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Causes of Interference:

Working Memory and Distraction

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Working memory accounts for various types of cognitive processing, including object and spatial processing. Distraction has been demonstrated to be domain-specific with the strongest interference coming from a distractor within the same realm of processing. Emotional distractors also typically generate a strong interference effect. Using an n-back working memory task for object and spatial working memory, we tested type of distractor (erotic, negative and neutral) and phase of working memory (maintenance and encode/retrieval). We found that object working memory was the most affected by these distractors. We also found that erotic images produced the strongest interference effect and distraction in the encode/retrieval phases caused decreased performance. This study further confirms the domain-specificity of working memory and makes inferences regarding emotion theory and cognitive interference.

Working Memory: Overview

Working memory, a functional short-term memory system that provides temporary information storage and maintenance, is necessary for many cognitive processes such as reasoning and language comprehension (Baddeley, 1986). Baddeley suggests a model for working memory with three components (1999). The core component, the central executive, coordinates the functioning of two slave systems, the visuospatial sketchpad and the phonological loop. The central executive component serves as an attentional control system and determines what information will be entered into and maintained in the slave systems. It is responsible for the overall functioning of working memory. Baddeley and colleagues have proposed that a fourth component, the episodic buffer, forms links between previously isolated concepts and representations, thus fully integrating the components of working memory (Baddeley, 2000).

Working memory involves a trial by trial updating of information through three phases: encoding, maintenance, and retrieval. During the encode face, one must commit information to the visuospatial sketchpad or phonological loop. The maintenance phase involves a period in which an internal representation of the stimulus must be held on line. Finally, the retrieval phase is the point in which one must recall or recognize the information or stimulus from the encoding phase. Retrieval can be tested through various methods including recognition, when one must only determine whether an external stimulus matches the original stimulus. Another possible retrieval test is free recall in which one must reproduce the stimulus without the aid of cues. Typically, recognition is an easier test of the retrieval phase.

Past research has demonstrated that in working memory experiments, as memory load increases, reaction time also increases (Jha & McCarthy, 2000; Cohen, Perlstein, Braver, Nystrom, Noll, Jonides & Smith, 1997). However, these effects of memory load are greater during the encoding phase than during the retrieval phase. Encoding and maintenance activate the prefrontal cortex, which is responsible for abstract and load dependent higher order processes (Rypma & D'Esposito, 1999). During both the maintenance and encoding phase, the occipital cortex is activated suggesting that the visual image representation resonates even after the image disappears in the concrete visual field (Cairo, Liddle, Woodward & Ngan, 2004).

Working memory can be assessed with a range of methods ranging from dual-task paradigms to reading and counting spans. Participants are often asked to recall or recognize words or digits that were previously presented. Previous research has shown that working memory is strongly associated with many other cognitive processes such as problem solving, language and reading comprehension, as well as general intelligence (Conway, Kane & Engle, 2003). In another measure of working memory called a Sternberg task, participants must find a probe within a memory set of varying set size in an exhaustive scanning process (Sternberg, 1975). All of these measures have been validated in the measurement of working memory.

In an n-back task, participants see a stream of stimuli, and they are to indicate whether the current stimulus is the same as the stimulus seen n previously. The n-back task varies in difficulty the higher n is. For example, a 2-back task, as used in this study, will be easier than remembering a stimulus seen 3 trials previously, and more difficult than remembering the stimulus directly before. Typically, n-back tasks are used with n between 1 and 3, with 2 representing medium difficulty.

The n-back test has been used in many functional neuroimaging studies concerning working memory. As with other working memory paradigms, the dorsal region is activated during this task (Owen, McMillan, Laird & Bullmore, 2005). Experimental studies increasingly rely on the n-back paradigm as a measurement of working memory. An advantage of this paradigm is the independence of the task from mathematical and language skill, promoting increased universality and directness of the task for those who do not excel in math and/or language (Parmenter, Shucard, Benedict & Shucard, 2006). A strong convergence in results between the n-back task in neuroimaging techniques as well as various other validated working memory tasks has been found, thus further validating the n-back test as a dependable measure of working memory (Smith, 2000).

Interference and Emotional Influences

Interference in working memory storage is domain-specific as suggested by various research studies. Greater inference will occur when the processing task and interference stimulus are comprised of the same content. For example, an auditory interference task will have a stronger effect on auditory processing in working memory than will an arithmetic task due to the differing content. Although storage is domain-specific, processing efficiency is domain-general, implying that these are two separate resources in working memory, thus further supporting Baddeley’s model (Bayliss, Jarrold, Gunn & Baddeley, 2003). With unrelated tasks or stimuli, only minimal decreases in performance occur. Distractors within the domain of the given type of working memory produce the strongest interference effect in working memory processing (Logie, Zucco & Baddeley, 1990). In Baddeley’s working memory model, each slave system involves many different types of working memory. For example, the visuo-spatial sketchpad involves both spatial and object processing. Additional research indicates that spatial and object processing differ in cognitive operations, thus further strengthening the argument for selective interference (Tresch, Sinnamon & Seamon, 1993). Consequently, a domain-specific visual distractor will generate the largest interference effect in a visual working memory task.

