(2,96) = 1.12$, $MSE = 3.64$, $p = .33$, $\eta_{2\ partial} = .023$ or modality of detail recalled $F(1,96) = .32$, $MSE = 0.2.41$, $p = .57$, $\eta_{2\ partial} = .087$.

There was no interaction between distraction and modality of detail, $F(1,96) = 0.02$ $MSE = 2.41$, $p = .885$, $\eta_{2\ partial} < .001$, between distraction and video presentation $F(2,96) = 0.28$ $MSE = 3.64$, $p = .755$, $\eta_{2\ partial} = .006$ or between modality of detail and video presentation, $F(2,96) = 1.73$, $MSE = 2.41$, $p = .183$, $\eta_{2\ partial} = .035$.

Finally, there was no 3-way interaction between distraction, modality of detail and video presentation, $F(2,96) = .692$ $MSE = 2.41$, $p = .503$, $\eta_{2\ partial} = .014$.

3.10.4.2 Incorrect Recall

3.10.4.2.1 Normality testing on experiment 6 incorrect recall data

Experiment 6 incorrect recall data followed a 2 (Distraction: DVN, Blank) x 3 (Video Presentation: combined verbal track and visual list, verbal track first, visual list first) x 2(Modality of detail recalled: visual vs verbal) design with repeated measures on the last factor. Skew and kurtosis z-scores presented in Table 20 suggest normally distributed data across subgroups, with the exception of incorrectly recalled verbal details when presented after the visual track. Analysis was therefore carried out with parametric tests, with results interpreted with caution.

Table 20: Normality testing of incorrect recall data

Distraction condition	Video presentation	Modality of detail	Skew z-score	Kurtosis z-score
Blank	Combined	Visual	0.30	-0.58
		Verbal	1.48	-0.03
	Verbal first	Visual	-0.35	-0.76
		Verbal	0.21	-1.44
	Visual first	Visual	-0.30	0.76
		Verbal	2.36*	3.58*
DVN	Combined	Visual	0.36	0.39
		Verbal	0.22	-0.33
	Verbal first	Visual	1.40	-0.12
		Verbal	0.91	-0.69
	Visual first	Visual	0.18	-1.07
		Verbal	0.53	-0.75

3.10.4.2.2 Analysis of incorrect recall data

Figure 15 shows the mean number of incorrectly answered questions about visual and verbal details under DVN and Blank screen.

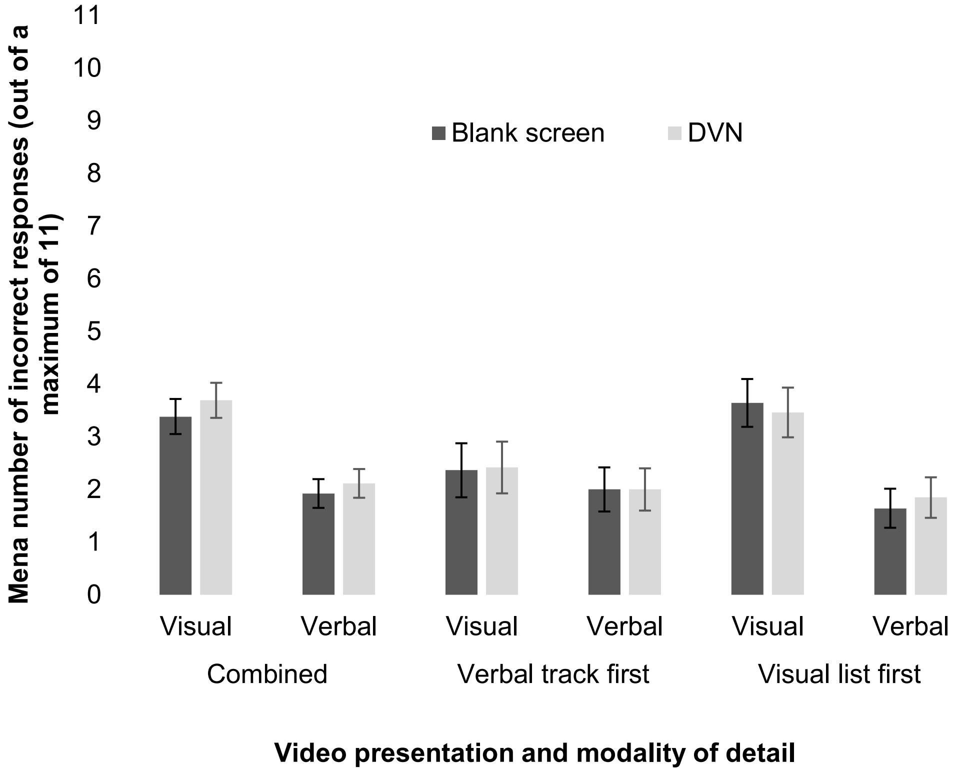

Figure 15: The mean number of incorrectly answered questions about visual and verbal details, under blank screen and DVN. Error bars represent standard errors of the mean.

A 2 (Distraction: DVN, Blank) x 3 (Video Presentation: combined verbal track and visual list, verbal track first, visual list first) x 2 (Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the last factor found no main effect on incorrect recall of distraction, $F(1,96) = 0.13$, $MSE = 3.21$, $p = .720$, $\eta_{2\ partial} = .001$ or video presentation $F(2,96) = 1.70$, $MSE = 3.21$, $p = .19$, $\eta_{2\ partial} =$

.034. However, there was a main effect of modality of detail recalled $F(1,96)=.42.93$, $MSE = 1.61$, $p < .001$, $\eta_{2\ partial} = .309$ where overall more incorrect responses were given about visual details ($M = 3.16$, $SD = 1.73$) than verbal ($M = 1.94$, $SD = 1.36$).

There was no interaction between distraction and modality of detail, $F(1,96) = 0.04$ $MSE = 1.61$, $p = .849$, $\eta_{2\ partial} < .001$ or between distraction and video presentation $F(2,96) = 0.11$ $MSE = 3.21$, $p =.899$, $\eta_{2\ partial} = .002$. However, there was an interaction between modality of detail and video presentation, $F(2,96) = 4.39$, $MSE = 1.61$, $p =.015$, $\eta_{2\ partial} = .084$. Simple effects analysis reveal that more visual than verbal errors were made when visual and verbal details were presented as combined $F(1,96) = 37.25$, $p < .001$, $\eta_{2\ partial} = .280$ or when the visual list was presented before the verbal track $F(1,96) = 27.34$, $p < .001$, $\eta_{2\ partial} = .220$ but there is no difference between the two when the verbal track was presented before the visual list $F(1,96) =1.08$, $p = .300$, $\eta_{2\ partial} = .011$.

Finally, there was no 3-way interaction between distraction, modality of detail and video presentation, $F(2,96)=.180$ $MSE= 1.61$, $p=.835$, $\eta_{2\ partial} =.004$.

3.10.4.3 Accuracy

3.10.4.3.1 Normality testing on Experiment 6 recall accuracy data

Experiment 6 recall accuracy data followed the same design as for correct and incorrect recall and skew and kurtosis z-scores presented in Table 21 suggest normally distributed data across subgroups. Analysis was therefore carried out with parametric tests.

Table 21: Normality testing of recall accuracy data

Distraction condition	Video presentation	Modality of detail	Skew z-score	Kurtosis z-score
Blank	Combined	Visual	-0.94	0.27
		Verbal	1.48	-0.03
	Verbal first	Visual	-0.35	-0.76
		Verbal	0.21	-1.44
	Visual first	Visual	-0.37	-0.47
		Verbal	2.36*	3.58*
DVN	Combined	Visual	0.36	0.39
		Verbal	-1.72	1.08
	Verbal first	Visual	0.62	0.25
		Verbal	-0.33	-0.76
	Visual first	Visual	0.18	-1.07
		Verbal	-0.76	0.39

3.10.4.3.2 Analysis of recall accuracy

Figure 16 shows the recall accuracy of visual and verbal details under DVN and Blank screen.

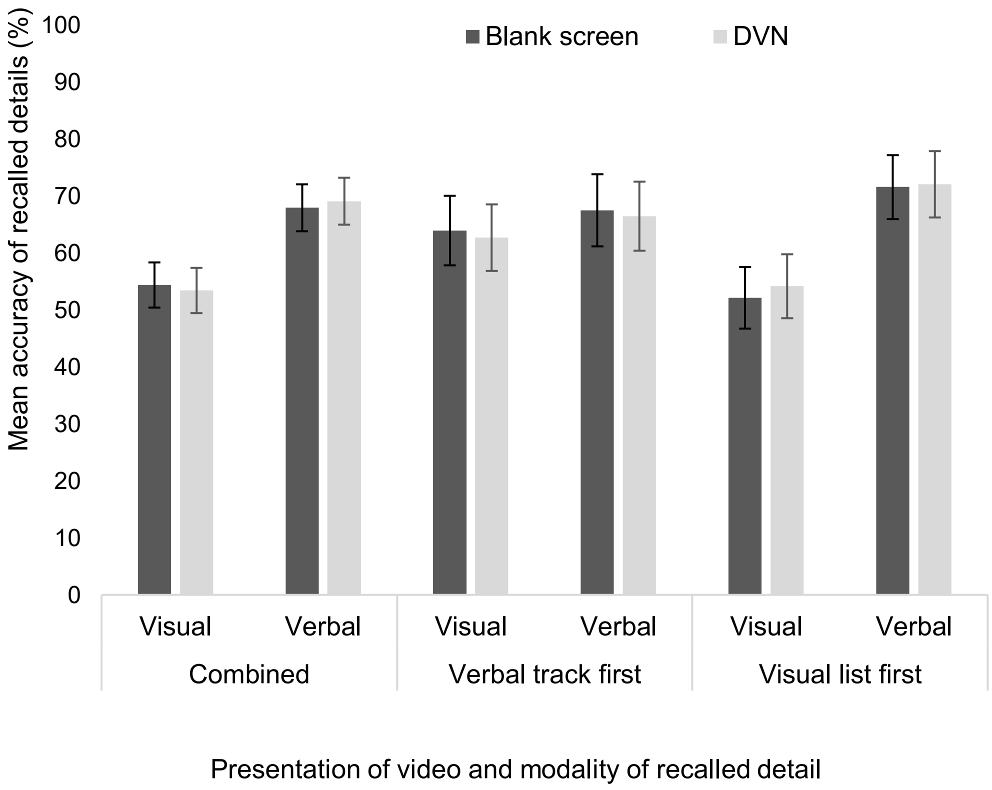

Figure 16: The mean accuracy of recalled visual and verbal details (as a percentage). Error bars represent standard errors of the mean.

A 2 (Distraction: DVN, Blank) x 3 (Video Presentation: combined verbal track and visual list, verbal track first, visual list first) x 2(Modality of detail recalled: visual vs verbal) mixed ANOVA with repeated measures on the last factor found no main effect on recall accuracy of distraction, $F(1,96) < 0.001$, $MSE = 491.44$, $p = .983$, $\eta^2_{partial} < .001$ or video presentation $F(2,96) = 0.503$, $MSE = 491.44$, $p = .606$, $\eta^2_{partial} = .010$. However, there was a main effect of modality of detail recalled $F(1,96) = 19.05$, $MSE = 358.44$, $p < .001$, $\eta^2_{partial} = .166$ where overall, responses were less accurate for visual details ($M = 55.80$, $SD = 20.14$) than verbal details ($M = 69.03$, $SD = 20.55$).

There was no interaction between distraction and modality of detail, $F(1,96) = 0.002$ $MSE = 358.44$, $p =.964$, $\eta^2_{partial} < .001$, between distraction and video presentation $F(2,96) = 0.11$ $MSE= 491.44$, $p =.964$, $\eta^2_{partial} = .001$ or between modality of detail and video presentation, $F(2,96) = 2.09$, $MSE = 358.44$, $p =.129$, $\eta^2_{partial} = .042$.

Finally, there was no 3-way interaction between distraction, modality of detail and video presentation, $F(2,96) = .04$ $MSE = 358.44$, $p = .958$, $\eta^2_{partial} = .001$.

3.10.5 Discussion of Experiment 6

The aim of Experiment 6 was to test the effect of distraction on recall of static visual details presented with and without flowing verbal details. Analysis found no evidence of a distraction effect on correct or incorrect recall, or recall accuracy of visual static details. The lack of statistical evidence of a distraction effect on recall of static visual details is commensurate with Experiment 5 however, Experiment 5 revealed a numerical pattern where distraction led to an increase in recall of incorrect unimodal static visual details but, this was not found in Experiment 6's data. Experiment 6 included three presentation conditions where the verbal stream was presented before, during or after the visual stream but, no detrimental distraction effect was found for any of the conditions. In addition, there was no evidence of a distraction effect on recall of flowing verbal details. Taken in isolation, this is not unexpected because Experiment 4, which tested distraction on recall of flowing verbal details, also found no evidence of an effect. In contrast, Experiment 5 found a distraction effect on recall of verbal details but this was not for flowing verbal details, it was for pseudo-static verbal details. The theoretical stance discussed earlier in the chapter which was argued to predicted that distraction would disrupt recall of flowing verbal details cannot explain why a distraction effect was found on recall of pseudo-static and not flowing verbal details. In summary, findings from Experiment 4 and 6 suggest that distraction has little effect on the incorrect recall of flowing verbal details but, the numerical recall pattern seen in Experiment 5 implies that visual distraction may have a disruptive effect on the incorrect recall of pseudo-static verbal details. However, this comparison is not a clear one because the comparison of verbal details was flowing versus pseudo-static rather than flowing versus static.

The pattern elsewhere in Experiment 6's data is also difficult to interpret. For example, the control condition shows that bimodal presentation of visual and verbal details was no more advantageous to memory than presenting details as unimodal. This is surprising because research reviewed earlier in the chapter demonstrated that memory for bimodal information (audio-visual streams) was consistently superior to memory for the same streams presented as unimodal (Meyerhof & Huff, 2015). Yet in terms of effect sizes under control conditions, bimodal presentation compared to unimodal presentation in Experiment 6 was marginally disadvantageous, not advantageous, to recall accuracy of both visual (*d* = -0.15) and verbal details (*d* = -0.09). The lack of evidence of a bimodal superiority effect may be because visual details were static and not flowing. This in turn may have disrupted the semantic congruency between the two streams. That is, the static visual images did not consist of the same richness of information as seen in the flowing visual images. Thus, the accompanying verbal track from the original video clip may have a greater degree of congruency with the flowing visual image track than with the static visual image list because the static visual image list does not hold the same magnitude of information that the flowing list does. However, as this was not under experimental control, the explanation remains a speculative one.

Overall, Experiment 6 recall data elicits more questions than answers. This may be due to the different manipulations on how the to-be-recalled details were presented or, it may simply be due to an extraneous variable unaccounted for and unique to Experiment 6. The general discussion section will thus consider the recall pattern across all three experiments in an attempt to tease out a clearer understanding of Chapter 3's data.

3.11 General Discussion

In summary, work in Chapter 3 found visual distraction to disrupt recall of an event. This was demonstrated in Experiment 4 where Boxes and DVN compared to SVN and a blank screen, led to both an increase in incorrect recall of visual event details and a reduction in recall accuracy of visual event details. This implied that the lack of evidence of a distraction effect in word-list Experiments 1 to 3 cannot be explained by DVN failing to act as a distraction to long-term memory processes. In addition, this also implied that event recall may involve different cognitive processes to word-list recall and that distraction differentially impacts on these processes.

The literature review presented at the beginning of the chapter identified three key features which both differentiate events from word-lists and imply that different cognitive processes are involved in each. These features were based on movement, modality of detail and unimodal versus bimodal presentation. Experiments 5 and 6 were thus designed to explore whether manipulations of these features moderate the effect of distraction on recall. In other words, details of Experiment 4's event were manipulated to appear more like a list of details. To labour the point, the same target details presented in Experiment 4 were presented in Experiments 5 and 6 which affords the opportunity to directly compare memory for the same detail when the detail is embedded in an event versus a list. Experiment 5 presented visual and verbal details of the event in a unimodal static and pseudo static list format. Experiment 6 presented visual static details and verbal flowing details in both unimodal and bimodal formats.

There were three central hypotheses to the work in this Chapter. The first, based on event segmentation theory (Zacks et al, 2001) predicted that if distraction disrupts cognitive processes involved in encoding and retrieving details based on movement there will be no evidence of a distraction effect on recall of static details. The second, based on Vredeveldt et al's (2011) cognitive resource framework, predicted that if distraction is moderated by the modality of detail being recalled there will be a greater detrimental impact of visual distraction on recall of visual details than on recall of verbal details. The third hypothesis, based on the role of Baddeley et al's (2011) episodic buffer and central executive, predicted that if distraction disintegrates bindings between details encoded in bimodal presentations and thus weakens memory traces for those details then distraction will selectively impair memory of bimodal presented details and not unimodal.

Experiment 5 found a detrimental distraction effect on incorrect recall of both unimodal static visual and unimodal pseudo-static verbal details but found no evidence of a distraction effect on recall accuracy. The effect on incorrect recall of unimodal static visual details was weaker than the effect found in Experiment 4 on incorrect recall of bimodal flowing details which suggests that either movement or bimodal presentation or both, may play a role in moderating the effect of distraction on recall of visual details. That is, it suggests that distraction has a greater detrimental effect on incorrect recall of visual details when they are presented as flowing and bimodal than when they are static and unimodal. However, as there was no evidence of a distraction effect in Experiment 4 on incorrect recall of flowing bimodal verbal details, Experiment 5's findings also implied that distraction has a greater detrimental effect on recall of verbal details when they are not flowing or bimodal. Experiment 6 found no evidence of an effect on incorrect recall of flowing bimodal verbal details which is in line with Experiment 4's finding. However, contrary to Experiment 5, Experiment 6 also found no evidence of a distraction effect on incorrect recall of visual static details. While the pattern of data in Experiment 5 had hinted that presenting the verbal stream before the visual stream might moderate the effect of distraction, there was no evidence of this in Experiment 6.

There is thus no clear support for any of the theoretical accounts the three central hypotheses were based on. One aspect of the work in this chapter that is clear however, is that visual distraction has a detrimental effect on recall accuracy of flowing visual details because Experiment 4 data demonstrated this twice (DVN versus SVN d = -0.78; Boxes versus blank screen d = - 1.04). These effect sizes are comparable to the consistent and robust effects reported by eyewitness studies whose methods were used in Experiment 4. For example, Experiment 4 presented participants with a news-bulletin and created questions to test memory of both visual and verbal details of the bulletin under conditions of distraction and quiet. In line with eyewitness methods, questions were based on information that was presented only verbally or only visually. There was no attempt to match questions on visual details with questions on verbal details in any way other than the number of questions asked. None of the eyewitness studies report purposefully matching the type of visual target details to the type of verbal target details. However, eyewitness studies did not investigate the effect of distraction on recall of details which were manipulated to be static and unimodal. That is, there is no set precedent for matching, or not matching, the type of visual and verbal detail recalled in eyewitness studies because these studies have not tested for nuanced effects of distraction on different features of events versus lists.

One potential issue is that the quantity of target detail type was not matched in number. For example, Table 22 below shows a summary of the types of target details by content and proportion out of 11 visual targets and 11 verbal targets.

Table 22: Summary of the content of target details, with mean recall accuracy rates, under control conditions

	Content of target detail	Mean accuracy of recall under control condition *(SD)*	Proportion of target details in each modality
Visual details	**Count**	57.37 % *(32.20)*	0.36 (4/11)
	Name	50.00 % *(49.51)*	0.18 (2/11)
	Colour	67.92 % *(25.37)*	0.46 (5/11)
Verbal details	**Count**	30.45 % *(28.53)*	0.18 (2/11)
	Name	75.80 % *(29.85)*	0.54 (6/11)
	Time	74.04 % *(32.41)*	0.27 (3/11)

Target details with a count content are for example, the number of wallabies lying down in a park, the number of museums in a short-list, the number of medieval stone slabs hanging on a wall. A name target detail is for example, the name of an abandoned oil platform, a colour detail is the colour of the sports presenter’s tie and a time content detail is the number of years ago a city-centre curfew was introduced. Table 22 shows the unequal distribution of these types of detail both within each modality and across modalities.

Work presented in the next chapter will thus exert greater experimental control over recall material by matching the content of details recalled. As a secondary aim, this will also provide opportunity to investigate whether distraction differentially disrupts recall of detail type when the contents are matched.

Chapter 4: The Effect of Visual Distraction on memory for a sequence of events, pictures and words

4.1 Introduction to Experiments 7 and 8

As discussed in Chapter 3, distraction showed a clear detrimental effect on memory for details of an event. However, when details were manipulated to appear with list-like features, the effect was inconsistent. One methodological explanation for the inconsistency was that visual and verbal target details were not matched by content, either within each modality or across modalities. Therefore the primary aim of work in Chapter 4 is to match visual and verbal target details based on the content of the detail being recalled before again testing the effect of distraction on recall. Matching visual and verbal target details is done in two ways in two separate experiments.

Experiment 7 matches the content of visual and verbal target details across a sequence of different video-clips of short-duration events. Participants are asked to recall two target details from each video-clip: one visual and one verbal. Each pair of visual and verbal target details are matched for content such that they are both about: colour, count or, a sequence. Experiment 8 matches the type of visual and verbal target detail by presenting the same words (concrete nouns) in two different modalities, verbally (spoken or written) and visually (as a picture).

4.2 Experiment 7

Experiment 7 will present participants with a sequence of 18 short-duration video-clips in order to match the type of visual and verbal target detail to be recalled. This design is explained in more detail in the method section however it is useful for now to note that information for later recall will be presented in multiple distinctly different videos. While the primary aim of Experiment 7 is to match the type of visual and verbal detail recalled, the multiple design of this study also lends itself to two secondary explorations which are explained below.

4.2.1 A list of events

Experiment 7's design can be thought of as a list, of events. The full presentation of the sequence of videos is the full list and the segments within the list are the individual videos. What makes this format like a list is the way in which each segment is distinct from the other in content and also in presentation because each segment will be separated by a temporal break and a blank white screen. This has similar features to Experiment 1 to 3's lists where each segment (a word) was distinct from another in both content and in presentation. Although some words in Experiment 2 and 3 shared the same semantic category, the words were distinct from each other because each word in the list was unique. Words were also distinct in presentation because they were pre-segmented with the use of temporal breaks and blank white screens between the words. Segmentation is one feature of a list which differentiates it from an event (as discussed in Chapter 3) and as has already been seen, recall of segmented lists does not typically suffer from detrimental distraction effects but recall of non- segmented events does. Experiment 7's method thus gives an opportunity to explore distraction effects on recall of a sequence of flowing bimodal segments: a list of events.

As discussed in Chapter 3, event segmentation research shows that memory for details of an event which has been segmented with distinct boundaries between segments is superior to memory for details of an event which has not been segmented (Gold, Zacks, & Flores, 2017). Furthermore, while it is understood that segmentation is an automatic process on the part of a participant, experimental trials have also shown that memory improves even further when researchers insert additional distinct boundaries in to the memory source. This has been found for recall of events (Gold et al., 2017), of sequences of objects (Horner, Bisby, Wang, Bogus, & Burgess, 2016) and of sequences of words (Pettijohn, Thompson, Tamplin, Krawietz, & Radvansky, 2016). Radvansky and Zacks' (2014) event horizon model proposes that a mental event model is constructed for each event segment and that when segments are distinctly different, accessing any specific model is not 'difficult'. In fact, distinctly different segments mean that retrieval competition is reduced between event models (Ezzyat & Davachi, 2011).

Therefore, the list design of Experiment 7 may elicit a weaker distraction effect because the representational event model for each segment should be easily distinguishable from event models for other segments. This is because the distinct boundaries between segments act as a framework from which to mentally search for target details. Although segmentation in Experiment 7 is not a variable under experimental control, it is possible to speculatively explore this through a comparison of distraction effect-sizes found here with those found in Experiment 4 and eyewitness studies.

4.2.2 Interference-by-process

Experiment 7's design also allows for an exploration of potential differential distraction effects on the type of detail recalled. That is, it presents opportunity to explore an interference-by-process effect of DVN on recall by including target details which are thought to predominantly engage the same visual-spatial processes used to analyse DVN.

As discussed in Chapter 1, a duplex mechanism account of distraction suggests that distraction may have both a general-effect and an interference-by-process effect on recall (for example, Hughes, 2014). Thus, distraction can interfere with a retrieval task per se as well as showing additional interference with a retrieval task which engages the same cognitive process as the distractor. The visual distractor used in this thesis, DVN, appears to move around the screen and will therefore engage visual-spatial processes. A retrieval task which engages visual memory processes may be less vulnerable to detrimental effects from DVN than a retrieval task which engages visual-spatial processes (such as recalling a visual-spatial sequence). Findings reported by Wallentin, Kristensen, Olsen, and Nielsen (2011) lend some support to this argument. With respect to Experiment 7, retrieval involving visual-spatial processes involves participants retrieving the spatial location of a visual detail. For example, one of Experiment 7's video clips shows a Halloween parade with a series of themed displays. From the viewer's angle, watching the video clip, the parade passes by from the left of the screen to the right. At the front of the parade is a display of skeletons and this is followed by a display of pumpkins, and so on. At one point in the video clip, the viewer therefore sees the skeletons on the right hand side of the screen and the pumpkins on the left hand side. Participants are later asked to recall what they saw before the pumpkins. In order to answer the question, it may therefore be necessary to retrieve the spatial location of the pumpkins (on the left) in order to retrieve the visual detail of the display which was temporally before them, on the right of the screen.

Wallentin et al. (2011) demonstrated a differential effect of eye-movement suppression on recall of different types of detail. The assumption here is that eye-movement suppression has a similar effect on cognitive processes as a moving visual distractor. A moving visual distractor engages visual-spatial processes which are also involved in the retrieval of visual-spatial details thus when both distractor and retrieval tasks are being processed the resource for visual-spatial processing is depleted. This could equally be thought of in terms of the visual distractor limiting or preventing the use of visual-spatial processes in the retrieval task. Wallentin et al.'s (2011) method of suppressing eye-movement also limits or prevents the use of visual-spatial processing.

Participants in Wallentin et al.'s (2011) experiment were asked to study arrays of two to four simple shapes at a time. Each shape was different to the other and each came complete with a snout and two eyes to denote a 'mouse'. The reason for providing mouse features was so that the shapes could be spatially orientated in mind and thus perceived as being behind or in front of each other. Each mouse was given a name (Hun, Han, Den and Det) and presented in different locations in different strengths of luminosity on a screen. Participants were asked to remember both the relative location of the mice on the screen (for example, whether Hen was in front of Den), the relative luminosity (was Det darker than Han?) and the number of mice in an array. The eye-movement suppression condition involved presenting an additional screen during recall, this was a simple '+' which moved around the screen and jumped from one location to another in an apparent erratic and high-speed manner. Participants were asked to ignore the erratic cross and instead focus fully on a static cross in the centre of the screen. In this way the authors sought to suppress eye-movement throughout recall. There was no effect of eye-movement suppression on recall accuracy of the spatial orientation, number or luminosity of mice. However, there was a significant effect on response time to spatial questions, with no disruption to luminosity or number. Participants took much longer to respond to spatial questions in the eye-movement suppression condition. The authors suggest that the slowness of response to spatial questions reflects an interference of eye-movement suppression with the ability to manipulate the memory representation in order to recall specific information of the spatial aspect of the representation.

Thus Wallentin et al.'s study implies that a visual-spatial distractor may differentially affect retrieval processes which predominantly engage visual-spatial processes compared to those which do not predominantly engage these processes. Therefore, the prediction for Experiment 7 is that DVN will interfere with retrieval of details embedded in a flowing event, as was found for Experiment 4. This is because it is feasible that DVN engages visual-spatial processes. In addition, there is evidence that retrieving details of a flowing event also engages visual-spatial processes. For example, as discussed in Chapter 1, eye-tracking studies show an association between the pattern of visual-spatial movement of a visual detail and the pattern of eye-movement recorded while watching the movement of the visual detail (Heremans et al., 2008; Bone et al. 2018; Laeng et al., 2014). While it is possible that participants are able to ignore the movement of the DVN and therefore do not experience eye-movement while processing the DVN, the distraction ratings taken in Experiment 4 imply that this is not the care. Participants rated looking at a screen of DVN to be significantly more distracting than looking at a blank screen. This implies that participants process DVN rather than ignore it. One possibility is that DVN will have a stronger detrimental effect on retrieval of specific details whose content suggests that a greater resource of visual-processes is involved in retrieval. For example, retrieving a detail which was presented within a sequence within an individual video-clip will engage visual-spatial processes to greater extent than a detail which was not within a sequence within the clip. This is because the video-clip the detail is presented in has flowing movement and because the sequence it was part of within the clip has a visual-spatial aspect. As a further example, one video-clip in Experiment 7 shows a child completing a home-made obstacle course of hoops, jumps, bean bags and so on. Participants are asked, ‘What was the second obstacle Jake tackled on his obstacle course?’ Thus, participants are engaging visual-spatial processes to reinstate the flowing details of the video-clip and also, are relying on visual-spatial processes to reinstate the sequence in which the obstacles were tackled. Recall of these details under distraction conditions will be compared to recall of other visual details which demonstrated distraction effects in Experiment 4; colour and count details. While both of these details will rely on visual-spatial processes because they are embedded in a moving video-clip, neither have the same sequential feature of for example, the obstacle course detail.

Experiment 7 thus provides the opportunity to ask participants to recall a subset of target details which theoretically engage visual-spatial processes more so than other target details.

4.2.3 Bimodal and unimodal

Experiment 7 provides an opportunity for exploring distraction effects on recall of flowing details from bimodal versus unimodal presentations. Chapter 3 found a numerical trend where distraction disrupted recall of unimodal visual details to a greater extent when the visual details had been presented after the verbal details. However, this was tested on recall of static visual details and not flowing.

Experiment 7 also provides opportunity to explore a potential methodological issue related to how recall data was collected for unimodal and bimodal presentations. For example, in Experiment 4 participants studied the bimodal presentation of the video-clip and were later asked questions about both visual and verbal details in one sitting. However, in Experiments 5 and 6 participants were shown for example, visual details in a unimodal presentation and asked to recall the visual details in one sitting before moving on to study the verbal details. That is, participants knew they would be asked about visual details only or, verbal details only, and thus could possibly control their search strategy by focussing on one modality at a time and, on a lower number of candidate details.

Therefore, Experiment 7 will be designed to compare recall of unimodal flowing visual and verbal details when verbal details are presented before the visual details, to recall of the same details presented as bimodal. In addition, recall of the details from both modalities will take place in one sitting.

4.2.4 Aims of Experiment 7

The primary aim of Experiment 7 is to test the effect of distraction on recall of matched visual and verbal target details of an event. The design of Experiment 7 also affords an exploration of three possible moderators of distraction: segmentation, interference-by-process and bimodal/unimodal presentations.

The first exploration considers the possibility that recalling details from a sequence of distinct segments is similar to recalling details from a list. Thus if the segmentation feature of a list is responsible for a lack of distraction effect (or a weakened effect) on recall of details from a list, there should be a relatively weaker effect of distraction on recall.

The second exploration is a nuanced exploration of the potential interference-by-process mechanism of distraction on the type of detail recalled. The prediction is that DVN will interfere with retrieval of details embedded in a flowing event however, DVN will have a stronger detrimental effect on retrieval of details which engage visual-spatial processes. In the case of Experiment 7 this translates as stronger effects on recall of sequence details than count or colour details.

The third exploration continues to look at whether bimodal and unimodal presentation of details moderates the distraction effect. If the bimodal presentation of details is responsible for the consistent and robust distraction effects seen in eyewitness studies then the bimodal presentation condition in Experiment 7 should show greater detrimental distraction effects than the unimodal presentation condition.

4.2.5 Method

4.2.5.1 Power

Experiment 7 presented two levels of distraction as a between variable. A power analysis based on detecting the main effect of distraction (in the design reported below) with f = .04 and power = 0.95 indicated a minimum total sample size of 84 participants was needed.

4.2.5.2 Participants

Eighty-eight participants (56 females), average age 20.12 years (*SD*= 3.9) took part for course credit. All participants had normal or corrected to normal vision and hearing and were fluent English speakers. The same recruitment procedure as for Experiment 4 was followed as regards a flickering computer screen warning: no participants withdrew from the study.

4.2.5.3 Design and Materials

Experiment 7 follows a 2 (Distraction: DVN, Blank Screen) x 2 (Presentation: unimodal vs bimodal) x 2 (Modality of detail: visual vs verbal) x 3 (Type of detail:

colour, count, sequence) mixed design with repeated measures on the latter two factors.

Visual track of video-clips.

Eighteen different visual flowing video-clips lasting between 10 and 15s were selected from videos posted in the public domain of 'YouTube'. Accompanying audio tracks were purposefully not downloaded. Visual clips were selected for their non-contentious content and on the basis of having good visual quality whereby questions could be asked about clearly discernible visual details based on colour, count or sequence. The clips were presented in a power-point presentation and each was given a unique title by which it could later be identified. Each title was displayed in bold capital type at the top of the slide on which the visual clip was presented. For example, a visual clip showing an elderly gentleman's birthday party was given the title, 'The Birthday Party' and, this title remained on screen throughout the length of both the visual and verbal clip.

Verbal track of video-clips.

Eighteen verbal clips were created to accompany each visual clip. Original audio-clips were not used due to the limitation it would place on the experimental control of target verbal details. The created verbal clips were the same length as their accompanying visual clip and consisted of only spoken sentences providing additional information about the visual clip. None of the verbal information could be guessed from or discerned from the visual clip. The content of verbal information was varied so as not to make it obvious what a target detail might be. So for example, verbal information about 'The Birthday Party' included the colours of the balloons, the number of guests, the name of the venue and the colour of shirt the birthday gentleman spilt wine on. The same female voice was used to create each clip and there was no background noise.

Matching the content of visual and verbal target details.

Multiple video clips were included in the design so that the type of visual and verbal target details could be matched. There were two reasons for this.

The first reason was because it was not possible to match the type of verbal and visual target detail in Experiment 4; the news bulletin was a real bulletin and was not created as counterbalanced experimental material. For example, Experiment 4 asked,, ‘what colour tie was the sport presenter wearing?’ This detail was clearly one that had been presented visually because nowhere in the news bulletin video-clip was any verbal reference made about the colour of an item. In contrast, questions about verbal details could have been presented visually. For example, the answer to the question about a verbally presented detail ‘In which city is the museum?’ could equally have been presented visually because in several instances in the video-clip names of places and people were clearly displayed on screen.

The second reason was because Experiment 4 presented participants with questions about visual and verbal details in a mixed list but Experiment 5 presented participants with a list of visual questions and then, a list of visual questions (or vice versa). When participants studied the bimodal presentation of the video-clip in Experiment 4 and were later asked questions, they did not know whether they would be asked about a visual or verbal detail because there was no discernible order to asking visual and verbal questions. Experiment 4 found detrimental effects of distraction on recall. However, when participants were shown for example, visual details in a unimodal presentation in Experiment 5 and 6 they were asked to recall the visual details in one sitting. That is, participants knew they would be asked about visual details. Furthermore, Experiment 5 and 6 showed relatively weak to little detrimental effects of distraction on recall. In summary, the way in which recall data was collected for unimodal and bimodal presentations was different and may have played a role in moderating distraction effects. Experiment 7 will therefore match the type of visual and verbal target details within each event and, regardless of unimodal or bimodal presentations, will ask participants to recall both visual and verbal details in one sitting.

Thirty-six questions were therefore created for Experiment 7 in order to probe memory for specific details: one verbal and one visual detail, of the same type, for each video-clip. Recall for three types of details was tested: colour; count and sequence. For example, questions for the Birthday Party's visual and verbal clips were both colour questions. The question about a verbal colour detail was, 'At the Birthday party, what colour shirt did Harold, the birthday gentleman, spill wine on?' The question about a visual colour detail was, 'At the Birthday party, what colour tie did Harold, the birthday gentleman, wear?' Questions for the Halloween parade video-clip were both sequence questions. The question about a visual sequence detail was, 'What came before the pumpkin lanterns in the Halloween parade?' The question about a verbal sequence detail was, 'What came before the ghosts in the Halloween parade?'

The number of visual and verbal target detail types was balanced equally across video-clip so that overall participants were asked to recall six verbal colour details and six visual colour details, six visual and six verbal count details and six visual and six verbal sequence details.

*Distraction conditions***.** This between-design experiment has the same two distraction conditions as Experiments 5 and 6: DVN versus Blank screen.

4.2.5.4 Procedure

Participants either watched the visual clips at the same time as listening to the verbal clip in a bimodal presentation or they listened to the verbal clip directly before watching the visual-clip (unimodal presentation). This manipulation was between participants. As with Experiments 4 to 6, participants watched and/ or listened to both verbal and visual tracks twice. Therefore, there were two presentation conditions: unimodal and bimodal. Participants in the unimodal condition watched the visual clip of for example, ‘Harold’s Birthday Party’. This was immediately followed by the verbal clip of ‘Harold’s birthday party’. After a short pause, participants then saw the next visual clip, the ‘Halloween Parade’ and immediately afterwards, listened to the verbal clip of the ‘Halloween Parade’. Participants in the bimodal presentation condition watched ‘Harold’s Birthday Party’ at the same time as listening to the verbal clip of ‘Harold’s Birthday Party’ and then after a short pause, watched the ‘Halloween Parade’ at the same time as listening to the ‘Halloween Parade’.

Due to the data-size of the power-point file the video-audio clips were presented in, the file was separated into two but both files were presented one after the other as if it were one continuous sequence. The order in which the two files was presented was counterbalanced. To ensure that counterbalancing the two halves was carried out correctly for each participant, it was necessary for the experimenter to take charge of running the presentation. Therefore, unlike Experiments 4 to 6, the experimenter stayed in the room for the entire study phase. Although this did not follow the same procedural protocol as the earlier experiments the effect of experimenter was consistent: that is, the same experimenter was present for each participant and sat in the same position, away from the participant whilst they studied each half of the presentation.

After studying the clips through twice participants were asked questions about details of the clips in a pseudo random order and not in the order in which clips were presented. Questions about visual details were randomly mixed with questions about verbal details but no two consecutive questions asked about the same video clip. Participants were asked not to guess and were given the option of responding ‘I don’t know’.

4.2.6 Results

4.2.6.1 Correct recall

4.2.6.1.1 Normality testing on Experiment 7 correct recall

Experiment 7 correct recall data followed a 2 (Distraction: DVN, Blank Screen) x 2(Presentation: unimodal vs bimodal) x 2(Modality of detail: visual vs verbal) x 3(Type of detail: colour, count, sequence) mixed design with repeated measures on the latter two factors. Skew and kurtosis z-scores presented in Table 23 suggest, with the exception of visual count details in a bimodal presentation, data are normally distributed. Therefore, analysis was carried out with parametric tests and results interpreted with caution regards the skewed subgroup of data.

Table 23: Normality testing of correct recall data

Distraction condition	Presentation	Modality of detail	Type of detail	Skew z-score	Kurtosis z-score
Blank	Unimodal	Visual	Colour	1.52	0.33
			Count	1.24	0.04
			Sequence	-0.28	-1.27
		Verbal	Colour	-0.33	-0.79
			Count	-0.86	-0.85
			Sequence	-1.16	-0.01
	Bimodal	Visual	Colour	0.96	-0.08
			Count	2.13*	1.29
			Sequence	-0.02	-0.07
		Verbal	Colour	-0.66	-0.04
			Count	0.44	-0.93
			Sequence	0.84	-1.09
DVN	Unimodal	Visual	Colour	0.70	-0.33
			Count	-0.26	-0.37
			Sequence	0.21	-1.34
		Verbal	Colour	1.29	-0.33
			Count	-0.69	-0.72
			Sequence	-1.14	-0.13
	Bimodal	Visual	Colour	-0.23	-0.68
			Count	1.00	-0.05
			Sequence	0.49	-1.03
		Verbal	Colour	-0.05	-1.02
			Count	0.54	1.07
			Sequence	-0.02	-0.79

4.2.6.1.2 Analysis of correct recall

A 2 (Distraction: DVN, Blank Screen) x 2 (Presentation: unimodal vs bimodal) x 2 (Modality of detail: visual vs verbal) x 3 (Type of detail: colour, count, sequence) mixed ANOVA with repeated measures on the latter two factors was carried out. Figure 17 shows the mean number of correctly answered questions about visual and verbal details broken down by method of presentation (unimodal, bimodal) and type of detail (colour, count, sequence) under each distraction condition.

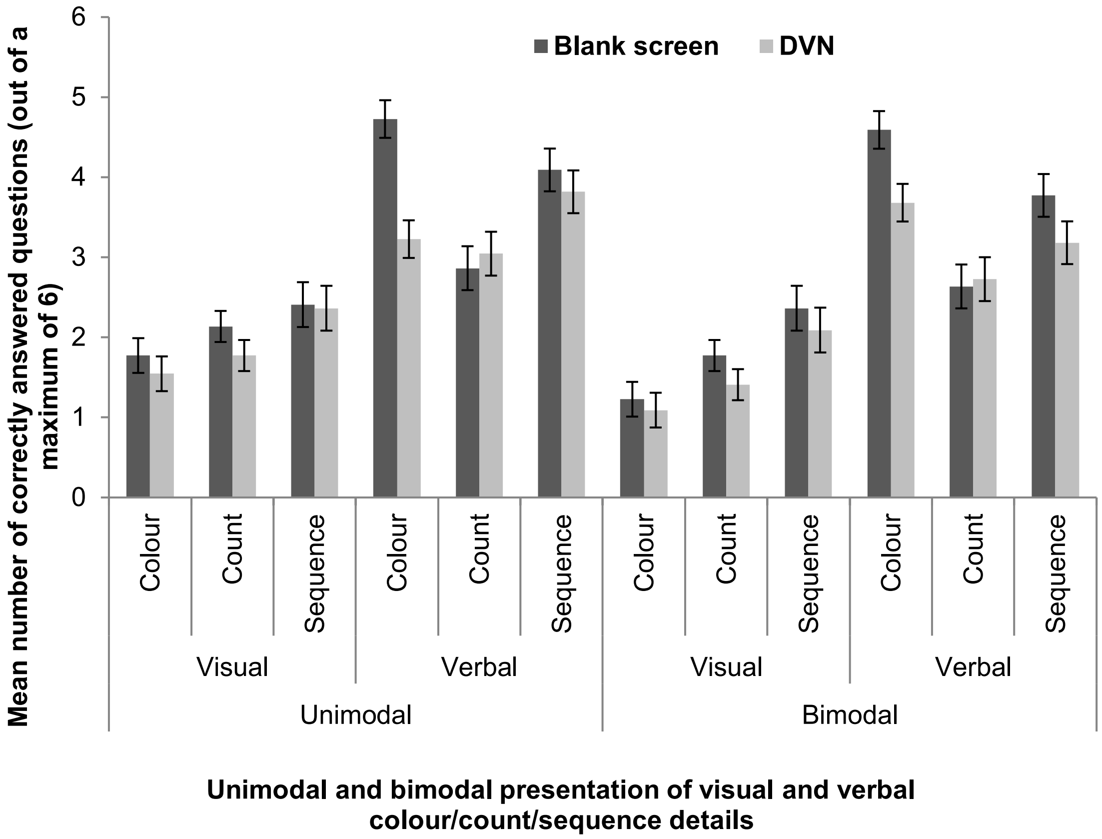

Figure 17: Correct recall of visual and verbal details under each distraction condition, by presentation format, modality of detail and type of detail. Error bars represent standard errors of the mean.

Main effects

There was a main effect of distraction condition on correct recall, $F(1,84) = 8.601$, $MSE = 2.07$, $p = .004$, $\eta_{2\ partial} = .093$. Out of the total number of thirty-six questions asked, fewer correct responses were given by participants in the DVN condition ($M = 14.98$, $SD = 3.82$) than Blank screen condition ($M = 17.18$, $SD = 3.32$). There was also a main effect of Presentation, $F(1,84) = 4.601$, $MSE = 2.07$, $p = .035$, $\eta_{2\ partial} = .052$ where participants who studied the visual and audio tracks concurrently (bimodal presentation) gave fewer correct responses ($M = 15.37$, $SD = 3.14$) than those who had studied the tracks sequentially ($M = 16.89$, $SD = 4.11$). In addition, there was a strong main effect of Modality of detail, $F(1,84) = 295.376$, $MSE = 1.29$, $p < .001$, $\eta^2_{partial} = .78$ where out of 18 questions about each modality participants gave more correct answers about verbal details (M =10.59, SD = 2.46) than visual (M = 5.49, SD = 2.18). Finally, there was also a main effect of Type of detail, $F(2,168) = 19.287$, $MSE = 1.19$, $p < .001$, $\eta^2_{partial} = .19$ where out of 12 questions each on count and colour and on sequence, pairwise comparisons revealed that participants gave more correct answers about sequences (M = 6.02, SD = 1.95) than colour (M = 5.47, SD = 1.78) $p = .018$, and more correct answers about colour than count (M = 4.59, SD = 1.58) $p < .001$.

Two-way interactions

There was no interaction between Distraction and Presentation conditions, $F(1,84) =19.287$, $MSE= 0.001$ $p =.976$, $\eta^2_{partial} < .001$ or Distraction and Modality of detail, $F(1,84) = 1.795$, $MSE = 1.293$, $p = .184$, $\eta^2_{partial} = .021$. However, there was a weak interaction between Distraction and Type of detail, $F(2,168) = 3.252$, $MSE = 1.188$, $p = .041$, $\eta^2_{partial} = .037$ where pairwise comparisons show that participants gave fewer correct colour details under DVN than Blank screen ($p < .001$) but there was no difference between the two distraction conditions for correct recall of count ($p = .499$) or sequence details ($p = .154$).

There was no interaction between Presentation and Modality of detail, $F(1,84) = 0.529$, $MSE = 1.293$, $p =.0.469$, $\eta^2_{partial} = .006$ or between Presentation and Type of detail, $F(2,168) = 0.269$, $MSE = 2.377$, $p = .764$, $\eta^2_{partial} = .003$.

There was a moderate interaction between Modality and Type of detail, $F(2,168) = 27.00$, $MSE = 1.150$, $p < .001$, $\eta^2_{partial} = .243$ and pairwise comparisons reveal more correct visual sequence details than count ($p = .002$) and more correct visual count details than visual colour ($p < .001$) but marginally more correct verbal colour details than verbal sequences (p = .051) and more correct verbal sequences than verbal count (p < .001).

Three-way interaction

There was a weak interaction between Distraction, Type of detail and Modality of detail, $F(2,168) = 5.545$, $MSE = 1.150$, $p = .005$, $\eta_{2\ partial} = .062$ where pairwise comparisons show fewer correct verbal colour details under DVN than Blank screen (p < .001) but no difference in visual colour details between the two distraction conditions (p = .404). There was no significant reduction in visual count details under DVN compared to Blank screen (p = .065) there was no difference for verbal count detail (p = .620) and no difference between the two distraction conditions for visual sequence details (p = .572) or verbal sequence details (p = .110).

There were no interactions between Distraction, Presentation and Type of detail, $F(2,168) = 0.891$, $MSE = 1.188$, $p = .348$, $\eta_{2\ partial} = .010$, between Distraction, Presentation and Modality of detail, $F(1,84) = 0.072$, $MSE = 1.293$, $p = .789$, $\eta_{2\ partial} = .001$ or between Presentation, Type of detail and Modality of detail, $F(2,168) = 2.304$, $MSE = 1.150$, $p = .103$, $\eta_{2\ partial} = .027$.

Four-way interaction

There was no interaction between all four factors, $F(2,168) = 0.278$, $MSE = 1.150$, $p = .757$, $\eta_{2\ partial} = .003$.

4.2.6.2 Incorrect recall

4.2.6.3 Normality testing on incorrect recall

Incorrect recall data was collected using the same design as for correct recall. Skew and kurtosis z-scores reported in Table 24 suggest data followed normal distributions with the only exception of verbal count details presented in a unimodal format. Therefore, analysis used parametric testing.

Table 24: Experiment 7, normality testing on incorrect recall

Distraction condition	Presentation	Modality of detail	Type of detail	Skew z-score	Kurtosis z-score
Blank	Unimodal	Visual	Colour	-1.09	-0.37
			Count	0.37	-1.12
			Sequence	0.00	-0.44
		Verbal	Colour	1.19	-0.86
			Count	2.21*	0.31
			Sequence	0.72	-1.36
	Bimodal	Visual	Colour	0.88	-1.02
			Count	1.76	0.13
			Sequence	-0.06	-1.72
		Verbal	Colour	0.88	-0.25
			Count	0.24	-1.18
			Sequence	1.25	0.03
DVN	Unimodal	Visual	Colour	-0.51	-1.05
			Count	1.41	0.62
			Sequence	0.03	-0.71
		Verbal	Colour	0.08	-1.49
			Count	-0.69	-0.72
			Sequence	1.91	0.83
	Bimodal	Visual	Colour	-1.41	-0.64
			Count	1.42	0.06
			Sequence	0.49	-0.87
		Verbal	Colour	-0.87	0.33
			Count	1.47	-0.51
			Sequence	-0.22	-0.21

4.2.6.4 Analysis of incorrect recall

Figure 18 shows the mean number of incorrectly answered questions about visual and verbal details broken down by method of presentation (unimodal, bimodal) and type of detail (colour, count, sequence) under each distraction condition.

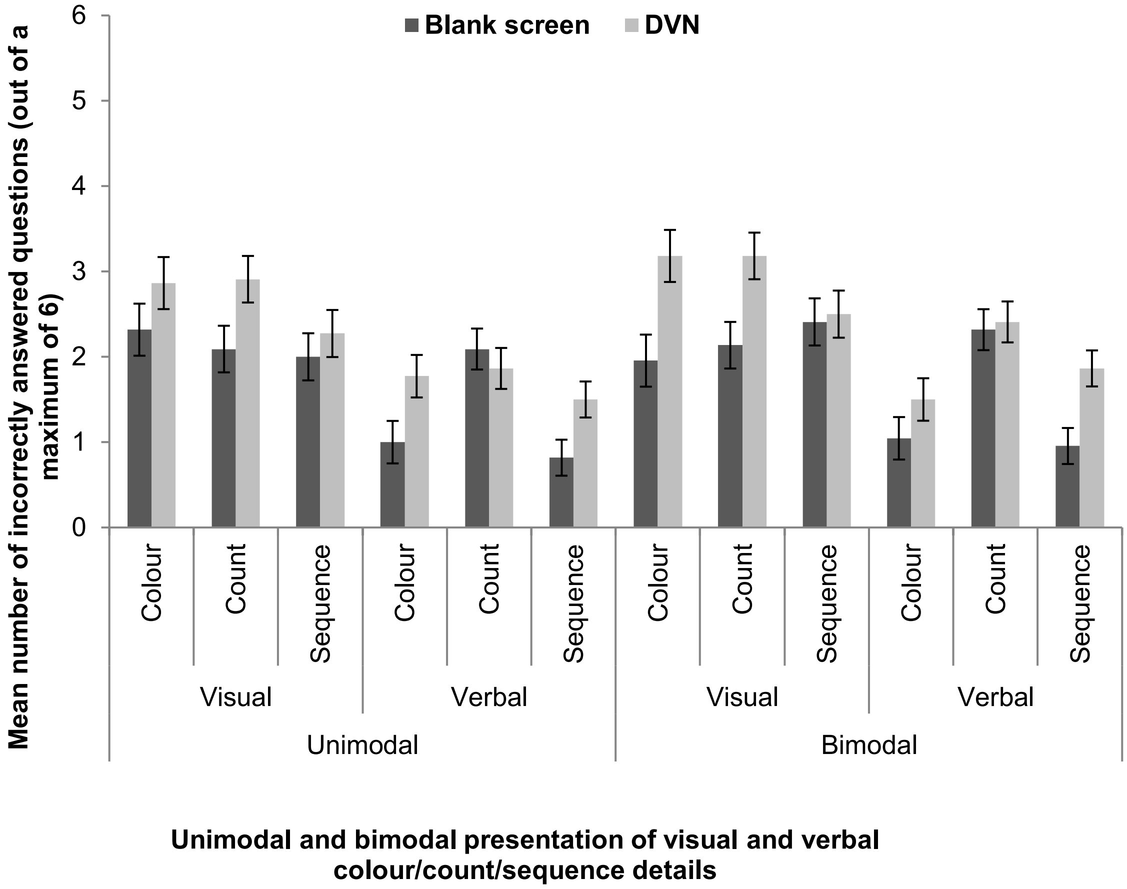

Figure 18: The mean number of incorrectly answered questions about visual and verbal details under blank screen and DVN, by presentation, modality and type of detail. Error bars represent standard errors of the mean

Main effects

A 2(Distraction: DVN, Blank Screen) x 2(Presentation: unimodal vs bimodal) x 2(Modality of detail: visual vs verbal) x 3(Type of detail: count, colour, sequence) mixed ANOVA with repeated measures on the latter two factors, found a main effect of distraction condition on incorrect recall, $F(1,84) = 14.221$, $MSE = 2.878$, $p < .001$, $\eta_{2\ partial} = .145$. Out of the total number of thirty-six questions asked, more incorrect responses were given by participants in the DVN condition ($M = 13.91$, $SD = 2.65$) than Blank screen condition ($M = 10.57$, $SD = 4.52$). There was a strong main effect of Modality of detail, $F(1,84) = 73.173$, $MSE = 1.429$, $p < .001$, $\eta_{2\ partial} = .47$ where out of 18 questions about each modality participants gave more incorrect answers about visual details ($M = 7.45$, $SD = 3.11$) than verbal ($M = 4.78$, $SD = 2.10$). Finally, there was also a main effect of Type of detail, $F(2,168) = 13.725$, $MSE = 1.17$, $p < .001$, $\eta_{2\ partial} =.14$ where out of 12 questions on count and colour and on sequence, pairwise comparisons revealed that participants gave more incorrect answers about count details ($M = 4.75$, $SD = 1.92$) than both colour ($M = 3.91$, $SD = 2.16$) $p = .001$ and sequences ($M = 3.58$, $SD = 1.71$) $p < .001$ with no statistical difference between the number of incorrect for colour and sequence, $p =.156$.

There was no main effect of Presentation on incorrect recall, $F(1,84) = 1.217$, $MSE = 2.878$, $p = .273$, $\eta_{2\ partial} = .014$.

Two-way interactions

There was no interaction between Distraction and Presentation conditions, $F(1,84) = 0.290$, $MSE = 2.878$, $p = .591$, $\eta_{2\ partial} = .003$ or Distraction and Modality of detail, $F(1,84) = 1.114$, $MSE = 1.429$, $p = .294$, $\eta_{2\ partial} = .013$ or between Distraction and Type of detail, $F(2,168) = 1.085$, $MSE = 1.168$, $p = .340$, $\eta_{2\ partial} = .013$. There was no interaction between Presentation and Modality of detail, $F(1,84) = 0.529$, $MSE = 1.293$, $p= .0.469$, $\eta_{2\ partial} = .006$ or between Presentation and Type of detail, $F(2,168) = 1.510$, $MSE = 1.168$, $p = .224$, $\eta_{2\ partial} = .018$.

There was an interaction between Modality and Type of detail, $F(2,168) = 7.104$, $MSE = 1.163$, $p = .002$, $\eta_{2\ partial} = .078$. Pairwise comparisons show no difference between the number of incorrect visual details (colour : count, *p* >*.999;* colour : sequence, *p* = *.120;* count : sequence, *p* = *.080*). However, there are more incorrect verbal count than colour ($p < .001$) or sequence ($p < .001$) and a comparable number of verbal incorrect colour and sequence ($p = .788$).

Three-way interactions

There was a weak interaction between Distraction, Type of detail and Modality of detail, $F(2,168) = 6.176$, $MSE = 1.163$, $p = .003$, $\eta_{2\ partial} = .068$ where pairwise comparisons reveal no distraction effect on incorrect visual sequence details ($p = .512$) but a detrimental effect on incorrect visual colour ($p = .005$) and count details ($p = .001$). A different pattern emerges for verbal details with a distraction effect on incorrect recall of both verbal colour ($p = .016$) and sequence details ($p < .001$) but no effect on incorrect count details ($p = .777$).

There were no interactions between Distraction, Presentation and Type of detail, $F(2,168) = 0.151$, $MSE = 1.168$, $p = .860$, $\eta_{2\ partial} = .010$, between Distraction, Presentation and Modality of detail, $F(1,84) = 0.160$, $MSE = 1.429$, $p = .690$, $\eta_{2\ partial} = .002$ or between Presentation, Type of detail and Modality of detail, $F(2,168) = 1.291$, $MSE = 1.1163$, $p = .743$, $\eta_{2\ partial} = .004$.

Four-way interaction

There was no interaction between all four factors, $F(2,168) = 1.291$, $MSE = 1.163$, $p = .278$, $\eta_{2\ partial} = .015$

4.2.6.5 Accuracy

4.2.6.5.1 Normality testing on recall accuracy

Skew and kurtosis z-scores reported in Table 25 suggest recall accuracy data followed normal distributions with the exception of unimodal verbal count details under control conditions and bimodal visual colour details under distraction. Therefore, analysis was carried out with parametric tests but, with results interpreted with caution regards the skewed data.

Table 25: Experiment 7, normality testing of recall accuracy data

Distraction condition	Presentation	Modality of detail	Type of detail	Skew z-score	Kurtosis z-score
Blank	Unimodal	Visual	Colour	1.05	-0.41
			Count	0.64	-0.94
			Sequence	1.08	-0.27
		Verbal	Colour	1.13	-0.90
			Count	2.24*	0.24
			Sequence	-1.39	-0.55
	Bimodal	Visual	Colour	0.64	-0.89
			Count	0.79	0.65
			Sequence	-0.70	-0.08
		Verbal	Colour	-0.71	-0.47
			Count	0.07	-1.38
			Sequence	-0.46	-0.79
DVN	Unimodal	Visual	Colour	-0.07	-1.23
			Count	-0.63	-0.88
			Sequence	0.15	-1.25
		Verbal	Colour	0.40	-1.75
			Count	-0.24	0.40
			Sequence	-1.41	-0.02
	Bimodal	Visual	Colour	2.71*	1.85
			Count	0.09	-1.18
			Sequence	0.31	-0.85
		Verbal	Colour	-0.60	-0.90
			Count	-0.40	-1.41
			Sequence	0.16	-0.57

4.2.6.5.2 Analysis of recall accuracy

Figure 4.3 shows the mean accuracy percentages of answers to questions about visual and verbal details broken down by method of presentation (unimodal, bimodal) and type of detail (colour, count, sequence) under each distraction condition.

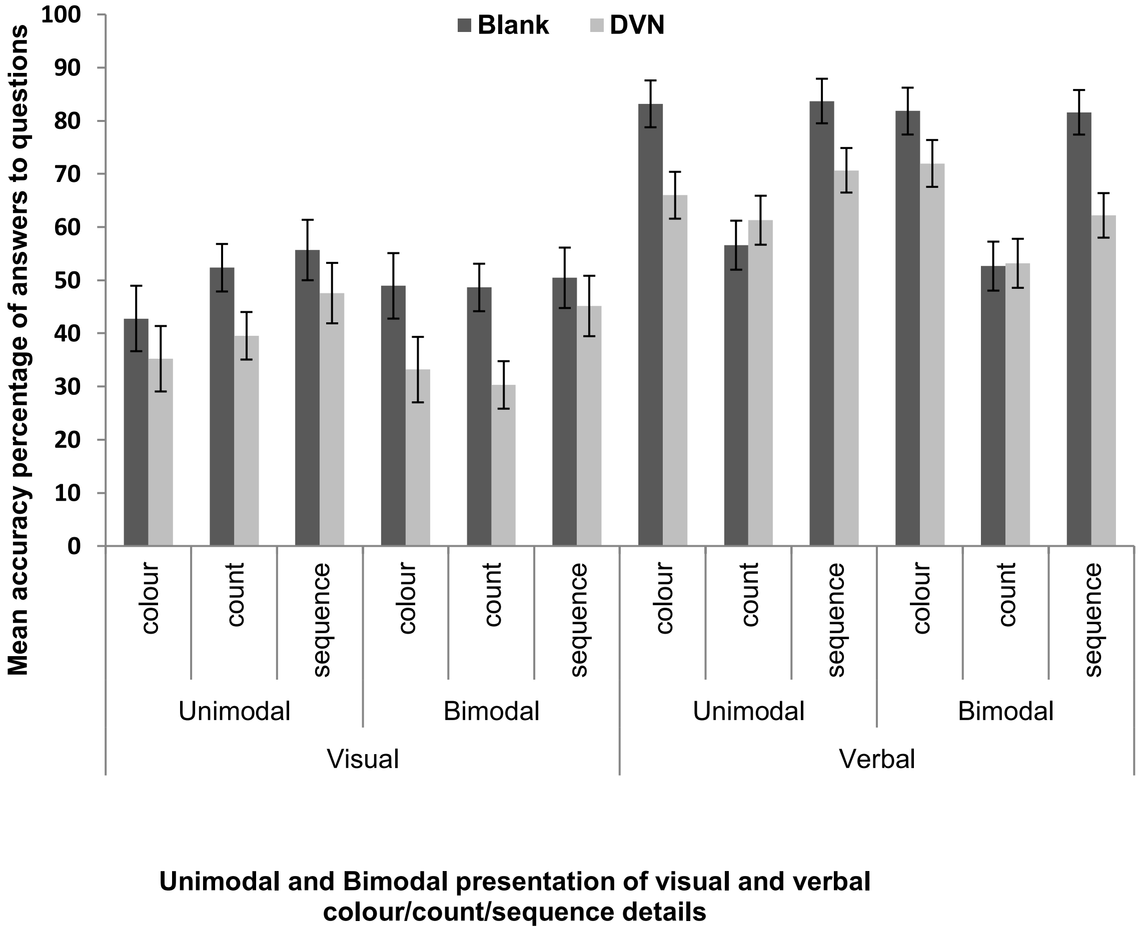

Figure 19: Mean recall accuracy (%) of visual and verbal details under blank screen and DVN conditions, by presention format and type of detail. Error bars represent standard errors of the mean.

Main effects

A 2 (Distraction: DVN, Blank Screen) x 2 (Presentation: unimodal vs bimodal) x 2 (Modality of detail: visual vs verbal) x 3 (Type of detail: count, colour, sequence) mixed ANOVA with repeated measures on the latter two factors, found a main effect of distraction condition on accuracy of recall, $F(1,84) = 19.00$, $MSE = 719.551$, $p <$

.001, $\eta_{2\ partial}$ = .184 . Out of the total number of thirty-six questions asked, participants' responses were more accurate under Blank screen (*M* = 61.30%, *SD* = 10.33) than under DVN (*M* = 51.28%, *SD* = 11.00). There was no main effect of Presentation, $F(1,84)$ =1.217, *MSE* = 2.88, *p* = .273, $\eta_{2\ partial}$ = .014. There was a strong main effect of Modality of detail, $F(1,84)$ = 73.173, *MSE* = 1.429, $p < .001$, $\eta_{2\ partial}$ = .47 where out of 18 questions about each modality participants gave more accurate answers about verbal details (*M* = 69.00, *SD* = 12.72) than visual (*M* = 43.61, *SD* = 16.47). Finally, there was also a main effect of Type of detail, $F(2,168)$ = 13.725, *MSE* = 1.168, $p < .001$, $\eta_{2\ partial}$ = .14 where out of 12 questions each on count and colour and on sequence, pairwise comparisons revealed that participants were less accurate when answering questions about count details (*M* = 49.32, *SD* = 21.92) than sequences (*M* = 62.13, *SD* = 23.85) $p < .001$, or colour (*M* = 57.89 *SD* = 25.30) *p*= .001, but there was no difference in accuracy between colour and sequences, *p* = .08.

Two-way interactions

There was no interaction between Distraction and Presentation conditions, $F(1,84)$ = 0.253, *MSE* = 719.55, *p* = .616, $\eta_{2\ partial}$ = .018 or Distraction and Modality of detail, $F(1,84)$ = 0.306, *MSE* = 557.30, *p*= .582, $\eta_{2\ partial}$ = .004 or between Distraction and Type of detail, $F(2,168)$ = 0.943, *MSE* = 494.081, *p* = .392, $\eta_{2\ partial}$ = .011.

There was no interaction between Presentation and Modality of detail, $F(1,84)$ = 0.306, *MSE* = 557.295, *p* = .0.582, $\eta_{2\ partial}$ = .004 or between Presentation and Type of detail, $F(2,168)$ = 1.771, *MSE* = 494.081, *p* =.173, $\eta_{2\ partial}$ = .021.

There was an interaction between Modality and Type of detail, $F(2,168)$ =11.113, *MSE*= 500.442, $p < .001$, $\eta_{2\ partial}$ = .117 and pairwise comparisons reveal greater accuracy for visual sequence details than visual count (p = .019) and visual colour details (p = .046) but no difference between accuracy of visual colour and count (p = .422) and, a greater accuracy for verbal colour details than verbal count details (p < .001) and greater accuracy for verbal sequence than verbal count (p < .001) but no difference between verbal colour and sequence (p = .710).

Three-way interactions

There was a weak interaction between Distraction, Type of detail and Modality of detail, $F(2,168) = 4.494$, $MSE = 500.442$, $p = .013$, $\eta_{2\ partial} = .051$ where pairwise comparisons reveal a poorer accuracy of visual count details under DVN than blank screen (p = .001) but no difference in accuracy between the two distraction conditions for visual colour (p = .062) or visual sequence (p = .242) For verbal accuracy there is a poorer accuracy of verbal sequence details under DVN than blank screen (p < .001) and a poorer accuracy of verbal colour details under DVN than blank screen (p = .003) but no differed in accuracy between the two distraction conditions for verbal count details (p = .572).

There were no interactions between Distraction, Presentation and Type of detail, $F(2,168) = 0.115$, $MSE = 494.081$, $p = .892$, $\eta_{2\ partial} = .001$, between Distraction, Presentation and Modality of detail, $F(1,84) = 0.098$, $MSE = 557.295$, $p = .755$, $\eta_{2\ partial} = .001$ or between Presentation, Type of detail and Modality of detail, $F(2,168) = 0.025$, $MSE = 500.44$, $p = .972$, $\eta_{2\ partial} < .001$.

Four-way interaction

There was no interaction between all four factors, $F(2,168) = 0.844$, $MSE = 500.442$, $p = .432$, $\eta_{2\ partial} = .015$.

4.2.7 Discussion

The primary aim of Experiment 7 was to test the effect of distraction on recall of matched visual and verbal target details of an event. Matching the type of details appears to have led to comparable effect sizes of distraction on recall of both visual and verbal details. Unlike Experiment 4, there was no interaction of distraction with modality of detail recalled. The mean size of distraction effect on recall accuracy of visual details in Experiment 7 (*d* = - 0.68) was similar to that on recall accuracy of verbal details (*d* = - 0.81). In comparison, Experiment 4 did not match detail-type and data showed a much stronger size of distraction effect on recall accuracy of visual details (*d*= - 0.91) than verbal (*d* = - 0.23). However, it is not clear whether Experiment 7's comparable effect is due to matching the type of details because eyewitness studies presented in Chapter 3 also showed comparable distraction effects on recall of both visual and verbal details but, did not mention whether detail-type was matched across the two modalities. This therefore would benefit from further investigation.

A secondary aim of Experiment 7 was to compare the size of distraction effect found to that found in Experiment 4 and other eyewitness event studies. This is because details in Experiment 7 were presented in a segmented sequence which shares similar features to a list and may thus weaken the effect of distraction through placing greater distinctiveness to each segment. However, the above reported effect sizes and those presented in Chapter 3's literature review show no indication that the effect of distraction here was weakened by the segmented format of detail presentation.

Another secondary aim of Experiment 7 was to explore the potential interference-by-process mechanism of DVN on recall of details. The expectation was that the effect of distraction on recall of sequence details would be greater than for count or colour. Table 26 shows a summary of distraction effects on recall accuracy (Cohen's *d*).

Table 26: Distraction effect sizes (Cohen's *d*) on recall accuracy of visual and verbal details

Type of detail	**Visual**	**Verbal**
Sequence	- 0.26	- 0.84
Count	- 0.60	- 0.12
Colour	- 0.41	- 0.67

With reference to Cohen's (Cohen, 1992) categorisation of effect sizes, it appears that a stronger effect of distraction is seen on recall accuracy of verbal sequence details than count and colour details but the difference between sequence and colour is not particularly pronounced. However, this pattern of effect gives support to an interference-by-process account of visual distraction (supporting the theoretical account presented in Chapter 3). In contrast, the same pattern is not seen for recall of visual details and instead, the strongest effect is seen on recall of count details and the weakest is seen for sequences. One possibility is that skewed data found for sub-groups unimodal verbal count and bimodal verbal colour subgroups disrupted the analysis, although, considering the majority of data subgroups followed normal distributions, this seems unlikely to have had a pivotal impact. Instead, the afore mentioned pattern raises two questions about the content of the details coded as count and sequence.

The first question it raises is about whether the visual sequence questions were probing temporal sequences rather than visual-spatial sequences. For example, visual and verbal memory for the obstacle course was probed with the question, ‘What was the second obstacle Jake tackled on his obstacle course?’ for the visual detail and probed with the question, ‘What was the second job Jake’s dad did before building the obstacle course?’ for the verbal detail. Thus the visual detail could be construed as more of a temporal detail because the participant would have seen this happening after the first obstacle was tackled. The verbal detail however, was embedded in a short story of how Jake’s dad walked the dog, washed the car and so on. This had little reference to time and although the activities happened one after the other it is feasible that the verbal nature of the narrative created more of a visual-spatial moving sequence than a temporal one.

The second question it raises is about the degree to which visual-spatial processes may have been involved in retrieving some of the visual count details. For example, one visual probe question asked, ‘At the wedding, how many bridesmaids wore purple?’ and verbal probe question asked, ‘At the wedding, how many waiters served champagne?’ Retrieving the visual detail may have engaged visual-spatial processes because it may have been necessary to mentally search for the spatial positions of bridesmaids in order to count them. Retrieving the verbal detail however may be more likely to rely on verbatim memory traces than visual-spatial.

The final secondary aim of Experiment 7 was to explore distraction effects on recall of flowing details presented as bimodal versus unimodal. Analysis revealed there to be no interactions between distraction and presentation (bimodal versus unimodal) condition on correct, incorrect or accuracy of, recall. Therefore, there is no evidence to suggest that bimodal presentation of visual and verbal details moderates the distraction effect for flowing details.

Overall Experiment 7 data shows that distraction impairs memory for a list of flowing details but provides no evidence to suggest that segmentation and bimodality moderate distraction effects. However, the exploration of an interference-by-process mechanism of distraction raises a new methodological question and that is, how to gain more experimental control over matching visual and verbal details for later recall. It is clear from the issues raised above that not only are the details difficult to match but also of consideration is that the richness of visual details far out-weigh the richness of information conveyed in the verbal tracks. It was not possible to present the same amount of information verbally as there was visually because verbal tracks would then exceed the duration of visual tracks and this would make it impossible to present the clips in a true bimodal format because the verbal track would be playing after the visual track had ended. However, the greater amount of visual detail presented may mean that participants searching for a visual target detail during retrieval processes would have had to mentally assess many more competing candidate answers than when searching for a verbal target detail. Recall accuracy data show that participants were more accurate in recalling verbal details, which perhaps reflects the issue of discrepancy in richness of information.

In addition, it is possible that data suffered from stimulus sampling issues (Wells & Windschitl, 1990). For example, although colour details were presented in both visual and verbal format, the same colour details were not counterbalanced to be presented in both modalities. This is because video clips were taken from the public domain (in order to widen the breadth of topics across the clips) and were thus not under the control of the current author. The video clip of Harold’s birthday party include visual images of Harold wearing a red tie. The red tie was the target visual detail for the Birthday party clip. This visual detail (as all visual details were) was fixed within the visual track. The verbal track however, was under the control of the experimenter. These details were matched to the visual details in terms of colour or count or sequence but the verbal colour detail was not the same as the visual colour detail. Thus, the target verbal detail in Harold's birthday clip was not the same as the visual 'red' (tie) but instead, was a verbally presented 'green' (shirt). According to Wells and Windschitl's (1999) explanation of stimulus sampling issues, it is possible that a red tie is less memorable than a green shirt. The red tie is only ever presented as a visual detail and the green shirt only ever presented as a verbal detail. The green shirt may be recalled more accurately than the red tie because the green shirt is more memorable than the red tie rather than because the green shirt was presented verbally. However, because the visual video tracks were fixed in their content, it was not possible to fully counter balance this aspect of the experiment. That is, the visual red tie could have been presented as a red tie in the verbal track however, the verbal and visual track would then have been identical and it would not then have been possible to attribute recall of the tie's colour to a visual detail or to a verbal detail.

One method of controlling the richness (and type) of visual and verbal information presented to participants for later recall is to present information as words and pictures. Concrete nouns allow for the same information to be presented verbally (as spoken or typed) and visually (as a picture) and so this is the method used in Experiment 8.

4.3 Experiment 8

4.3.1 Introduction

Experiment 8 will present visual and verbal to-be-recalled information in a list format of spoken, typed and picture words as a within factor. This design gives more control over matching the richness of verbal and visual information because each picture-noun can be thought of as a single unit in the same way that each spoken-noun or typed-noun can be viewed as a single unit. Picture nouns are clearly visual details and spoken nouns are clearly verbal. The primary focus here is to compare recall of details from these two modalities under distraction and control. However, the design of Experiment 8 also provides opportunity for secondary explorations and so participants will also be asked to recall nouns presented as typed. Typed words have been defined as verbal details throughout but typed words are presented visually and thus are predominantly verbal but they also have a visual feature. Although Rae (2011) found no difference in recall between words which had been presented as spoken and typed, Experiment 8 allows an exploration of spoken versus typed word recall when they have both been presented with background pictures. This is discussed further in the following section on binding of details in memory.

In order to test memory for specific words in a cued format, it is necessary to attach an identifier to each word. One method of doing this is to present each word with a background picture so that participants can be asked to recall the word which was presented with each named background picture. Thus rather than asking participants to freely recall words from the list, this cued design allows more control over what is recalled and enables a measure of recall accuracy for words presented in each modality. For example, one of the background pictures in this experiment is a landscape scene of a valley and the concrete noun presented with it is 'HAND'. The concrete noun 'hand' is either presented in type, as spoken or, as a picture of a hand. During the recall phase participants are asked to recall which word was presented with the background picture of the valley. Participants can either respond 'I don't know' or give an answer. Participants who were presented with a picture of hand will thus have been cued to recall a visual item, those who were presented with the spoken word 'hand' will have been cued to recall a verbal item and so on.

Each pair of background picture and word can also be thought of in terms of binding. Following this line of thought, a visual-verbal binding is created when the background picture (visual) is presented with a spoken or typed word (verbal) and a visual-visual binding is created when a background picture (visual) is presented with a picture of a word (visual). Although it is possible that participants may subvocalise aspects of pictorial stimuli, there is evidence to suggest that typed versus pictorial stimuli are processed in different ways. For example, Goolkasian and Foos (2002) asked participants to study a series of concrete nouns presented as either typed words or pictures and to later recall the names of the nouns while also performing a reading task, or not. Participants performing the reading task were better at recalling picture words than typed words. The authors suggest that the reading task disrupted the verbal processing of typed words because verbal processing was also involved in the reading task and therefore selectively interfered with recall of typed but not picture words. Thus, while it could be argued that an aspect of pictorial stimuli may be processed verbally, Goolkasian and Foos' study implies that a substantial, or influential, part of pictorial processing is not verbal.

The visual, verbal feature of Experiment 8's design therefore affords secondary explorations of whether distraction differentially disrupts memory for visual-visual and visual-verbal bindings.

Another secondary exploration this design allows is whether distraction impairs memory for a detail presented within the background picture. For example, Experiment 5 found distraction to increase the number of incorrectly recalled visual details presented in static scenes. Therefore, participants will also be asked to recall a detail of the background picture. Using the earlier example of a valley, participants are asked to recall how many birds were flying in the sky.

In addition, participants will also be asked to recall the modality in which the word was presented because this allows an exploration of whether distraction interferes with memory of a detail at the same time as interfering with memory for the modality the detail was presented in. For example, this exploration will show whether poorer word-recall accuracy under distraction is accompanied with poorer modality-recall accuracy.

4.3.1.1 Visual-verbal and visual-visual binding

As discussed earlier in Chapter 3, Baddeley (2000) proposed that the episodic buffer is a component of memory responsible for temporarily storing bindings of visual and or verbal details at both encoding and retrieval. Details which are bound are stored as a single percept, however, weaker traces of each separate detail are also stored in the appropriate modality-specific subsystem. Bindings are both created and retrieved through the central executive whose functioning is dependent on attention. Therefore, distraction, which depletes attention, will interfere with retrieval of information that is stored as bound. Allen et al. (2006) suggest that bindings can be differentiated in terms of being active versus passive. Active bindings require attention, passive bindings are automatic and therefore do not. Baddeley's (2001) model would thus imply that automatic bindings should be largely protected from detrimental distraction effects. The question is, which types of bindings in long-term memory are active, which are passive and is it even possible to define the features of these bindings?

Research into understanding how reading skills are developed may help to answer the question. One area of the research has shown that the ability to learn visual and phonological associations (visual-verbal binding) strongly predicts reading ability but the ability to learn either verbal-verbal or visual-visual bindings does not (Hulme, Goetz, Gooch, Adams, & Snowling, 2007). Developmental dyslexia is strongly associated with an inability to make visual-verbal bindings (Messbauer & de Jong, 2003) and in turn, dyslexia is associated with lower attentional capacity (Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulos, 1990). This body of work suggests therefore, that cross-modal bindings are more effortful and require attention. If attention is depleted during retrieval of details stored as visual-verbal bindings, memory for those details will be impaired.

The working memory literature lends support to this prediction. Most work on binding has been carried out on visual features of objects. Allen et al. (2006) suggest that commonly co-occurring object features (for example, the colour of a shape, location of a shape) are automatically bound in mind. These commonly co-occurring features appear to be of the same modality rather than cross-modal. Although there has been relatively less work on exploring bindings for uncommonly co-occurring details such as shapes and sounds (visual-verbal bindings), it is thought that these cross-modal bindings rely more on attentional resources than same-modality bindings (Hommel & Colzato, 2009). Perhaps as a way of preserving attentional resources, Cowan, Saults, and Morey (2006) found that participants were more likely to store visual-verbal details separately than as bound.

In summary, the above work and theoretical stance predict that distraction will reduce recall accuracy of spoken nouns (visual-verbal binding) more than picture nouns (visual-visual bindings) because visual-verbal bindings require more attention to maintain than visual-visual bindings. In addition, if typed nouns are encoded and retrieved in as predominantly verbal material there should be a similar pattern of distraction effect on recall of typed nouns as for spoken nouns.

4.3.1.2 Hippocampal evidence of binding at encoding and retrieval

In a behavioural and fMRI study, Horner, Bisby, Bush, Lin, and Burgess (2015) demonstrate that a key function of the hippocampus is in binding multimodal details together. The authors asked participants to study groups of up to four details at once (the name of a person, a location, an object and an animal). Participants were later given a cue from one group (such as the name of the person from that group) and asked to recall the other details which had presented in that group. Thus, each group consisted of up to four bound details. Memory was measured in terms of ‘complete pattern recall’, that is, whether participants were able to recall all of the details that had been presented in the group associated with the given cue. Horner et al found that during encoding each detail in the group was associated with activation in separate brain regions and encoding of the group as a whole was represented by activation of the hippocampus. During retrieval, complete pattern recall was associated with the same hippocampal activity. The authors argue that details are bound at encoding into an ‘engram’ in the hippocampus and that during retrieval the hippocampal engram is activated by the cue detail which leads to reinstatement of details in the various separate brain regions. This work lends support to the earlier discussed assumption that details which are bound together at encoding may also be retrieved as bound details.

Wais, Kim and Gazzaley (2012) conducted an fMRI study on the mechanism of visual distraction. They found that the detrimental effect of visual distraction on memory is accompanied by a disruption to a neural network involving the hippocampus. This implies that distraction disrupts activity in the hippocampus and as Horner et al.'s (2017) work suggests, this will result in poorer recall of details which were bound at encoding.

4.3.2 Aims of Experiment 8

The primary aim of Experiment 8 is to control the richness of visual and verbal information presented for later recall and compare recall under distraction and control conditions.

The design for Experiment 8 also affords secondary explorations including comparing distraction effects on recall of spoken versus typed nouns, on recall of visual-visual bindings versus visual-verbal bindings and on recall of visual details of static scenes.

4.3.3 Method

4.3.3.1 Power

Experiment 8 presented two levels of distraction as a between variable. A power analysis based on detecting the main effect of distraction with d = .08 and power = 0.95 indicated a minimum total sample size of 23 participants was needed.

4.3.3.2 Participants

Thirty-six participants (28 females), average age 21.53 years (*SD*= 6.61) took part for course credit. All participants had normal or corrected to normal vision and hearing and were fluent English speakers.

4.3.3.3 Design and Materials

A 2 (Distraction: DVN; Blank Screen) x 3(Word Format: spoken, typed, picture) x 3(Type of Detail recalled: background, noun-name, noun-mode) repeated measures design was used.

Background pictures.

Thirty-six background pictures were created from photographs posted in the public domain. Pictures were selected for their mundane, non-contentious content and, on the basis of having good visual quality so that questions could be asked about a specific aspect of the image such as the colour or number. Pictures were distinguishable and identifiable by a single reference word, for example, the ‘valley’, or, the ‘classroom’.

Each background picture was presented for a total of 9 seconds with a two-second inter-stimulus blank white screen between pictures. They were shown in two separate lists of 18. The time taken to present each of the lists was therefore 3 minutes and commensurate with the time taken for the video-clips in Experiments 4 to 7. In addition, a pilot study showed that after one viewing of one list, participants were on average able to correctly answer 80.5% of questions about details of the pictures. Therefore, unlike the previous video-clip experiments, each list was presented only once.

Concrete nouns: word format

Nouns (words) were presented in one of three modalities (formats): spoken, in type or as a picture. Thirty-six concrete nouns were selected on the basis that a clear unambiguous photograph, with no background context, could be located and used to represent the noun.

A pilot study showed that participants used the same spoken noun to name the picture word as the experimenter had used to present the noun in a spoken/typed format. For example, participants in the pilot were shown a picture of a hand and were asked to say what word the picture represented. All participants named the picture as 'hand'; this was the same name the experimenter had used to present the word as spoken and in type. There was one exception to this: one out of ten participants used the word, 'shovel' and not the target word of 'spade'. For this reason, the word 'shovel' was accepted as a correct recall of the picture word (however, only two people used this word in the main study). As with the background pictures, none of the picture words were graphically created or termed as 'clipart'; all were photographs from real-life.

Background picture-noun pairings

One concrete noun was presented with each picture in a fixed pairing. Pairings were fixed in order to avoid any obvious semantic connections between the two that may go undetected should pairings be randomised for each participant. The background picture was shown continually for 9 seconds and during the 4th to 6th seconds only, the noun was also presented. Each noun was paired with one background picture. While background picture-noun pairings were fixed throughout, a total of three different pairs of lists were created so that after counterbalancing, each background picture-noun pairing was presented with the word in all three formats. Therefore, across all participants the noun ‘hand’ would be paired with the same background picture but would be presented in the format of a picture-word (picture of a hand) or a spoken word (sound of the word ‘hand’) or a typed word (letters spelling the word ‘hand’).

Questions about the background pictures

Thirty-six questions were created; one question for each background picture. These were designed to encourage participants to re-instate the background picture before attempting to recall the paired noun. There were 17 colour and 17 count target details and two details about visual-spatial location (‘from your view point, was the sun to the left, right, top, or bottom of the screen?’).

Questions about nouns and modality

Participants were asked which noun was presented with each background picture and regardless of answer, were then asked in which format the word had been presented: spoken, typed or picture.

Distraction conditions

This within design experiment has the same two distraction conditions as Experiments 5 to 7: DVN and Blank screen.

4.3.3.4 Procedure

Participants studied two lists of 18 picture-word pairs, one at a time. Each list was followed by a recall phase, one of which was under DVN and the other was under blank screen. List and distraction order were fully counterbalanced. Figure 20 below summarises the timings of slides. The background picture slide, depicted in Figure 20 as a valley, was presented for 3s alone, followed by 3s with its concrete noun pairing, followed by 3s alone. A blank screen of 2s separated each 9s set of picture-noun pairing. Each participant saw or heard the background picture's paired noun in one of three formats: either as a typed noun, a picture noun or a spoken noun. The background picture of the valley and the noun 'hand' (for example) were always paired together. The noun format was counterbalanced across participants and distraction conditions. This means that some participants were asked to recall the noun 'hand' under DVN conditions while other participants were asked to recall the same noun under blank screen conditions. In addition to this, participants either saw 'hand' as a typed word, saw 'hand' as a picture or heard 'hand' as a spoken word.

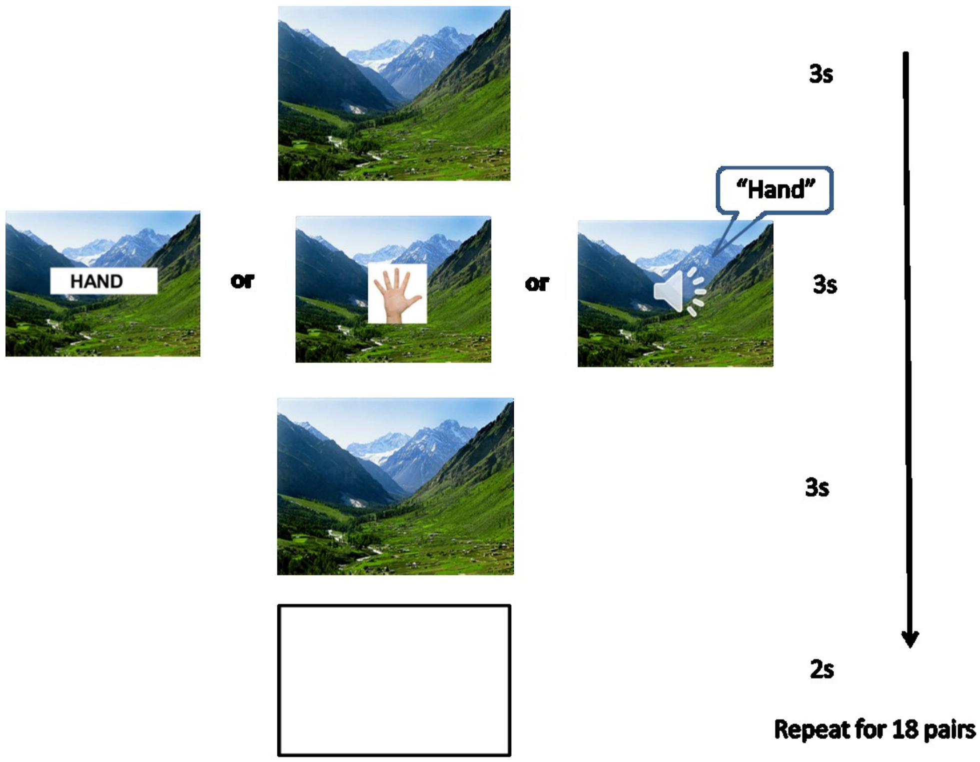

Figure 20: Experiment 8, an example of a background picture paired with a concrete noun

Participants were told that a series of pictures, in two separate lists, would be presented and after a few seconds, each picture would be accompanied with a noun which may be as a spoken, typed or a picture word and that if the paired noun was a typed word or a picture word, it would appear in a small box, centre screen. Participants were also told that they would be asked questions about each background picture-noun pair after each list had been presented. Participants were unaware whether recall would be under DVN or Blank screen prior to the recall phase. During retrieval, participants watched either a blank screen or a screen of DVN while answering three questions about each of the 18 background picture-noun pairs shown. The first question always asked about a detail of the background picture, in this way, participants were cued to then go on to recall the noun which had been paired with the background picture. The second question asked the name of the noun which had been presented with the background picture and the third question asked whether that noun had been presented as a spoken, typed or picture word.

4.3.4 Results

A 2(Distraction: DVN; Blank Screen x 3(Word Format: spoken, typed, picture) x 3(Type of Detail recalled: background, noun-name, noun-mode) repeated measures ANOVA was carried out separately for analysis of correct, incorrect and accuracy of, recall. Greenhouse-Geisser statistics are presented where sphericity is violated.

4.3.4.1 Correct recall

4.3.4.1.1 Normality testing on Experiment 8 correct recall data

Collection of correct recall data followed the above reported design. Table 27 suggests that data subgroups overall followed normal distributions however, correct recall data of background details presented with picture-nouns under control conditions were negatively skewed relative to normal.

Table 27: Experiment 8, normality testing of correct recall data

Distraction condition	Word Format	Type of detail	Skew z-score	Kurtosis z-score
Blank	Spoken	Background	-1.68	-0.19
		Noun name	-0.21	-1.68
		Noun mode	-0.36	-1.16
	Picture	Background	-2.73*	1.10
		Noun name	-0.70	-1.11
		Noun mode	-1.10	-0.85
	Typed	Background	0.35	-1.00
		Noun name	-1.35	-1.02
		Noun mode	-1.30	-0.10
DVN	Spoken	Background	-0.22	-0.57
		Noun name	-0.05	-1.76
		Noun mode	0.28	-1.36
	Picture	Background	-0.68	-1.48
		Noun name	-1.29	-0.45
		Noun mode	-1.29	-0.45
	Typed	Background	-0.95	-0.35
		Noun name	-1.95	0.66
		Noun mode	-1.95	-0.85

4.3.4.1.2 Analysis of correct recall

Figure 21 overleaf shows the mean number of correctly recalled details of background picture-noun pairings under both distraction conditions.

There was no main effect of distraction on overall correct recall, $F(1,35) = 0.644$, $MSE = 4.230$, $p = .43$, $\eta_{2\ partial} = .018$ and no main effect of Type of detail recalled, $F(1.29,45.08) = 1.032$, $MSE = 4.767$, $p = .335$, $\eta_{2\ partial} = .029$. However, there was a main effect of word-format, $F(2,70) = 6.860$, $MSE = 3.480$, $p = .002$, $\eta_{2\ partial} = .164$ and pairwise comparisons show that fewer correct answers were given in general when the noun was presented as a spoken word than when it was presented as a picture word (p = .007) or a typed word (p = .003); there was no difference between picture and typed words (p = .614).

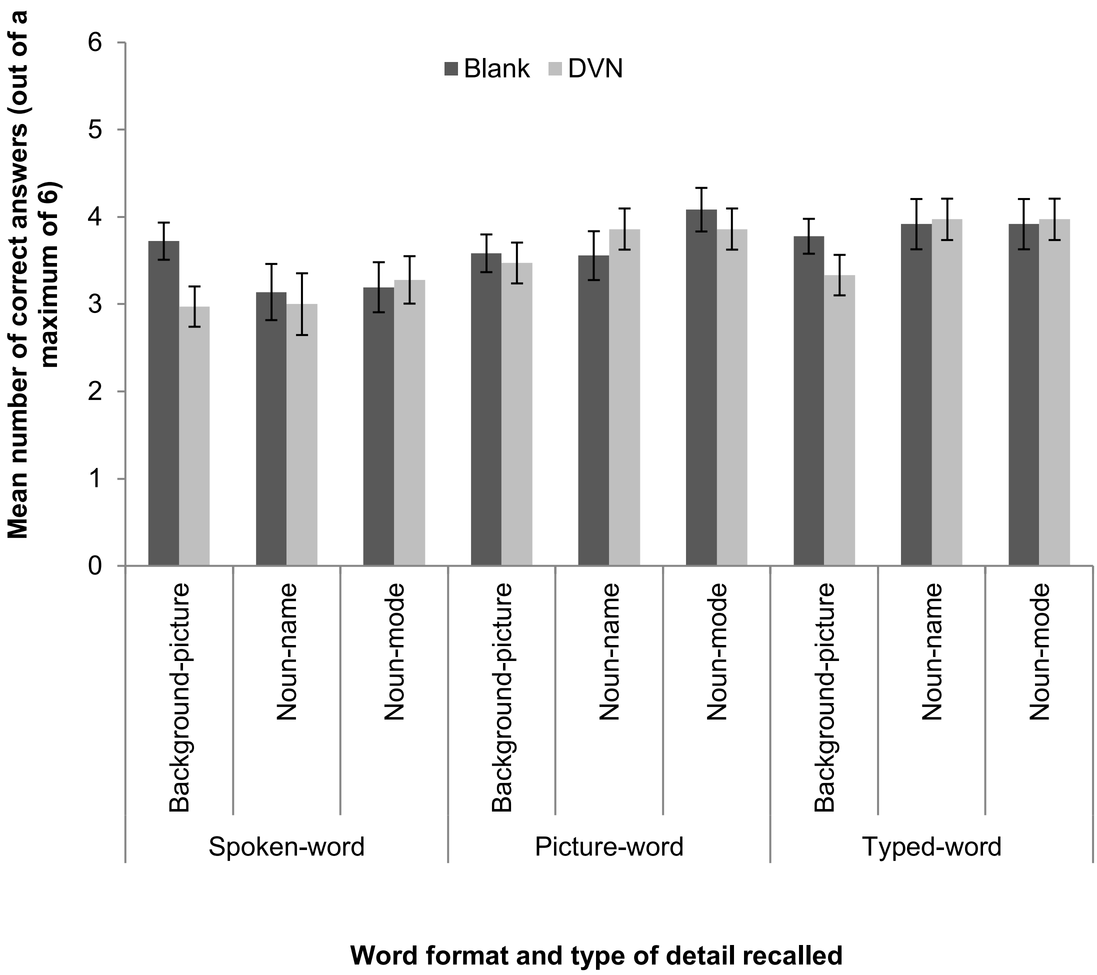

Figure 21: The mean number of correctly recalled details under blank screen and DVN, word format and type of detail recalled. Error bars represent standard errors of the mean.

There was no interaction between distraction and type of detail recalled, $F(1.33,46.49) = 2.39$, $MSE = 2.468$, $p = .120$, $\eta_{2\ partial} = .064$, between distraction and word format, $F(2,70)$ =0.414, MSE=2.224, p=.663, $\eta_{2\ partial}$=.012 or between type of detail recalled and word format, $F(3.02,105.77)$ =2.037, MSE=1.776, p=.113, $\eta_{2\ partial}$=.055.

Finally, there was no interaction between distraction, type of detail recalled and word format, $F(2.93,102.52)$ =1.385, MSE=1.146, p=.242, $\eta_{2\ partial}$=.038.

4.3.4.2 Incorrect recall

4.3.4.2.1 Normality testing on Experiment 8 incorrect recall data

Skew and kurtosis z-scores presented in Table 28 suggest more than half the subgroups of data have non normal distributions. Due to the magnitude of some scores, data transformation was not attempted and instead, non-parametric testing was carried out.

Table 28: Experiment 8, normality testing of incorrect recall data

Distraction condition	Word Format	Type of detail	Skew z-score	Kurtosis z-score
Blank	Spoken	Background	3.35*	3.32*
		Noun name	9.38*	19.31*
		Noun mode	1.20	-0.04
	Picture	Background	1.90	0.82
		Noun name	7.42*	10.53*
		Noun mode	2.07	-0.81
	Typed	Background	1.81	0.49
		Noun name	2.37*	0.29
		Noun mode	2.30*	0.30
DVN	Spoken	Background	1.44	0.59
		Noun name	6.13*	9.78*
		Noun mode	0.10	-1.43
	Picture	Background	2.33*	0.48
		Noun name	2.97*	0.66
		Noun mode	2.96*	0.70
	Typed	Background	1.75	0.44
		Noun name	3.53*	2.66*
		Noun mode	3.28*	2.56*

4.3.4.2.2 Analysis of incorrect recall

Figure 22 shows the mean number of incorrectly recalled details of background picture-noun pairings under both distraction conditions.

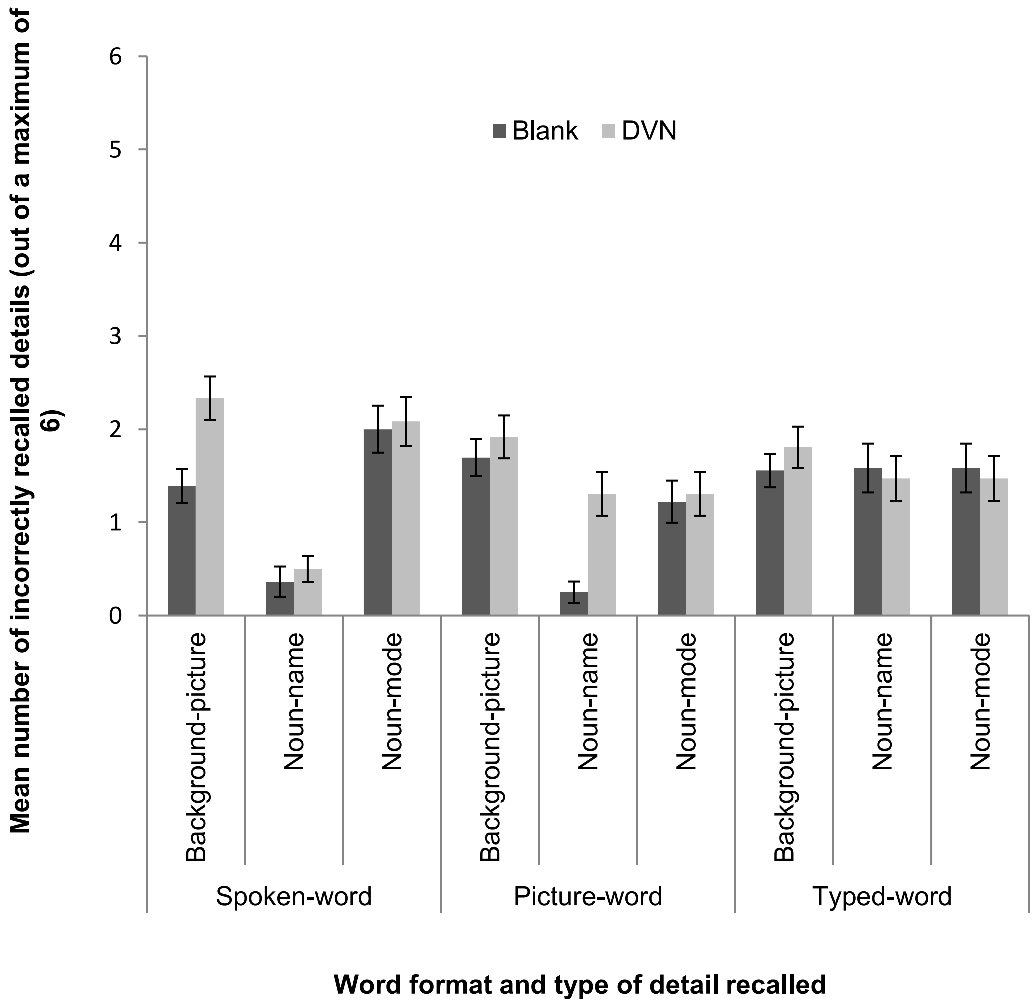

Figure 22: The mean number of incorrectly recalled details under blank screen and DVN, by word format and type of detail recalled. Error bars represent standard errors of the mean.

A Friedman's ANOVA showed a significant difference in incorrect recall across the three variables distraction, word-format and type of detail, $\chi^2(17)$ = 144.001, *p* = <.001.

Three follow-up analyses examining the main effect of each variable were carried out and alpha was therefore adjusted to .0167 (.05/3). Although numerically more errors were made under DVN than blank screen, a Wilcoxon signed ranks test showed that there was no significant difference between the two conditions, DVN (*Mdn* = 11.00, *M* = 14.19, *SD* = 7.36) and blank screen (*Mdn* = 11.00, *M* = 11.64, *SD* = 6.96), *z* = -2.270, *p* = 0.023. A Freidman's ANOVA comparing incorrect scores between the three word formats showed no significant difference, $\chi^2(2) = 0.797$, p= .671. However, a further Friedman's ANOVA comparing the number of incorrectly recalled types of detail revealed a significant difference across the three types, $\chi^2(2) = 36.100$, $p < .001$. More errors were made recalling details about the background picture (*Mdn* = 10.50, *M* = 10.69, *SD* = 3.95) and noun mode (*Mdn* = 9.00, *M* = 9.67, *SD* = 5.75) than made when recalling the noun name (*Mdn* = 4.00, *M* = 5.47, *SD* = 5.00).

In order to explore secondary aims of Experiment 8, a further nine follow-up Wilcoxon signed ranks tests were conducted comparing the effect of distraction condition on incorrect recall between the different word formats and types of detail recalled. Alpha was adjusted to .0055 (.05/9) and results are summarised in Table 29. Analysis revealed that participants made more errors in recalling background-picture details under DVN than blank screen when the background had been presented with spoken words and made more errors in recalling names of nouns when nouns had been presented as picture words rather than typed or spoken words.

Table 29: Wilcoxon signed ranks, incorrect recall

Word Format	Type of detail	DVN vs SVN z-score	*p*-value
Spoken	Background	2.796	0.005*
	Noun name	0.876	0.381
	Noun mode	1.069	0.285
Picture	Background	0.994	0.320
	Noun name	3.596	0.000*
	Noun mode	0.353	0.724
Typed	Background	0.273	0.785
	Noun name	0.222	0.824
	Noun mode	0.353	0.724

**significant at alpha=.0055*

4.3.4.3 Accuracy

4.3.4.3.1 Normality testing on Experiment 8 recall accuracy data

Table 30 shows over half the subgroups of data showed signs of non-normal distributions therefore analysis was carried out using non-parametric tests, in a similar method as for incorrect recall data.

Table 30: Experiment 8, normality testing of recall accuracy data

Distraction condition	Word Format	Type of detail	Skew z-score	Kurtosis z-score
Blank	Spoken	Background	-2.03*	0.27
		Noun name	6.41*	7.37*
		Noun mode	-0.45	-1.01
	Picture	Background	-2.26	0.88
		Noun name	-6.96*	9.80*
		Noun mode	-2.33*	-0.23
	Typed	Background	-0.88	-0.04
		Noun name	-2.14*	-0.10
		Noun mode	-2.14*	-0.13
DVN	Spoken	Background	-0.75	-0.47
		Noun name	-3.36*	0.49
		Noun mode	0.16	-1.56
	Picture	Background	-1.33	-0.44
		Noun name	-2.35*	0.00
		Noun mode	2.35*	0.07
	Typed	Background	-1.44	0.00
		Noun name	-2.96*	1.97*
		Noun mode	-2.61*	1.68*

4.3.4.3.2 Analysis of recall accuracy

Figure 23 shows the mean accuracy (percentage) of recalled details of background picture-noun pairings under both distraction conditions.

A Friedman's ANOVA showed a significant difference in recall accuracy across distraction, word format and type of detail, $\chi^2(17) = 89.487$, $p = <.001$.

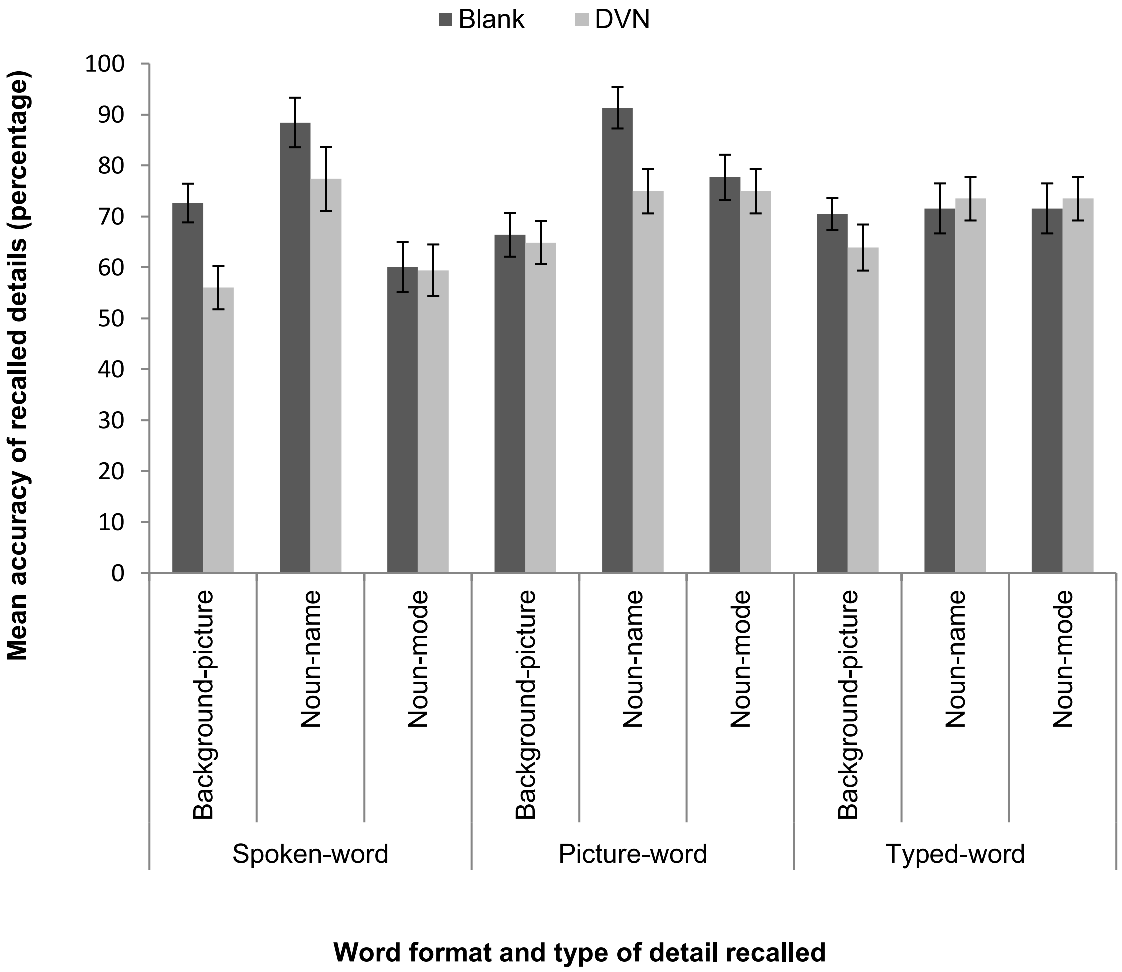

Figure 23: The mean accuracy (percentage) of recalled details under blank screen and DVN by word format and type of detail recalled. Error bars represent standard errors of the mean.

As with analysis of incorrect recall, three follow-up analyses examining the main effect of each variable on recall accuracy were carried out and alpha was therefore adjusted to .0167 (.05/3).

Numerically, participants were more accurate in their recall of details when recalling under control conditions of a blank screen (*M* = 74.39, *SD* = 15.16) than under DVN (*M* = 69.28, *SD* = 15.56). However, a Wilcoxon signed ranks test showed this difference was not significant, z=-2.109, p=0.035 (Blank screen, *Mdn* =77.04, DVN *Mdn* = 75.65).

A Freidman's ANOVA comparing recall accuracy between the three word formats showed no significant differences, $\chi^2(2) = 0.970$, $p = .616$. Thus participants were equally accurate in recalling details of background-picture noun pairs when the noun was presented as a picture-word as when it was presented as a typed or spoken word.

A further Friedman's ANOVA comparing recall accuracy across the three types of detail recalled showed participants were less accurate in recalling details about background pictures (*Mdn* = 67.08, *M*=66.25, *SD*=10.94) than recalling the noun-mode (*Mdn* = 71.94, *M* = 69.99, *SD* =16.77) or noun –name (*Mdn* = 86.67, *M* = 79.52, *SD* = 18.35). $\chi^2(2) = 25.939$, $p < .001$.

In order to explore secondary aims of Experiment 8, a further nine follow-up Wilcoxon signed ranks tests were conducted comparing the effect of distraction condition on recall accuracy between word formats and the types of detail recalled. Alpha was adjusted to .0055 (.05/9) and results are summarised in Table 31. As seen in the table, analysis revealed that DVN compared to blank screen impaired recall accuracy of the name of picture words (DVN *M* = 76.11, *SD* = 24.71; blank screen *M*=92.04, *SD* = 22.40).

Table 31: Wilcoxon signed ranks, recall accuracy

Word Format	Type of detail	DVN vs SVN z-score	*p*-value
Spoken	Background	2.515	0.012
	Noun name	1.455	0.146
	Noun mode	0.033	0.974
Picture	Background	0.619	0.536
	Noun name	2.864	0.004*
	Noun mode	0.036	0.971
Typed	Background	1.105	0.269
	Noun name	0.422	0.698
	Noun mode	0.437	0.662

**significant at alpha=.0055*

4.3.5 Discussion

The primary aim of Experiment 8 was to control the richness of information conveyed by visual and verbal details while testing the effect of distraction on recall. This was done by asking participants the name of a noun which had been presented as a visual, spoken or typed word. Under control conditions, participants were equally accurate at recalling the name of spoken, picture and typed words. This suggests that the method of balancing information presented in visual and verbal modalities through presenting information as a spoken and a picture noun was successful.

In terms of the size of distraction effect on recall accuracy of noun names, distraction impaired memory for picture words (*d* = - 0.52) to a greater degree than spoken words (*d* = - 0.27) and had a negligible effect on typed words (*d*= - 0.10).

This does not reflect a modality-specific effect because the expected pattern in that case would show either a comparable detrimental effect on recall of spoken and typed nouns or, a stronger detrimental effect on recall of typed nouns (assuming an element of visual processing alongside verbal) than spoken nouns. .

The design of Experiment 8 also gave opportunity for secondary explorations on same and cross-modality binding. One line of theoretical thinking (Baddeley et al, 2000, Allen et al, 2006) can be argued to predict that distraction will disrupt visual-verbal bindings more so than visual-visual. With respect to material presented to participants in this experiment, this translates to a prediction that distraction will reduce recall accuracy for noun names and details of background pictures when the nouns are presented as spoken words compared to when they are presented as picture words. This is because spoken words will theoretically form a visual-verbal binding with their paired background pictures and picture words will form a visual-visual binding with the paired background picture. The pattern of distraction effect on memory for these bindings however is not clear. Participants who had seen the noun as a picture-word were less accurate in recalling its name under DVN than when they had seen the same noun as a typed word or heard it as a spoken word. However, there was no concurrent reduction in recall accuracy of the paired background picture. Thus recall of one of the pair of visual-visual bindings was impaired by distraction but, not the other.

Another secondary aim was to explore distraction effects on recall of details of background pictures and as seen above, distraction did not have an overall effect on recall accuracy.

A third secondary aim was to explore the effect of distraction on complete pattern recall. That is, to explore whether there was any evidence that distraction disrupts recall of all three target details or not. Distraction led to a decrease in recall accuracy overall thus implying that overall, distraction disrupted complete pattern recall. That is, if participants were inaccurate in recalling a detail of the valley scene they were also inaccurate in recalling the name of the noun which had been presented with it as well as the mode in which the noun had been presented. This finding is in line with Horner et al (2015) who found evidence to suggest that if distraction disrupts recall of one detail in a bound group, it will most likely disrupt recall of all details within the group. However, as seen earlier, the detrimental effect of distraction on accurately recalling the name of a picture word was not also seen for recall of the picture word's background picture or indeed, the picture word's noun-mode.

4.4 Summary

The primary aim of work in Chapter 4 was to match visual and verbal target details based on the content of the detail being recalled before again testing the effect of distraction on recall. Experiment 7 tackled the problem by matching the type of visual and verbal detail participants were asked to recall in a sequence of video-clips. Experiment 8 focussed on controlling the richness of information conveyed by presenting information as visual and verbal. Both experiments found evidence of a detrimental effect of distraction on recall accuracy but both found inconsistent patterns when secondary research aims were explored. It is difficult to reconcile these patterns in isolation with theoretical accounts of distraction however, the final discussion chapter will consider effect patterns across all experiments.

Chapter 5: General Discussion, Meta-analyses and Conclusion

5.1 Introduction to Chapter 5

The purpose of this thesis was to investigate when and how visual distraction disrupts long-term memory. This final Chapter will therefore summarise and discuss when and how distraction disrupted memory across Experiments 1 to 8. This is followed by a presentation of four meta-analyses. Alongside this, consideration will also be given to the theoretical implications of the analyses. After this, there will be a discussion on methodological limitations and future work. Finally, the chapter and thesis will close with a short conclusion of what the work herein adds to the distraction literature.

5.2 Summary of Experiments 1 to 8

The effect of distraction across experiments is mixed and in order to navigate through these findings, results will be discussed in two steps. First there will be a recap on both the purpose and findings of Experiments 1 to 3 and then, 4 to 8. These experiments are presented separately because the former measured the quantity of free recall and the latter measured the quality of cued recall.

5.2.1 Experiments 1 to 3

5.2.1.1 Recap on background

Work for this thesis began with a review of what is known about the effect on memory of environmental distraction during retrieval. Eyewitness studies demonstrate consistent detrimental distraction effects on memory for events however, only one study has demonstrated the effect on memory for word-lists (Glenberg et al., 1998). This latter study was of particular interest because earlier work by the present author (Rae, 2011) consistently failed to find evidence of a distraction effect on word-list recall. However, because there were several key differences between Glenberg et al. (1998) and Rae's (2011) methodology and analysis, experimental work for the thesis began with a part-replication of Glenberg et al.'s multiple list method but with tighter control over materials and analysis of not only mid-list recall but also of full-list recall (which Glenberg et al. did not report).

5.2.1.2 Summary of findings

Experiment 1's part-replication found no evidence of a distraction effect on full- list recall but like Glenberg et al. (1998), found a detrimental effect on mid-list recall. Glenberg et al. cited Glenberg's (1997) finite cognitive resource theory to argue that disruption to mid-list recall was because distraction disrupts memory only for moderately difficult tasks. Therefore, Experiments 2 and 3 investigated task difficulty as a potential moderating factor of distraction. Presentation duration and inter and intra-list interference were manipulated across sets of word-lists in order to vary task difficulty. The task of recalling words presented for short durations was expected to be more difficult than the task of recalling words presented for longer durations. Likewise, word-lists consisting of numerous exemplars from the same semantic category were expected to be more difficult to recall than lists with only one exemplar per category. In addition, build-up of interference across the multiple lists was expected to increase the task difficulty. Task difficulty was indexed by correct and incorrect responses under control conditions. However, although the manipulations were shown to successfully provide several levels of task difficulty these two experiments failed to find any evidence of a selective detrimental distraction effect. Of most concern was the failure to find robust evidence of a detrimental effect across both these and Rae's (2011) word-lists experiments.

Recall under Dynamic Visual Noise (DVN) was compared to recall under Static Visual Noise (SVN) across all three experiments. Thus, while the above findings gave rise to several research questions about why distraction did not appear to disrupt word-list recall, it was more pressing to first establish that the materials used to create DVN and SVN were in actuality creating two different conditions. That is, that DVN was an effective distractor and that SVN was not in itself, distracting.

5.2.2 Experiments 4 to 8

Experiment 4 tested the effect of DVN on memory for an event for two reasons: eye-witness studies had consistently shown event memory to be disrupted by distraction and, none of the eye-witness studies had tested the effect of DVN on event memory. Thus if DVN is an effective distractor it should disrupt event memory. The effect of DVN was compared to that of Boxes (a distractor which had been shown to disrupt memory for an event, Perfect et al, 2012), SVN and a blank screen. Both DVN and Boxes showed a detrimental effect on recall-accuracy relative to SVN, with effect sizes d= -0.77and d= -0.56 respectively (for visual details) which implied that the DVN condition in Experiments 1 to 3 was distracting. In addition, there was no difference in performance under SVN compared to the blank screen condition which implied that the SVN condition in Experiments 1 to 3 was not in itself significantly more distracting than looking at a blank screen. Therefore the lack of evidence of a detrimental distraction effect across Experiments 2 and 3 is unlikely to be due to a failure to create two distinctly different levels of distraction.

Thus, the investigation turned its focus towards considering what other differences between the word-list and event experiments might explain the difference in distraction effect. One obvious difference was in the way in which details had been presented to participants for later recall. Experiments 1 to 3 presented details as a list and Experiment 4 presented details as an event. Thus, one possible explanation was that distraction disrupts cognitive processes which are involved in recalling details from an event but has a lesser effect on cognitive processes involved in recalling details from a list. There are many ways in which cognitive processes may differ between recalling lists and events however, a review of wider literature led to a focus on three factors: modality of detail being recalled (visual versus verbal), bimodal versus unimodal presentation of details and, static versus flowing presentation of details.

Each of these factors has two levels, one of which is not fully present in the wordlists. For example, the event consisted of both visual and verbal details but the wordlists were predominantly verbal (albeit presented visually); the event details were presented as bimodal but the list details were presented as unimodal; the event was a flowing video-clip but the word-lists were a series of static segments. Therefore, these three factors became recurring research themes across Experiments 4 to 8.

In addition to the above research themes, the experimental conditions can also be thought of in terms of presenting details from one memory source versus multiple memory sources. It is thought that correctly identifying a source from which a memory item comes, improves memory accuracy (for example, Koriat & Goldsmith, 1996). For example, a participant answering questions about a detail of a video clip may bring more than one candidate answer to mind. The participant will assess the candidate answers for correctness and as part of this process, will attribute each candidate answer to a memory source. Thus the question, ‘At the birthday party, what colour was Harold’s tie?’ may conjure candidate answers, ‘red’ and ‘green’. If the memory source of ‘red tie’ is attributed to the birthday party clip but ‘green tie’ is not, ‘red tie’ will be offered as an answer. However, this example, which is from Experiment 7, involves 18 different memory sources (18 video clips) whereas Experiment 4 involved one memory source (one video clip). One possibility therefore, is that distraction may disrupt source monitoring and this may be more evident for recall of details presented across multiple sources rather than presented in one source. Johnson, Hashtroudi, and Lindsay (1993) proposed the Source Monitoring Framework (SMF) as a theoretical approach to understanding factors affecting the process of attributing a source to, for example, an item of memory. Research into the effect of single versus multiple source monitoring on memory accuracy suggests that disruption to attentional resources leads to poorer source monitoring which in turn leads to poorer memory (Hashtroudi, Johnson, Vnek, & Ferguson, 1994). Therefore, it may be that distraction depletes attentional resources and so interferes with source monitoring. This hypothesis predicts that recall of details presented from multiple sources will show a greater detrimental effect of distraction than recall of details from one source.

These four potential moderators of distraction are explored with meta-analyses in the next section (5.3) however, before moving on to this exploration the remainder of this section provides a summary overview of the findings of Experiments 4 to 8.

Experiments 4 to 6 asked participants the same questions about the same news-bulletin video-clip. Experiment 4 showed the news-bulletin in its original format (bimodal presentation of visual and verbal flowing details) and found that visual distraction led to an increase in incorrectly recalled visual details and a decrease in recall accuracy of visual details. However, Experiment 5 did not replicate this apparent modality-specific pattern. Instead, the distraction effect in Experiment 5 suggested that recall of visual and verbal details is disrupted equally when presented as static items (or pseudo-static for verbal details) in two separate unimodal lists. Experiment 6 tested whether this lack of modality-specific effect was because the fixed presentation duration of visual details in Experiment 5 did not match that of the original Experiment 4 video-clip. Thus Experiment 6 presented the same static visual details as in Experiment 5 but this time, for the same durations as they had been on screen in Experiment 4. Experiment 6 also resorted back to presenting verbal details as flowing (as in Experiment 4) rather than pseudo-static. In addition, details were presented as either bimodal or unimodal. However, there was no evidence at all of a distraction effect. That is, the earlier effect seen in Experiment 5 on recall of unimodal visual static details was not replicated.

These mixed effects led to a tightening of control over materials in Experiments 7 and 8. Experiment 7 paired the type of visual and verbal details to be recalled (details were either both a colour, a sequence or count) across a series of bimodal and unimodal presentations of short flowing video-clips. Distraction had an overall detrimental effect on recall with no suggestion of the effect being moderated by modality of detail or bimodal/unimodal presentation. Experiment 8 sought to match the richness of visual and verbal information presented by asking participants to study a series of nouns. Thus target verbal details were nouns in spoken form and target visual details were the same nouns in picture form. In addition, the same nouns were also presented as typed and this was assumed to be a predominantly verbal detail with a visual element. Visual distraction showed a stronger detrimental effect on recall of picture nouns than typed nouns and while the effect on picture-noun recall was also stronger than for spoken-noun recall, it was not as pronounced. Each noun was paired with a background picture and so presentation was bimodal.

Participants were asked questions about background pictures and then asked for the name of the paired noun. Under distraction conditions participants were less accurate in recalling background pictures which had been presented with spoken nouns but less accurate in recalling nouns when they had been presented as pictures. Thus distraction disrupted recall of bimodal static visual details but only under specific conditions.

Overall, the pattern of distraction across Experiments 4 to 8 is inconsistent because there is both evidence and a lack of evidence that the three factors (modality of detail, bimodal versus unimodal presentation and static versus flowing presentation) moderate distraction. One possible explanation for the inconsistent pattern is that some experimental conditions may have lower statistical power than others to identify significant effects. A related explanation is that the inconsistent pattern may be due to unsystematic noise. That is, there is variability of effect in any set of experiments. A meta-analysis on distraction effect-sizes can address these potential issues. The following section presents a rationale for carrying out a meta-analysis to uncover an overall distraction effect and for carrying out subsequent meta-analyses to explore potential moderators of distraction.

5.3 Meta-analysis and theoretical implications

Meta-analysis of effect sizes is a method strongly advocated by Cummings (2012) and one that takes focus away from the more polarised stance of null hypothesis testing where there is either statistical evidence of an effect or no statistical evidence of an effect. In addition to this, power analyses determining the sample size for each experiment did not always take in to account the total number of groups within each analysis and it is therefore possible that some studies were not fully powered. Thus, one way of mitigating this potential issue and of making sense of the mixed findings is to gather together recall data from across experiments and explore distraction effect-size patterns. The first analysis presented is a meta-analysis of Experiments 1 to 3 and Rae's (2011) distraction effect-sizes on correct recall. The second analysis presented is a meta-analysis of Experiment 4 to 8 distraction effect-sizes on recall accuracy. Both analyses give an estimate of the overall distraction effect-size. The first analysis showed homogeneity across effect sizes. Not surprisingly however, the second analysis showed heterogeneity (discussed in more detail later) across individual effect sizes and this provides a justification for carrying out four further analyses on these data to explore whether other factors are moderating the distraction effect and thus causing the heterogeneity. Four further meta-analyses were therefore carried out on Experiment 4 to 8 data to explore the potential moderating nature of: modality of detail recalled, multiple versus single memory source (explained in detail later), bimodal-unimodal presentation and static versus moving presentation of details. The sections below present a more detailed explanation about how and why the analyses were carried out.

The second and subsequent meta-analyses are carried out on recall-accuracy scores. This is because accuracy scores take into account all possible recall responses (correct, incorrect and don't know). For example, in Experiments 4 to 8 participants were asked a fixed number of questions about presented details with an option to withhold an answer by responding 'don't know'. Thus out of the fixed number of questions it is possible to identify whether distraction disrupts the quality of memory rather than simply the quantity. While it is possible to carry out the meta-analyses on either correct or incorrect answers instead of accuracy these analyses would not give as clear an overview of the distraction effect as recall accuracy scores. This is because an interpretation of analyses on correct/incorrect would need to take in to account any concurrent increases or decreases in correct and incorrect responses as any such pattern would signify a shift in willingness to respond rather than a change in quality of response. In contrast, accuracy scores are calculated as the percentage of correct answers out of all correct and incorrect answers given and thus already take any shift in willingness into account. The decision to carry out the meta-analyses on accuracy data however, rules out including word-list data in the same analyses. This is because word-list studies measured free-report and not cued recall for a set number of details and thus accuracy scores for these data do not reflect the same information as for Experiments 4-8. That is, participants recalling a word-list may either attempt to recall as many words as they wish or, give a ‘don’t know’ response if they are unable to recall any words. So for each word-list there is either one ‘don’t know’ response or one to several correctly/incorrectly recalled words but, never both ‘don’t know’ and correct/incorrect responses. Furthermore, participants are free to choose how many words they attempt to recall (whether correct or incorrect) and the number of attempts are free to vary across participants. Therefore, the meta-analysis for word-list recall was carried out separately on the quantity (correct recall) rather than quality of recall.

The meta- analyses presented here are based on Cohen’s *d* effect sizes, the formula for which is intended to describe the effect of a factor presented between groups of participants. However, not all experiments presented distraction as a between factor. Applying the same effect size formula to experiments using distraction as a within factor can give an exaggerated effect size depending on the size of correlation between the two conditions and therefore a correction to Cohen’s *d* which takes this correlation in to account is advised (Dunlap, Jose, Vaslow, &

Burke, 1996; Lakens, 2013) To address this, Morris and DeSchon's (2002) formula is used where distraction was presented as a within factor.

The meta- analyses were carried out using Cumming's ESCI (Exploratory Software for Confidence Intervals) software (Cummings, 2016). A random effects model was selected for the analyses because the alternative, a fixed effect model, assumes that each experiment tests a sample from the same population (Cumming, 2012) which is unlikely here given the idiosyncrasies of each experiment. In fact, the expectation across these experiments is that effect sizes will be heterogeneous because the purpose of the experiments has been to investigate factors which may moderate the distraction effect and thus cause heterogeneity. Cummings' method of meta-analysis gives a numerical indication of heterogeneity called the Diamond Ratio (DR) rather than relying on a more complicated but traditional calculation such as Q or I-squared. The DR compares the overall effect size and confidence intervals of the meta-analysis when carried out with a fixed effect model to when carried out with a random effect model. Cummings argues thus that the DR, a straightforward comparison, is more simple to interpret than for example, Q or I-squared. A DR equal to 1.0 suggests that both the fixed effects and random effects models give the same result. In other words, DR = 1.0 implies that there is little heterogeneity across the studies included in the meta-analysis. A DR above the value of 1.0 indicates heterogeneity across effect sizes within the analysis.

5.3.1 Word-list meta-analysis

Table 32 gives a summary of each experimental condition included in the word list meta-analysis. A summary of effect sizes with 95% confidence intervals (CIs) for all experimental conditions included in the meta-analysis are shown in Figure 24.

Table 32: Summary of each experimental condition included in the word-list meta-analysis

Experiment	Words presented as spoken or typed	Word position within list	Imagery: semantic association of cued-target word pairs. (high H, low, L)	Number of lists presented under each distraction condition	Presentation duration of words	Distraction presented as:
E1a	typed	First		5	2s	Within
E1b	typed	Mid		5	2s	Within
E1c	typed	Last		5	2s	Within
E2a	typed	First		5	2s	Between
E2b	typed	Mid		5	2s	Between
E2c	typed	Last		5	2s	Between
E2d	typed	First		5	0.5s	Between
E2e	typed	Mid		5	0.5s	Between
E2f	typed	Last		5	0.5s	Between
E3a	typed	First		4	2s	Within
E3b	typed	Mid		4	2s	Within
E3c	typed	Last		4	2s	Within
RaeA	typed		H:H	1	2s	Within
RaeB	spoken		H:H	1	2s	Within
RaeC	typed		H:L	1	2s	Within
RaeD	spoken		H:L	1	2s	Within
RaeE	typed		L:H	1	2s	Within
RaeF	spoken		L:H	1	2s	Within
RaeG	typed		L:L	1	2s	Within
RaeH	spoken		L:L	1	2s	Within

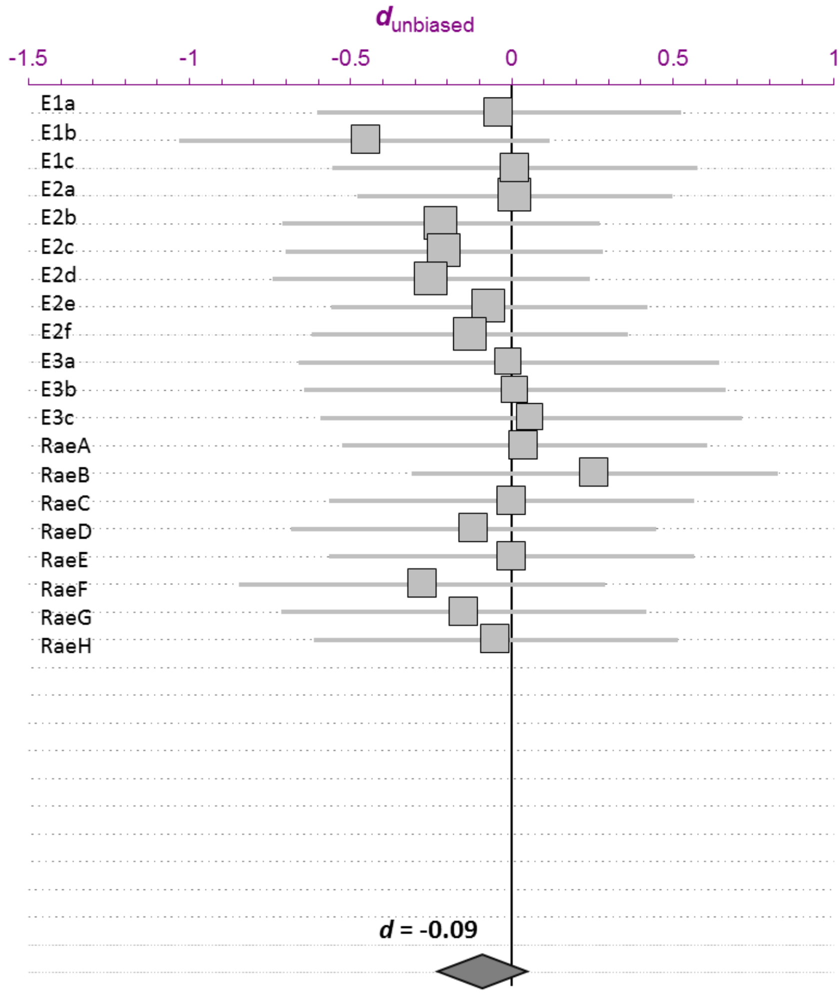

Figure 24: Diagrammatic presentation of meta-analysis on word-list data

Each box on the graph indicates the value of the experimental condition's distraction effect size on correct recall and the dimension of the box indicates its weighting in contributing to the final overall effect size: smaller boxes reflect smaller weightings. This weighting is based on both the heterogeneity of the full set of experimental conditions and the variance within each experiment's condition. Recall under Dynamic Visual Noise (DVN) was compared to recall under Static Visual Noise (SVN) across all of the above experiments. The overall effect size on word-list recall is very close to zero and its 95% confidence interval ranges from -0.21 to 0.034 thus encompassing a zero effect. The Diamond Ratio is 1.0 which indicates that effect sizes are homogenous throughout the word-list experiments. That is, distraction consistently showed little detrimental effect on recall of words presented in lists.

5.3.2 Experiment 4 to 8 meta-analyses

Table 32, overleaf, gives a summary of each experimental condition included in the meta-analyses. A summary of effect sizes with 95% confidence intervals (CIs) for all experimental conditions included in the meta-analyses are shown in Figure 25.

Table 33: Summary of each experimental condition included in the meta-analyses of Experiments 4 to 8

Experiment	Modality of detail recalled	Multiple or single source	Bimodal or unimodal presentation	Static or flowing	Distraction conditions	Distraction presented as:
E4a	Visual	Single	bimodal	flowing	DVN: SVN	between
E4b	Visual	Single	bimodal	flowing	BOXES: BLANK	between
E4c	Verbal	Single	bimodal	flowing	DVN: SVN	between
E4d	Verbal	Single	bimodal	flowing	BOXES: BLANK	between
E5a	Visual	Multiple	unimodal	static	DVN: BLANK	between
E5b	Visual	Multiple	unimodal	static	DVN: BLANK	between
E5c	Verbal	Multiple	unimodal	static	DVN: BLANK	between
E5d	Verbal	Multiple	unimodal	static	DVN: BLANK	between
E6a	Visual	Multiple	bimodal	static	DVN: BLANK	between
E6b	Visual	Multiple	unimodal	static	DVN: BLANK	between
E6c	Visual	Multiple	unimodal	static	DVN: BLANK	between
E6d	Verbal	Single	bimodal	flowing	DVN: BLANK	between
E6e	Verbal	Single	unimodal	flowing	DVN: BLANK	between
E6f	Verbal	Single	unimodal	flowing	DVN: BLANK	between
E7a	Visual	Multiple	bimodal	flowing	DVN: BLANK	between
E7b	Visual	Multiple	unimodal or bimodal	flowing	DVN: BLANK	between
E7c	Verbal	Multiple	bimodal	flowing	DVN: BLANK	between
E7d	Verbal	Multiple	unimodal or bimodal	flowing	DVN: BLANK	between
E8a	visual background picture	Multiple	bimodal - same modality versus cross-modal	static	DVN: BLANK	within
E8b	visual - picture noun	Multiple	bimodal - same modality versus cross-modal	static	DVN: BLANK	within
E8c	verbal - spoken noun	Multiple	bimodal - same modality versus cross-modal	static	DVN: BLANK	within
E8d	verbal - typed noun	Multiple	bimodal - same modality versus cross-modal	static	DVN: BLANK	within

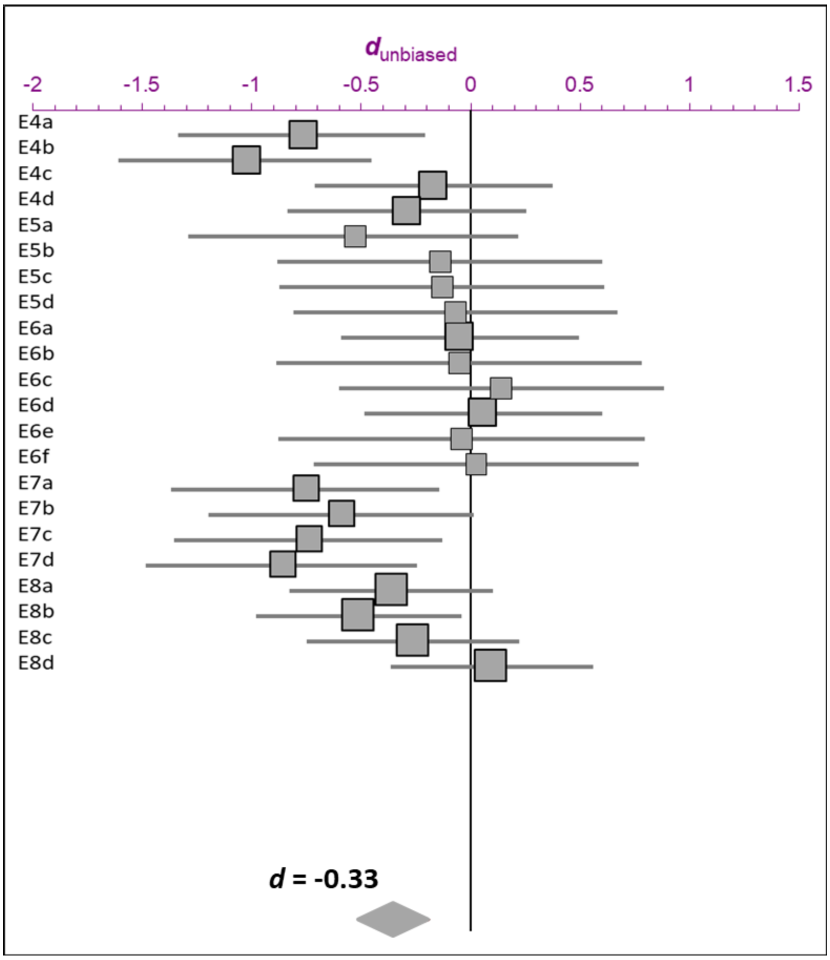

Figure 25: Effect sizes and 95% CIs for experimental conditions in Experiments 4 to 8

The weighted overall effect size using a random effects model is *d* = - 0.33 (95% CI -0.48 to -0.19) thus overall, regardless of experimental condition, across all experiments, distraction is shown to have a detrimental effect on recall accuracy.

The overall DR for the above experimental conditions is greater than one (DR = 1.16) which confirms there is heterogeneity across effect sizes and therefore justifies continuing with further meta-analyses to explore moderating factors. The following four sections present meta-analyses on four potential moderating factors.

5.3.2.1 Modality of detail recalled

Figure 26 shows the meta-analysis with modality of detail as a moderating factor. Red denotes distraction effects on recall accuracy of visual details and blue, on verbal details.

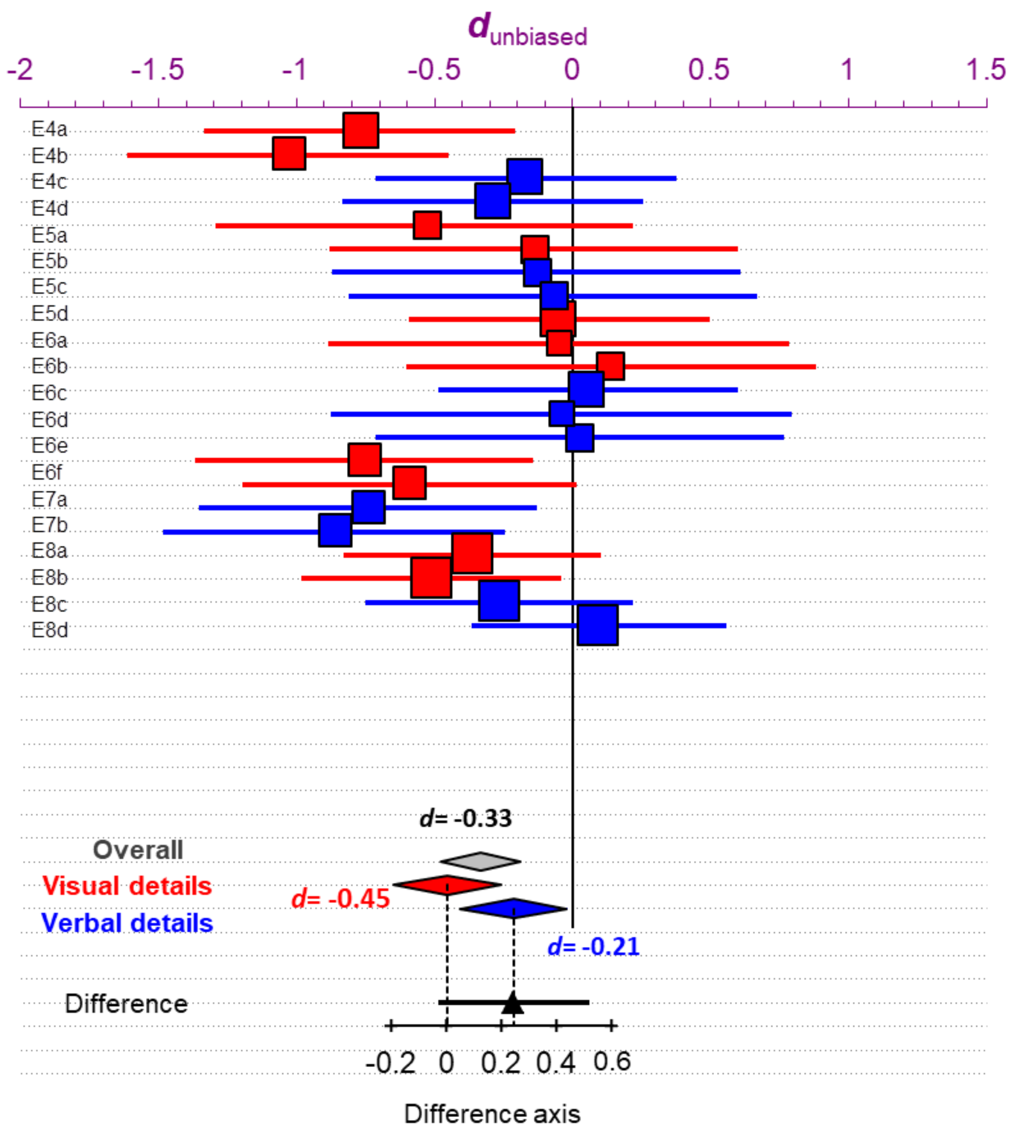

Figure 26: Meta-analysis of distraction effect sizes on recall accuracy with modality of detail as a moderator of distraction

The three diamond shapes at the bottom of the graph show the estimated distraction effect sizes on recall-accuracy for details overall (grey), for visual details (red) and for verbal details (blue). The points of the diamond lying on the horizontal plane represent the upper and lower limits of the 95% CI for the estimated effect size. Please note that in the graph these limits are relative to each other and not the actual numerical values of the upper and lower limits: actual values of CI limits will be given in the text. The 'Difference axis' lying at the bottom of the graph, below the three diamonds, provides an easy visual comparison between the effect size of the red group and that of the blue group. To aid comparison, the effect size for the red group is set to '0'. However, 0 is not necessarily the actual effect size for the red group and thus the numbers on the 'difference axis' aligning with the horizontal points of the red diamond (the CI limits) are not the actual numerical values of the CI limits.

Interestingly, there is an overlap between visual and verbal diamonds (visual CI ranging -0.65 to -0.26; verbal CI ranging -0.41 to -0.02) suggesting that while there is an overall impairment under distraction there is a stronger detrimental effect on recall accuracy of visual than verbal details. However, the DR for both visual and verbal details is 1.1, which suggests that there is still a degree of heterogeneity within each level of the moderator.

Thus, modality of detail appears to at least partly account for the pattern of distraction-effect on recall-accuracy seen across experiments. That is, there is evidence that distraction has a greater detrimental effect on recall of visual than of verbal details. When taking the modality of the distractor in to account, this pattern of effect is one predicted by Vredveldt's (2011) Cognitive Resources Framework (see Chapter 1 for a detailed explanation). To briefly recap, the cognitive resources framework is based on Baddeley and Hitch's (1974) model of working memory. Vredeveldt'sframework predicts that Baddeley and Hitch's general attentional resource component is vulnerable to distraction regardless of the modality of the distractor. This is because it is assumed that distracting environments are automatically processed (Glenberg, 1997) and thus take up attention. Therefore, the general attentional resource is vulnerable to any distractor, regardless of modality. Baddeley and Hitch's model also consists of two sub-systems and these process visual (visuospatial sketchpad) and verbal (phonological loop) information separately. Vredeveldt's framework predicts that distraction will also compete for resources with one of the subsystems depending on the modality of the distractor. Therefore, visual distraction will compete with the visuospatial sketchpad and verbal distraction will compete with the phonological loop. With respect to experiments here, visual distraction should disrupt memory per se but have a greater impact on memory for visual details than verbal. The meta-analysis across all 22 conditions appears to support this view however, the DRs of both verbal and visual groups suggest that an additional moderator may also account for some of the heterogeneity of effect sizes.

5.3.2.2 Multiple versus single source

Figure 27 shows the meta-analysis with multiple versus single source as a moderating factor (explained further on). Red denotes distraction effects on recall accuracy of single source details and blue, on multiple source details.

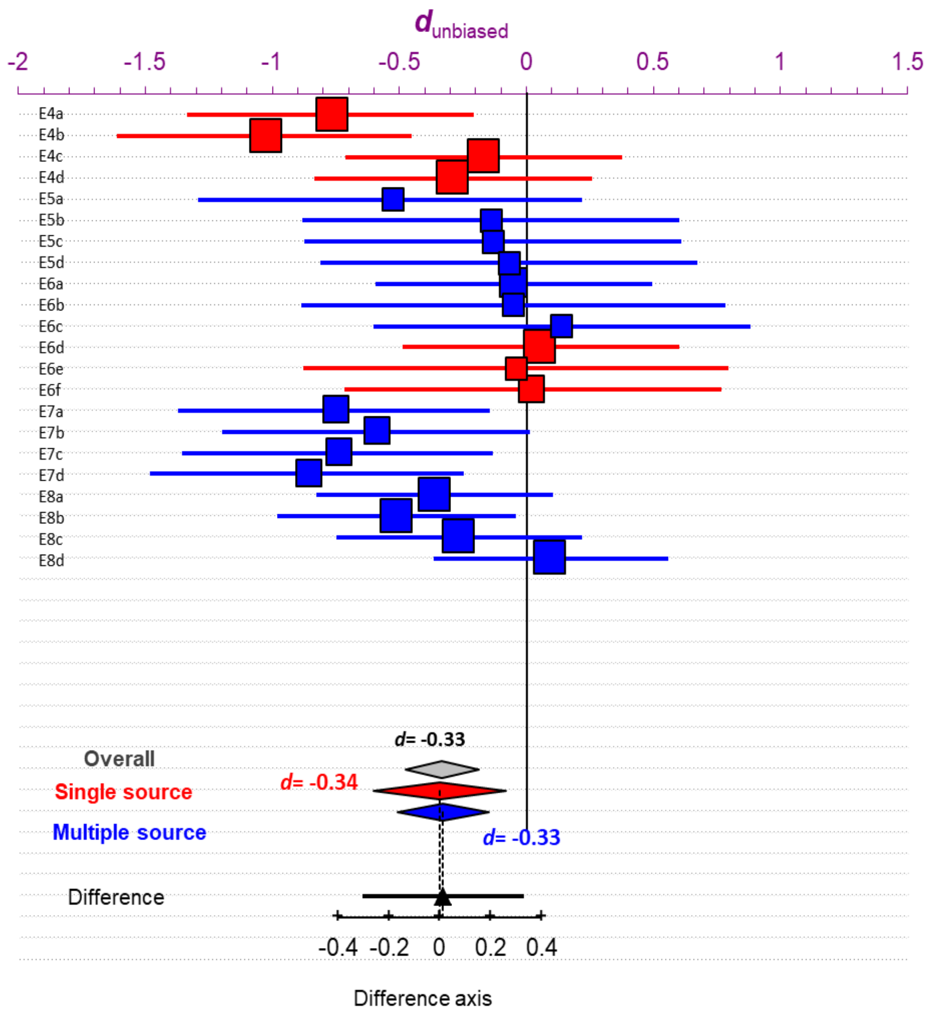

Figure 27: Meta-analysis of distraction effect sizes on recall accuracy with multiple and single source as a moderator of distraction

An underlying assumption of this analysis is that recalling details from a series of distinct units (such as a series of distinct video-clips or a series of picture-noun pairs) involves multiple shifts in context and therefore constitutes multiple memory sources. The purpose of exploring this as a potential moderator of the distraction effect is to test whether distraction interferes with the ability to correctly identify the source of a recalled detail. For example, Koriat & Goldsmith's (1996) theoretical account of the strategic regulation of memory argues that recall accuracy is dependent on accurate source-monitoring. Thus, recall involves not only generating a cohort of details in mind but also involves assessing whether each detail came from the target memory source. Koriat & Goldsmith's theory implies that poorer accuracy is a result of errors with memory source; participants mistakenly attribute the source of a recalled detail and report the detail believing it to be from the target source.

The meta-analysis shows no difference in estimated overall distraction effect sizes between recall from single and multiple sources (single CI ranging -0.60 to -0.08, DR = 1.18; multiple CI ranging -0.51 to -0.15, DR = 1.19). It does not appear that the distraction effect is moderated by source monitoring because recall of details from multiple sources showed no greater impairment than recall of details from a single source.

A limitation of the analysis here however is that details in Experiment 6 which have been defined as coming from multiple sources may in actuality be deemed by participants as coming from one source because they refer to pictures being shown one after another with no blank screen in between. Experiment 5 however presented details delineated by a blank screen and details defined as coming from multiple sources in Experiments 7 and 8 were even more obviously delineated in to separate sources because each video-clip was given a separate title and questions about background picture-noun pairs were targeted at specific pairs by referring to the name of the background picture. However, a visual inspection of Figure 27 strongly suggests that redefining details in Experiment 6 would have little, if any, impact on estimated distraction effect sizes. This is because all the effect sizes in Experiment 6 cluster closely together around ‘0’, thus redefining each condition and re-grouping the effect sizes will have little influence on the overall effect size for each group.

In summary, there is no evidence in these data that requiring source monitoring has an impact on the size of the distraction effect.

5.3.2.3 Bimodal versus unimodal presentation of details

This factor refers to the way in which details were presented; either unimodal or bimodal (presentation modality). However, it could be argued that this definition needs to extend to how details were recalled (recall modality). Participants in Experiment 5 and 6 studied one unimodal presentation and answered questions before moving on to study the second presentation and answer questions. Participants in Experiment 7 studied both sets of unimodal presentations one after the other and were asked questions about both sets at the same time. Therefore, Experiment 7 unimodal conditions involved unimodal presentations but the recall phase could be defined as bimodal because details from both unimodal presentations were recalled at the same time. Thus, participants may have inadvertently been encouraged to retrieve details as if they had been presented as bimodal. In order to explore whether this influences the estimated distraction effect sizes two analyses were carried out. Figure 28 displays the analysis of presentation modality (with Experiment 7b and d presentation conditions as unimodal) and Figure 29 as displays the analysis of recall modality (with Experiment 7b and d recall conditions as bimodal).

Figures 28 and 29 show the meta-analysis with bimodal-unimodal presentation and bimodal-unimodal recall as moderating factors. Red denotes distraction effects on recall accuracy of bimodal presentations and blue, on unimodal presentations. The reason for carrying two analyses on this factor is explained below.

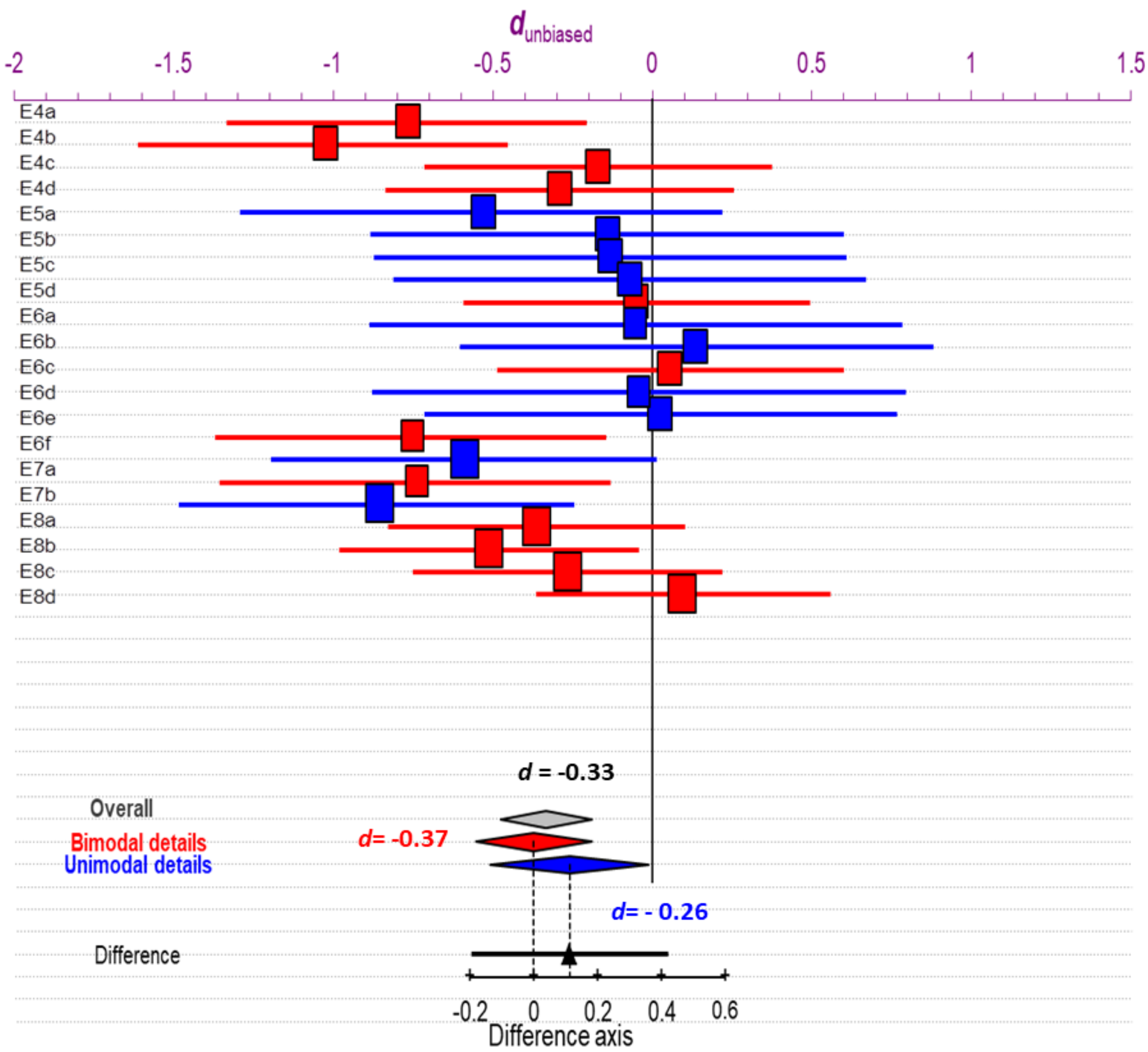

Figure 28: Meta-analysis of distraction effect size on recall accuracy with bimodal-unimodal presentation as a moderator of distraction. Experiment 7

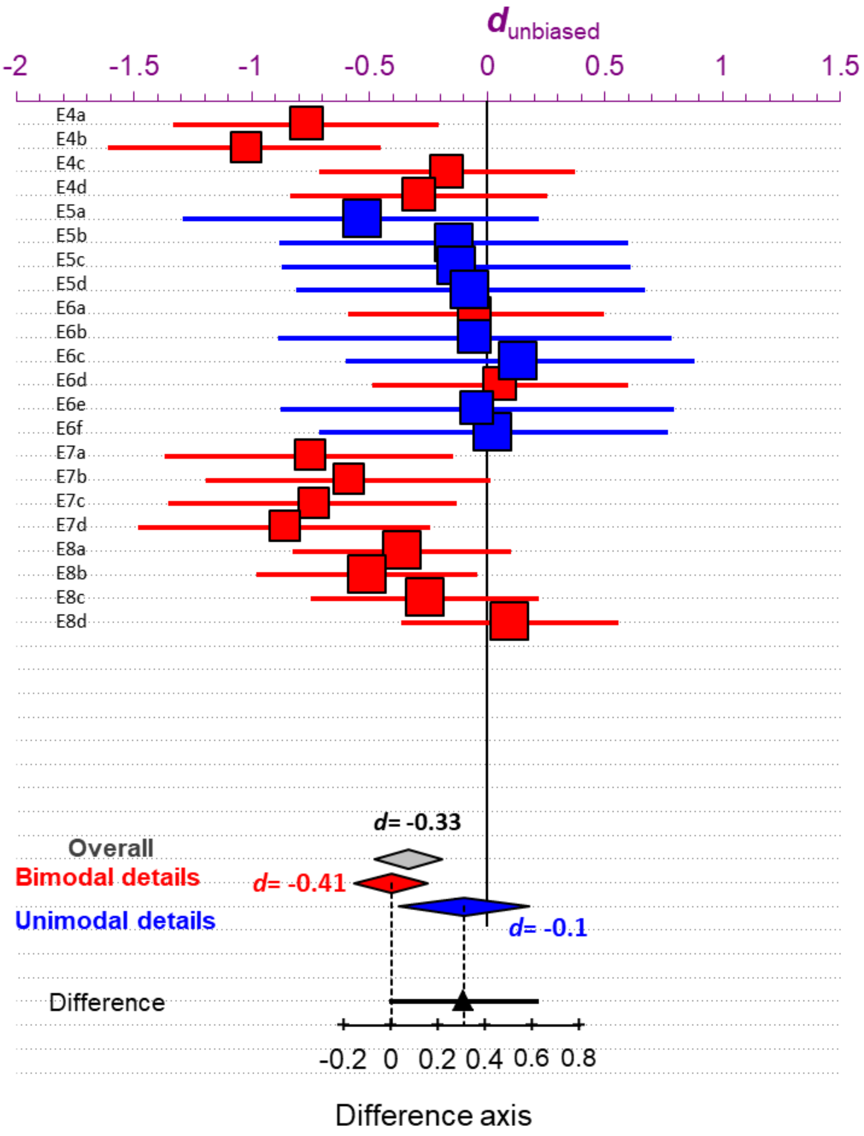

Figure 29: Meta-analysis of distraction effect sizes on recall accuracy with bimodal-unimodal recall as a moderator of distraction

When Experiment 7b and d presentation details are coded as unimodal the CI for the estimated effect size on unimodal details ranges from -0.51 to -0.01 and almost completely overlaps with the CI for bimodal details (ranging from -0.55 to -0.19). In addition the DRs (bimodal DR = 1.2, unimodal DR = 1.12) indicate that there is still some unexplained heterogeneity. However, when the recall details are coded as bimodal a slightly different model emerges with less overlap between effect-size CIs (bimodal ranging from -0.56 to -0.25 and unimodal from -0.38 to 0.18) and lower DRs (bimodal DR = 1.1, unimodal DR = 1.05). Thus, Figure 29 presents a better fit model. Both models are interpreted below in terms of Baddeley's (2001) theoretical episodic buffer.

As discussed in Chapter 4, Baddeley (2001), Allen (2006) and Baddeley et al.(2011) propose that the binding of bi-modally presented details takes place in the central executive. Bound details are then maintained in the episodic buffer which acts as a holding platform from which bound details then pass back through the central executive to long-term memory and back again during retrieval. The authors propose that bindings in the episodic buffer will disintegrate when attention is depleted because the central executive is an attentional component. Therefore, recall of details presented and thus encoded as bimodal (bound) should be poorer under distraction conditions than details presented as unimodal (unbound).

The first analysis appears to lend little support to this theory because there is only a small difference in the estimated distraction effect sizes and CIs between unimodal and bimodal details. Instead, the analysis suggests that maintaining and retrieving bound details via the episodic buffer does not rely solely on attention from the central executive. This possibility is alluded to by Allen et al. (2006) who tested the effect of attention-demanding tasks on short-term memory for bound and unbound visual details. They found no differential effect of lower attention on recall of bound details which suggests that the concept of an episodic buffer is superfluous. However, they argue that the process of binding is not necessarily the same for all details and propose that bindings such as visual features of an object are automatic and therefore require no attention while other bindings are active and do require attention. This may possibly be reflected in findings from Experiment 8 where for example, distraction reduced recall accuracy for details of background pictures bound to spoken-nouns but not for details of background pictures bound to picture-nouns. However, it is not possible to conclude this based on the estimated overall effect sizes of bimodal and unimodal presentations because the type of bound detail was not controlled across all conditions.

The second analysis which appears to be a better fit model to the data does support Baddeley's (2001) theory because the estimated detrimental distraction effect size for bimodal presentations is clearly stronger than that for unimodal. In addition, CIs for bimodal and unimodal details have less overlap and the upper limit for unimodal details straddles zero, suggesting a selective distraction effect on recall of bimodal details.

In summary, there is an argument for bimodal-unimodal recall presentation moderating the effect of distraction but this hinges on how recall is defined in Experiment 7. Both Experiment 4 and eyewitness methods included a bimodal recall condition. Similar to Experiment 7, these experiments found robust effects on memory of distraction. In contrast, word-list studies presented a unimodal recall condition and found little evidence of an effect of distraction on recall. In addition, the meta-analysis model created when Experiment 7 recall modality is coded as bimodal better fits the data than when the presentation modality is coded as unimodal. Thus while further investigation is needed to substantiate the claim, the argument for bimodal recall as a moderator of distraction is a compelling one.

5.3.2.4 Flowing versus static information

Figure 30 overleaf, shows the meta-analysis with flowing-static presentation as a moderating factor. Red denotes distraction effects on recall accuracy of flowing presentations and blue, on static presentations.

This analysis appears to indicate that flowing-static presentation is a moderator of distraction, for two reasons: there is no overlap of CIs (flowing CI ranges -0.74 to -0.36; static CI ranges -0.33 to 0) and the DRs for both flowing and static group's equal 1.0 suggesting relatively less heterogeneity than the previous potential moderators.

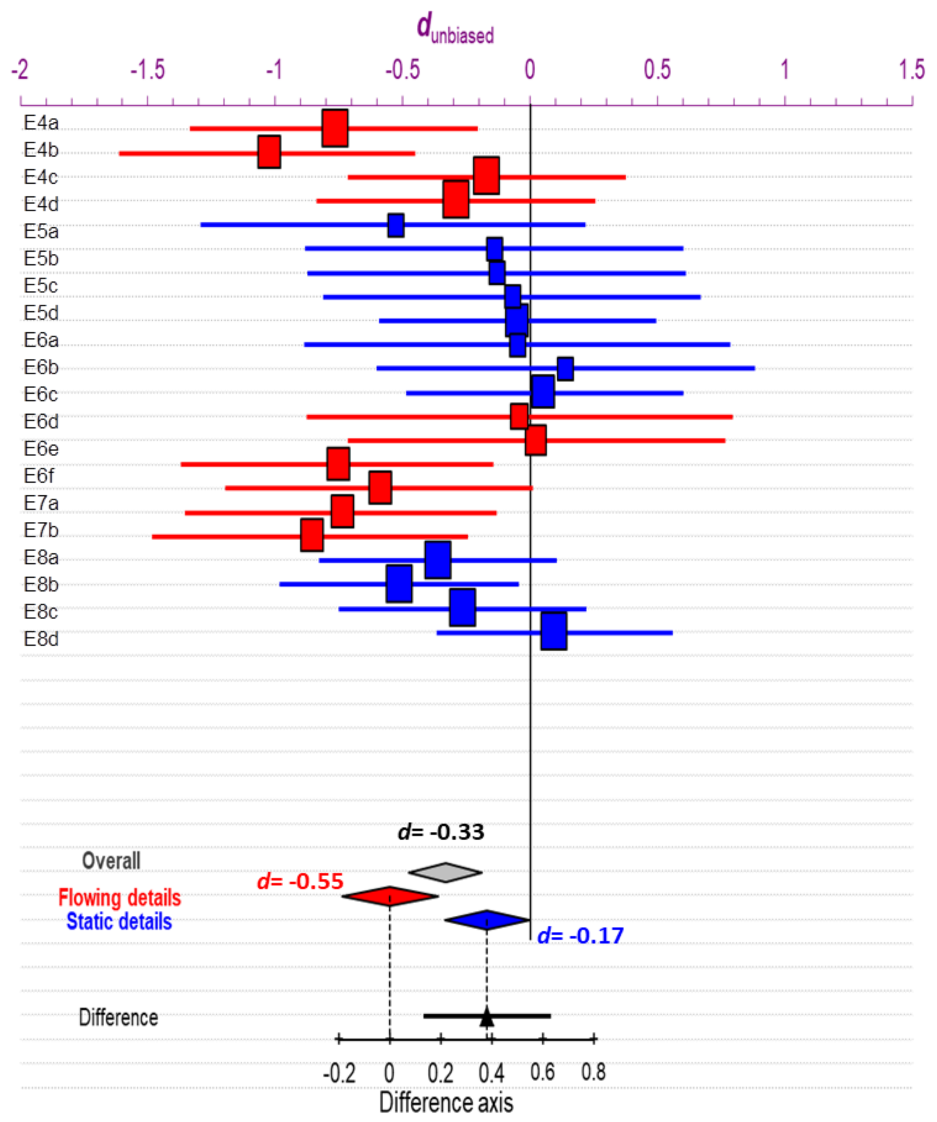

Figure 30: Meta-analysis of distraction effect sizes on recall accuracy with flowing-static presentation as a moderator of distraction

This analysis suggests that memory for flowing details is impaired by distraction but memory for static details is less affected. Several intertwined theoretical explanations for why distraction may disrupt memory for flowing but not static details were discussed in more detail in Chapter 3 but will be briefly summarised here. Although topic titles are used below, there is some overlap between topics.

5.3.2.4.1 Segmentation

The involvement of movement in retrieval processes

Zacks et al. (2011) argue that observers encode details of a flowing event through automatically parsing the event into segments. Segmentation is useful to an observer because it groups information together and thus aids memory. The process of event segmentation, in part, relies on movement. An observer uses movement within the event to create a series of boundaries. The boundaries parse the event in to a series of segments. This theoretical stance on the involvement of movement in segmentation, implies that static details are not automatically segmented in this way. This is because by definition, there is no movement in a static detail so an observer cannot use movement to segment static information. Therefore, one explanation of the apparent selective distraction effect on retrieval of flowing but not static details, may be the involvement of movement in retrieval processes. This explanation assumes that in general, movement is involved in segmenting a flowing event into segments. In addition, it assumes that if movement is involved in the encoding process, it is also involved in the retrieval process. This implies that visual distraction interferes with retrieval process which involve movement.

Distinctiveness

Another explanation from the field of segmentation theory is that static details are already segmented. That is, static details are not automatically segmented by an observer because the details have already been segmented and thus automatic segmentation would offer no additional benefit to memory. Static details are thus more distinct from one another than flowing details. In addition, the distinct boundaries between static details may provide a more structured framework from which to mentally search for and correctly select target memories thus protecting memory processes from reductions in attention caused by distraction. Both pre-segmentation and distinctiveness have been shown to improve memory (for example Gold et al.,2017).

5.3.2.4.2 Verbal labelling

Another possibility is that retrieval of static details may benefit from verbal labelling which has been shown to improve memory accuracy (Simons, 1996). This line of thought assumes that there is more time to label and sub-vocally rehearse the label when a detail remains static because attention is not being drawn away by ‘movement’ of flowing (visual and verbal) details. This was not tested in the experiments presented here but provides an interesting avenue for future research.

5.3.2.4.3 Visual imagery

In contrast, as discussed in Chapter 1, retrieval of flowing details may rely more on mental imagery to reinstate the memory trace and mental imagery has been shown to be disrupted by distraction.

For example, Baddeley and Andrade (Experiment 6, 2000) presented participants with arrays of 5 shapes and asked them to hold the visual image in mind and rate its vividness under conditions of blank screen or DVN. In comparison to the control condition, DVN led to a reduction in vividness ratings thus implying that visual distraction interferes with visual imagery. Earlier work has also found evidence to suggest that visual distraction interferes with visual imagery processes (Quinn and McConnell, 1996; Smyth and Waller, 1998).

However, it is not known whether auditory distraction would mirror this effect on auditory imagery. While Baddeley and Andrade (2000; Experiments 1 to 5) found that articulatory suppression led to a reduction in vividness of auditory imagery, this was a dual-task paradigm and is therefore not the auditory equivalent of visual distraction.

Matthews et al. (2010) argue that moving images are encoded as spatiotemporal object files. Therefore, retrieving details of moving images may also involve spatio processes. That is, visual imagery involved in retrieving visual details encoded from moving images may involve visual-spatial imagery. Therefore, one possibility is that DVN may interfere with visual-spatial processing during retrieval because DVN itself consists of (apparent) visual movement. In other words, DVN may deplete visual-spatial processing resources needed to retrieve details embedded in moving scenes.

In summary, there is evidence in these data that movement is a moderator of distraction. Furthermore, several theoretical stances offer possible explanations as to why distraction appears to have a greater detrimental impact on recall of details embedded in flowing rather than static presentations.

5.4 Summary of meta-analysis finding

The overall estimate of distraction effect-size across Experiments 4 to 8 showed recall accuracy to be poorer under distraction conditions. This not only supports findings in the eyewitness literature (for example Perfect et al., 2012; Vredeveldt et al., 2011) but also demonstrates that distraction disrupts the quality of what is recalled.

More specifically, distraction has the greatest detrimental impact on recall of flowing visual details. Thus modality of detail and movement appear to moderate the effect of distraction. There is also evidence to suggest that bimodal recall moderates the effect. In addition, there is also evidence that visual distraction has both a general and a modality specific effect on memory. This pattern of effect may be an indication that distraction interferes with retrieval processes which involve mental imagery, modality-specific memory resources and attentional processes which help maintain the bindings between details of event.

Thus, one explanation for the mechanism of distraction comes from the convergence of two theoretical accounts: Vredeveldt's (2011) Cognitive Resource Framework and Zacks et al.'s (2011) event segmentation theory. These theories suggest that distraction has a modality-specific effect (Vredeveldt, 2011) and depletes specific visual resources through interference-by-process. Thus, a visual-spatial distractor like DVN will impair performance on retrieval of visual details and will also impair performance on retrieval tasks which engage visual-spatial processes.

5.5 Methodological limitations and implications

Methodological limitations have been discussed in the body of the thesis, such as issues with matching the type of target visual details recalled to the type of verbal details recalled. There are however other issues to acknowledge and these are discussed below.

Although power calculations were carried out for each experiment, these were based on detecting a moderate to strong main effect of distraction on recall and did not take in to account secondary explorations of data. Experiment 6, for example, tested 52 participants in each distraction condition but, this reduced to 17 participants per experimental group when other between manipulations were examined. Lack of power may have led to a failure to detect distraction effects across all the manipulations tested. However, the power issue was addressed through a meta-analysis of effect sizes of distraction on recall accuracy. Using effect-sizes rather than dichotomous null effect statistical testing enables a more nuanced exploration of distraction effects across data.

Another limitation of work presented here is that of a potential stimulus sampling issue. For example, one method for exploring possible modality specific effects of distraction involves testing the effect of distraction on recall of details presented in two different modalities: visual versus verbal. One problem with this method is that details presented as visual are not the same as details presented as verbal. While Experiment 8 attempted to address this issue, this was only addressed for static details and not for flowing. One difficulty of counterbalancing flowing details in visual and verbal modalities is that the information conveyed in each modality cannot always be easily transferred from one modality to another. For example, details included in a busy shopping street filmed as a visual track for a video clip, cannot easily be presented in a verbal track. The length of time taken to describe all the visual details in the visual track alone, would cause an issue with material length presented to participants. For example, it is feasible that a 3-minute visual track would result in a half-hour verbal track.

Unfortunately, due to the time limited nature of a thesis scheme of work, there was not time to carry out a full cross over design testing the effect of auditory and visual distraction on recall of verbal and visual details. Therefore, drawing conclusions about the modality-specific nature of visual distraction is limited because, there is no comparison to the effect on recall of auditory distraction. For example, the research herein cannot indicate whether the apparent distraction effect on recall of visual details is because the distractor used here was a visual distractor or, because the distractor was simply distracting to recall of visual details, regardless of the distractor's modality.

The experiments here tested the effect of a semantically neutral visual distractor on memory but they did not test the effect of a semantically relevant or auditory distractor on memory. The purpose of the thesis was to further understanding specifically of visual distraction and not distraction per se. However, this specificity may limit the generalisability of the effect of distraction to natural day to day occurrences. For example, it is unlikely that daily experiences of distraction will consist of only semantically neutral visual distractions. It is more likely that daily distraction presents as a mix of the two modalities as well as being at times, semantically- relevant to the observer.

In common with laboratory research in general, the lack of ecological validity of work presented may also be problematic. Participants in these studies were asked to study and recall information of the type, and in a way, which would rarely, if at all, occur in everyday life. It is not unusual to be asked to recount a video clip, for example, if relaying the gist of a missed TV programme to a friend however, it is highly unusual to be asked specific questions about specific details of the number or colour of objects within those clips. In addition, it is unlikely participants in everyday life would be asked to study multiple lists of words so that they can later recall as many as possible. It is also unusual to be asked to complete a set of sums prior to recalling a list of words. Thus, experimental memory tests are staged and generally, are anticipated by participants. Experimental work is accountable, as it should be, to ethical committees. While presenting participants with an unexpected memory test may be more in line with day-to-day life occurrences, it is rarely justifiable to mislead participants as to the nature of an experiment. However, despite ecological validity issues, it remains that participants rely on the same types of cognitive processes in the laboratory as they do in the everyday world.

Overall, despite the limitations discussed above and despite testing memory in staged laboratory conditions, the patterns of effects seen across data collected from a variety of participants with a variety of characteristics, may still provide some insights in to the mechanisms of distraction. It must be stressed however, these insights need to be interpreted and applied with the above limitations in mind.

5.6 Practical application of research

Aside the earlier discussed theoretical application of this research relating to the mechanism of distraction, the research also has practical applications.

In accordance with eyewitness research, the research findings here generally agree that the quality of eyewitness accounts may be disrupted by the physical environment in which the details of the account are reported. So far in the eyewitness literature (see Chapter 3), we know that environmental distraction disrupts recall. There is evidence that this may be a modality-specific effect but there is also evidence that this may be a general effect. The findings here however, add more detail to this general conclusion. Firstly, the meta-analysis suggests that memory for visual details is more disrupted by visual distraction than memory for verbal details. Secondly, memory for flowing details is more likely to be disrupted than memory for static details. Thirdly, memory for bimodal details is more likely to be disrupted by visual distraction. Practically, these findings apply to the type of detail witnesses are asked to recall, as well as the type of environment witnesses are asked to recall them in. We already know that it is better for recall accuracy to interview witnesses in quiet environments but, this is not always practicable. For example, it may be necessary for police to conduct door-to-door questioning. In this case, the accuracy of eyewitness accounts may depend on the type of detail they are asked to recall. For example, an eyewitnesses responding on their door step to door-to-door questioning in a busy neighbourhood, may be more accurate in recalling the details of a since discarded ‘hate crime’ leaflet than the details of a ‘hate crime’ at the local shop. In this example, this is because details in the leaflet are static and unimodal but details of the altercation are flowing and bimodal. Thus, it is of use for interviewers of witnesses to be cognisant that distractions during interview may have a detrimental effect on recall of particular details, but not others.

Other applications of this research can be found in the field of education and medicine. Educationalists and students will find it helpful to know that recall accuracy can be enhanced by recalling information in quiet environments. This was demonstrated by Glenberg et al. (1998), for example, who found reducing visual distraction improved the accuracy with which students were able to recall general knowledge details. In addition, students keen to protect memory of specific details from external interference may wish to encode information in verbal lists rather than in the form of flowing details. Clinicians tasked with taking medial or psychological histories will also find it useful to know how particular memories may be vulnerable to inaccuracies under certain environmental conditions.

5.7 Future research

The research findings here raise questions which point to several future avenues of exploration, these are briefly discussed below.

5.7.1 Bimodal presentation and bimodal recall

As discussed earlier in this chapter, there may be differential effects of distraction based on whether recall was bimodal or unimodal rather than whether presentation was bimodal or unimodal. This was not fully tested here and further experimental investigation which manipulates bimodal and unimodal formats at both presentation and recall would help to clarify the issue.

5.7.2 Eye-tracking

One argument put forward in this chapter about the mechanism of the distraction effect is based on interference-by-process and the proposal that distraction interferes with eye-movement needed for retrieval of moving details. What is not known however, is how visual distraction disrupted eye-movement. There are three possibilities. One is that participants fixed their eye-movement on a small part of the screen. The second is that participants followed the seemingly moving distractor across the screen and the third, is a mixture of the two. What is not known is whether they are equally likely to lead to reduced recall accuracy or whether following the distractor in its movement is more closely associated with detrimental effects on recall. This is of interest because research investigating the effect of eye-movement desensitisation and reprocessing (EMDR) has found that such techniques alleviate symptoms of posttraumatic stress disorder (PTSD) developed through the experience of natural disasters, car accidents and war, (for example, Perez-Dandieu et al., 2015; Acarturk et al., 2016). EDMR is typically carried out by a trained psychotherapist. During therapy, a PTSD sufferer is asked to retrieve emotionally disturbing memories while a therapist directs their lateral eye-movement. Shapiro (2001) proposed that the beneficial effect of this technique is a result of increased associations being developed between traumatic memories and more adaptive memories. However, it is possible that the effect occurs more along the lines of the way in which visual distraction appears to disrupt memory. That is, the lateral eye-movements during retrieval of traumatic memories may serve to weaken the traumatic memory trace.

Overall however, an eye-tracking distraction study would shed light on how eye-movement is disrupted during periods of distraction and lend support, or not, to an interference-by-process account of visual distraction.

5.7.3 Mental imagery and retrieving visual-spatial sequences

Although Experiment 7 found no evidence to suggest that visual distraction interferes with a recall task involving retrieval of sequences, the sequences presented may have involved more of a temporal than spatial element. Should visual distraction have an interference-by-process mechanism, memory for visual-spatial sequences should be disrupted. One avenue for further investigation is thus based on improving on the method, by presenting participants with visual-spatial sequences to study and later recall which are less temporal and more sequential. One example of this is to ask participants to walk (physically or simulated) through a previously unknown shopping precinct and study the order of the shops they pass by. The recall phase would involve recalling the shops in order and would therefore rely on reinstating the shopping precinct in the mind’s eye using visual-spatial imagery processes to move from the start to finish. This would extend laboratory work carried out by Baddeley and Andrade (2000) which examined the effect of visual distraction on reported vividness of visual imagery. Baddeley and Andrade asked participants to imagine a range of stimuli. This included imaging previously presented shapes or, conjuring up images of static or active (moving) visual scenes. Active scenes were defined as either ordinary, such as a cat climbing a tree, or bizarre, such as two fish playing Scrabble. Although Baddeley and Andrade encouraged participants to imagine active scenes as if watching a film, it is not possible to know the extent to which participants imagined a visual-spatial sequence. The future work proposed here however, would present all participants with the same visual-spatial stimuli rather than ask participants to use their personal experience to imagine visual-spatial stimuli. It is feasible that encouraging participants to serially recall a sequence of stimuli, such as the sequence of shops in a shopping precinct, maximises the need to use visual-spatial processes.

5.7.4 Full cross-over design

Building on work by, for example, Vredeveldt et al. (2012) and Perfect et al. (2011), it would be useful to extend the experiments here through asking participants to recall the same details under auditory distraction conditions. This would enable an exploration of whether auditory distraction effects also appear to be moderated by modality of detail, bimodal-unimodal presentations and flowing-static details. In addition, a full cross over design also lends itself to exploring both visual and auditory distraction effects on the shopping precinct example above. In this case, a verbal track would also be presented with the visual-spatial track.

5.8 Conclusion

Overall, taking in to account all the data presented here there is no doubt that visual distraction can disrupt retrieval processes however, distraction does not appear to disrupt recall per se. That is, contrary to Glenberg's (1997) widely cited theoretical account of distraction, this thesis found little to no evidence to suggest that the distraction effect is driven by task difficulty. The central question was thus, under what condition *does* visual distraction disrupt memory? The meta-analyses on experimental data presented herein revealed a fairly clear pattern of distraction effects on recall of flowing visual details but it seems that the effect may also be dependent on situations where retrieval involves recalling details from more than one modality. That is, distraction appears to disrupt recall of flowing visual details when the details are retrieved at the same time as flowing verbal details. This is akin to recounting or reporting an experience where sights and sounds are both recounted together rather than listed separately. Thus rather than being driven by task difficulty, the visual distraction effect appears instead to be driven by features of the details being retrieved. In particular, the findings here suggest that recall of visual details which were presented in a naturally flowing format, such as an everyday event, are more vulnerable to distraction than recalling details from a static laboratory list.

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Appendix

I. Rae (2011): Master's degree experiment, example of imagery and semantic association word-pairs

Table 34: Appendix, Rae (2011) example of imagery and semantic association word-pairs

Cue word	Target word	EAT semantic association	Clark and Paivio imagery rating
TEACHER	MASTER	High	High
HONOUR	OBEY	High	Low
BASIN	CHRISTMAS	Low	High
DECEIT	EXACT	Low	Low

II. Experiment 1: master word list

The list below shows the section of the Toronto word pool from which each of Experiment 1's 15 x 15-word word lists were randomly created, per participant.

Table 35: Appendix, Experiment 1 word pool

ABLE	CARRIAGE	DREADFUL	HEALTHY	METHOD	PRETTY	TEMPLE
ABSENT	CHAPTER	DRIVEN	HELPLESS	MIDDLE	PROBLEM	THEORY
ACCOUNT	CHEERFUL	EAGER	HERSELF	MINGLE	PRODUCT	TIGER
ADMIRE	CHIMNEY	EARLY	HIGHWAY	MINUTE	PROSPECT	TRULY
ADMIT	CHOSEN	EFFECT	HITHER	MIXTURE	QUARTER	TWILIGHT
ADOPT	CIRCUIT	ENDLESS	HOSTILE	MODEL	RABBIT	UGLY
ADVISE	CITY	ENGAGE	HOTEL	MOISTURE	REASON	UNCLE
AFFAIR	CIVIL	ENJOY	HUMAN	MONSTER	RELEASE	UNDER
ALONE	CLEARLY	ENVY	IMAGE	MOUNTAIN	RELIEF	VALLEY
AMAZE	CLEVER	EQUIP	IMPORT	NARROW	RENEW	VESSEL
AMONG	CLOSELY	ESTATE	IMPULSE	NAVY	RETREAT	VILLAGE
ANGLE	CLOTHING	EVER	INCOME	NEITHER	REVENGE	VITAL
ANGRY	COLLAR	EXCITE	INSPIRE	NEPHEW	REVIEW	WEAPON
APART	COLONEL	EXIST	INSTRUCT	NERVOUS	RIFLE	WEARY
APPLY	COMBINE	EXTENT	INSULT	NUMBER	SADDLE	WEDDING
APPROVE	COMMENCE	FABRIC	INTEREST	OCCUR	SCATTER	WELCOME
ARMOR	COMMERCE	FAILURE	INVEST	OFTEN	SENTENCE	WIDOW
ARTIST	CONNECT	FAMOUS	JEWEL	ORANGE	SERVICE	WILLOW
AVOID	CONSIST	FANCY	JUDGMENT	OWNER	SHAKEN	WITHIN
AWAIT	CONTRACT	FATAL	JUSTICE	OYSTER	SHEPHERD	WITHOUT
AWAY	CONTRAST	FIERCELY	KITCHEN	PACKAGE	SILENCE	WITNESS
AWFUL	COUPLE	FIRMLY	LADY	PAPER	SILVER	WORKER
AWHILE	COURAGE	FLOURISH	LAZY	PARLOR	SINCERE	WORTHY
BEDROOM	COVER	FOLLY	LEGAL	PATIENCE	SLUMBER	YELLOW
BEING	CREDIT	FOOLISH	LIGHTLY	PENNY	STANZA	YONDER
BELONG	CUSTOM	FREQUENT	LISTEN	PERHAPS	STORY	YOURSELF
BENEATH	DECIDE	FRIENDLY	LITTLE	PERMIT	STRONGLY	YOUTHFUL
BITTER	DESPISE	FRONTIER	MACHINE	PICTURE	STUDENT	
BLOSSOM	DESTROY	FURTHER	MATTER	PLANET	SUMMON	
BULLET	DISEASE	GRAVELY	MEADOW	POINTED	SURFACE	
BUSY	DISGRACE	HAMMER	MEANING	PONY	SWIFTLY	
BUTCHER	DISPUTE	HARDLY	MERIT	PORTION	SYSTEM	
CARPET	DOORWAY	HASTEN	METAL	PRACTICE	TAKEN	

III. Experiment 2: example of master semantic-category word-lists, from which exemplars are taken randomly

Table 36: Appendix, Experiment 2, example of semantic category word lists

Category 1	Category 2	Category 3	Category 4	Category 5
MAGAZINE	RABBIT	LEATHER	MINNOW	PURPLE
NEWSPAPER	BEAR	WOOL	TROUT	GREEN
LETTER	PIG	SPANDEX	GOLDFISH	PINK
STORY	ELEPHANT	COTTON	CATFISH	MAROON
BOOK	HORSE	SATIN	TUNA	BLUE
JOURNAL	TIGER	POLYESTER	SHARK	MAGENTA
ARTICLE	CAT	SILK	SWORDFISH	BLACK
WEBSITE	GOAT	SUEDE	SALMON	BROWN
PAPER	GIRAFFE	LYCRA	CARP	RED
PERIODICAL	DEER	VELVET	COD	WHITE
ESSAY	LION	CASHMERE	ANGELFISH	INDIGO
FLYER	SQUIRREL	LINEN	DOLPHIN	GREY
NOVEL	MOUSE	DENIM	BLOWFISH	YELLOW
PAMPHLET	RAT	RAYON	HALIBUT	ORANGE
ENCYCLOPEDIA	DOG	NYLON	HERRING	TURQUOISE
COMIC	COW	FLEECE	PIKE	GOLD

IV. Experiment 3: example of a set of four High- and four Low-structured lists

Table 37: Appendix, Experiment 3 example of high and low structured word-lists

High 1	High 2	High 3	High 4
MAGAZINE	BOOK	PAPER	NOVEL
NEWSPAPER	JOURNAL	PERIODICAL	PAMPHLET
LETTER	ARTICLE	ESSAY	ENCYCLOPEDIA
STORY	WEBSITE	FLYER	COMIC
RABBIT	HORSE	GIRAFFE	MOUSE
BEAR	TIGER	DEER	RAT
PIG	CAT	LION	DOG
ELEPHANT	GOAT	SQUIRREL	COW
LEATHER	SATIN	LYCRA	DENIM
WOOL	POLYESTER	VELVET	RAYON
SPANDEX	SILK	CASHMERE	NYLON
COTTON	SUEDE	LINEN	FLEECE
MINNOW	TUNA	CARP	BLOWFISH
TROUT	SHARK	COD	HALIBUT
GOLDFISH	SWORDFISH	ANGELFISH	HERRING
CATFISH	SALMON	DOLPHIN	PIKE

Low 1	Low 2	Low 3	Low 4
MAGAZINE	NEWSPAPER	LETTER	STORY
RABBIT	BEAR	PIG	ELEPHANT
LEATHER	WOOL	SPANDEX	COTTON
MINNOW	TROUT	GOLDFISH	CATFISH
PURPLE	GREEN	PINK	MAROON
DOCTOR	BANKER	MANAGER	CARPENTER
STOOL	CHAIR	TABLE	SOFA
NOSE	EYES	HAND	HIP
KIWI	APRICOT	APPLE	MELON
FLUTE	CLARINET	TROMBONE	SAXOPHONE
BASKETBALL	BOWLING	TENNIS	LACROSSE
TOMATO	BEANS	LETTUCE	POTATO
CLIFF	HILL	VALLEY	LAKE
RAVEN	ROBIN	DOVE	PARROT
IRON	LITHIUM	OXYGEN	POTASSIUM
WASP	CENTIPEDE	BEE	COCKROACH

V. Experiments 4, 5 and 6: twenty-two questions about the news bulletin video clip

Table 38: Appendix, Experiments 4 to 6, questions about the news bulletin

	Questions about visual details	Questions about verbal details
1	The North Sea helicopter was painted white, red and what other colour	On what day of the week was this news-bulletin broadcast
2	How many people sat round the table with the axed editor-in-chief were wearing glasses?	What is the name of the abandoned platform in the north sea? 0.06 Elgin
3	What colour tie was he *[axed editor]* wearing?	What is the first name of the axed editor-in-chief
4	The burning trawler was painted blue and what other colour?	At what time do Inverness's pubs and clubs close their doors to new customers?
5	What two-digit number formed the name of a restaurant?	How long ago was the curfew introduced?
6	What was the first name of the lady from inverness's licensing forum?	How many years has it been since St Columba arrived on the island of Iona?
7	What was the last name of the lady from inverness's licensing forum?	1What is the name of the Sunday on which the islanders of Iona are planning to start their series of events?
8	How many medieval carved stones did you see lined up on the wall?	Why did they choose this particular Sunday?
9	A female visitor walks away from the camera and up the museum's mock-up shopping street, what colour is the rucksack on her back?	In which city is the Riverside museum?
10	In total, how many wallabies were lying down in the video-clip?	How many Scottish museums were in the shortlist?
11	What colour was the sports presenter's tie?	How did the missing wallabies escape from Linton zoo

VI. Experiment 7: video clip list questions

Table 39: Appendix, Experiment 7, multiple video-clips questions

	Name of clip	Question		Type of detail
		Visual detail	Verbal detail	
1	The Birthday Party	At the birthday party, what colour is Harold the birthday gentleman's tie?	At the birthday party, what colour shirt did Harold change out of before the party? GREEN	COLOUR
2	The Wedding	At the wedding, how many bridesmaids wore purple?	At the wedding, how many waiters served champagne?	COUNT
3	The Woods	In the woods, what did Tom, the older brother, do with his handful of leaves at the end of the clip?	In the woods, what did Tom, the older brother, do at the end of their walk today?	SEQUENCE
4	The Paddling Pool	In the paddling pool, how many yellow toys did Chloe and Charlie play with?	In the paddling pool, how many friends was Chloe playing with when she burst her red dingy?	COLOUR
5	The AA Van	Apart from the AA man, how many people were in the front of the AA van?	How many people had the AA man just dropped off?	COUNT
6	The Cookies	What did Luke do after his mum put the cookies in to the oven?	What did Luke do whilst the caramel cookies were cooling?	SEQUENCE
7	The Tea Dance	What colour were the table-cloths at the over-70's tea-dance?	What colour was the carpet that the over-70's tea-dance club rolled to the side?	COLOUR
8	The Rock Pool	How many children were at the top of the hill ready to go rock pooling?	How many crabs did the rock-pooling children catch?	COUNT
9	The Halloween Parade	What came before the pumpkin lanterns on sticks in the Halloween parade?	What came immediately before the headless horse riders in the Halloween parade?	SEQUENCE
10	The Football Match	One of the football teams was wearing white shirts, what colour were the other team wearing?	Pippenborough's football team home strip shirts are green and what other colour?	COLOUR
11	The Family Christmas	At the Chad family Christmas, what did Ben, the little boy, do with his arms after his mother laughed at her present?	At the Chad family Christmas, what did Ben, the little boy do after his mother had sprayed her new perfume?	SEQUENCE
12	Street Food	How many unstacked, empty green bowls were sat on the counter-top in the street food-stall?	How many stalls further down the street were selling almond cookies?	COUNT
13	The Domino Competition	What colour dominoes fell after the triangular group of pink ones?	What colour is the domino-run competitor, Chloe's, VW van?	COLOUR
14	The Construction Site	At the construction site, how many people were wearing red hard hats?	At the construction site, how many teams worked around the clock?	COUNT
15	The Obstacle course	What was the second obstacle Jake tackled on his obstacle course?	Obstacle course. What was the second job Jake's dad did before building an obstacle?	SEQUENCE
16	The Dinner Party	At the dinner party there was a vase of roses on the table, the	Before the dinner party, Terry took off his jacket, what colour was it?	COLOUR

		roses were yellow and what other colour?		
17	The Conveyor Belt	At the supermarket checkout, which fruit was put on the conveyor belt after the strawberries?	At the supermarket checkout there was an old lady in a purple hat at the back of the queue, what fruit the man in-front of her holding?	SEQUENCE
18	The skateboarding competition	At the skateboarding competition, what colour t-shirt was the fifth skateboarder wearing?	At the skateboarding competition, what colour was baseball cap was the fifth skateboarder given?	COLOUR

VII. Experiment 8: questions about background pictures

Table 40: Appendix, Experiment 8, questions about background pictures

Background picture	**Question 1** **Question about the background picture**	**Question 2** **Which noun was presented with the background picture?**	**Question 3** **Was the noun spoken, typed or a picture?**
1. Car	What colour was the car?	Box	*Each noun appeared in all three formats, counterbalanced across participants and distraction conditions*
2. Beach ball	How many beach balls were there	Bicycle	
3. Meer cats	How many Meer cats were there	Orange	
4. Merry-go-round	What colour is the little car in front of the bus on the merry-go-round?	Pan	
5. Footballers	How many footballers were wearing white shirts?	Lipstick	
6. Book	What colour was the book?	Spade	
7. Window	How many panes of glass did the window have? 8	Chicken	
8. Ship	What colour was the funnel on the ship?	Butterfly	
9. Fountain	How many water jets did the fountain have?	Baby	
10. lollipops	What were the pictures on the lollipops of?	Kite	
11. Tape measure	What colour was the tape measure?	Pyramid	
12. Valley	How many birds were flying in the sky?	Hand	
13. Classroom	What colour were the chairs?	Island	
14. Chair	What colour was the chair?	Glass	
15. Runners	What colour was the front runner wearing?	Purse	
16. Chess piece	How many chess pieces were there?	Kitten	
17. Birthday party	How many pink presents were there?	Cauliflower	
18. Slide	What colour was the slide?	Hammer	
19. Snowball fight	The person at the front of the snowball fight picture was wearing an orange coat, what colour trousers were they wearing?	Frog	
20. Piano	How many legs did the piano have?	Arrow	
21. Solar system	From your viewpoint, what side of the screen was the sun on?	Ear	
22. Tube station	In the tube station was the tube train travelling towards you or away from you?	Bed	
23. Swimmers	How many swimmers were there?	Castle	
24. Umbrella	What colour was the umbrella?	Sharpener	
25. Bus stop	What colour was the bus?	Fork	
26. Restaurant	How many waiters were walking through the restaurant?	Ladybird	
27. Coffee cup	How many cups of coffee were in the coffee bean picture?	Paint	
28. croc shoe	What colour was the shoe?	Plug	
29. Domino game	How many men were playing dominoes?	Teapot	
30. Telephone	From your point of view, where was the wire of the telephone receiver placed?	Penguin	
31. Lamp	What colour was the lampshade?	Scarf	

32. Fried Egg	How many fried eggs were there?	Aeroplane
33. Tree	How many trees were there?	Candle
34. Church	How many flags were flying from the church?	Bridge
35. Coloured crayons	How many coloured crayons were there?	Envelope
36. Cooker	What colour was the cooker?	Shed

VIII. Experiment 8: examples of background pictures

Table 41: Appendix, Experiment 8, examples of background pictures

Background picture name	Picture
8. Ship	
9. Fountain	
10. Lollipops	
11. Tape measure	

IX. Experiment 8: examples of noun pictures

Table 42: Appendix, Experiment 8, examples of concrete noun pictures

Noun name	Picture of noun
CHICKEN	
CAULIFLOWER	
BABY	
KITE