Emotional stimuli preferentially cause distraction. It is hypothesized that the amygdala is critical in this process of mediating the influence of emotional distractors. The amygdala has been shown to be activated by emotionally valenced stimuli and through this activation, biases attention when stimuli are behaviorally relevant. Amygdala activation has an effect on cognitive processes such as memory and attention (Zald, 2003). In addition, previous work by Smith and Zald has focused on the attentional blink demonstrating that emotionally charged stimuli disrupt attention (Smith, Most, Newsome, & Zald, 2006). Due to these results with attention, emotionally valenced stimuli are also hypothesized to affect the function of working memory. Furthermore, according to the multiple memory systems hypothesis, recent research suggests that amygdala activation due to emotional arousal may contribute to the interactions of the various memory systems (Packard & Cahill, 2001).

Emotional stimuli are remembered better than non-emotional stimuli, and can interfere with memory for the non-emotional stimuli. When an emotional distractor image is shown, the dorsal neural system, used for information processing in a working memory task, interacts with the ventral system, which is used for emotional processing, causing an adverse effect on working memory, thus essentially hindering cognitive processing. This cognitive-affective interaction has damaging effects on working memory performance when emotional stimuli are presented as a distraction (Dolcos & McCarthy, 2006).

The attentional blink, a concept studied by Smith and Zald among others, further strengthens the evidence concerning the relationship between attention and emotionally valenced stimuli. At 200 ms after an emotionally charged stimulus is shown, a failure of the stimulus to reach awareness occurs. This phenomenon occurs with conditioned or unconditioned stimuli. If a neutral image is paired with an aversive noise, conditioning the neutral image, there will be difficulty in finding a target for 200 ms when shown the neutral image (Smith, et al., 2006). Attention difficulties ensued by emotional stimuli generate a temporary processing deficit (Most, Chun, Widders & Zald, 2005). Certain images invoke a high level of anxiety which in turn produces a strong attentional bias in comparison with neutral images (Mogg & Bradley, 1999). When anxiety or another emotion is invoked, attentional biases occur which limit cognitive processes due to a competition of processing between the anxiety-provoking stimulus and the task (Bishop, Duncan, Brett & Lawrence, 2004). Some processing of the image does occur; however, not enough to reach awareness. This has interesting implications when this emotional distractor phenomenon is applied to other cognitive processes. If the images cannot reach awareness, they are not encoded completely or properly.

As demonstrated by sufficient experimental data, emotional stimuli seem to have an effect on attention as well as other cognitive processes. Cognitively, working memory and attention have significant differences. Working memory involves a continuous update of information or stimuli on a moment to moment basis. In attention paradigms used, focus has been on an allocation of attention towards detection of external stimuli, often emotionally valenced.

Studies have shown that as cognitive capacity is reached, the robust effect of the emotional stimuli on processing declines and thus the stimuli have a smaller effect on cognitive processes, particularly attention (Harris & Paschler, 2004). In addition, when healthy participants expect emotional stimuli to appear, they are able to reduce their attentional focus to the emotional distractors. Cognitively, when given cues leading to the lack of necessity of the distractors, participants partially filter out the unnecessary information in order to devote cognitive resources to the experimental task (Most, et al., 2005). On the other hand, research has also demonstrated that with erotic stimuli, the attentional blink remains regardless of the incentive to ignore the distraction (Most, Smith, Cooter, Levy & Zald, 2006). Since these concepts apply to attention, will these results replicate in other cognitive processes, such as memory? Implications from emotion and attention studies, such as the importance of avoiding cognitive overload, should be applied to other cognitive processes.

In past research, emotional stimuli have been limited to either positively or negatively valenced. Most negatively valenced images have been violent or gory images that typically evoke anxiety. Psychological research should continue to advance and explore other types of emotional stimuli. Erotic stimuli, for example, produce significant effects with attention, yet have not been studied in relation to other cognitive processes (Most, et al., 2006). More emotional stimuli, such as the arousing erotic stimuli, are included in this experiment and thus produce an improved and more inclusive model of the relationship between emotionally distracting images and working memory.

In addition, the role of individual differences with regards to emotionally distracting images is essential in this research. The valence should be individually evaluated in order to make proper concluding judgments on emotional distractions in general. For this reason, individual differences were considered in the research analysis of the effects of emotional distractors on working memory.

The differences in phases of working memory should be thoroughly analyzed. Past neurological research has indicated which areas of the brain are affected during the phases of working memory; however, research is needed to incorporate emotional distraction within the specific phases. Emotionally charged images producing amygdala activation during a working memory task would also activate the dorsolateral region. Elaborating on Packard and Cahill's

(2001) research, possible interactions between these systems lead towards possible future research.

Dolcos & McCarthy (2006) studied working memory interference in a specific face working memory context. They presented emotional distractors only during the maintenance phase which led to relatively small interference effects. They demonstrated a significant effect of emotional distractors on a face working memory task; however, they left open questions on the generalizability on different types of working memory tasks. What if distractors are presented at different phases of working memory? What if different types of emotionally valenced distractors impact different types of working memory—do the same effects hold, or even strengthen?

This study seeks the answer to multiple questions to expand on previous research. First, to what extent do aversive and erotic images disrupt working memory? Due to past research on other cognitive processes, we would hypothesize that both aversive and erotic images have a significantly harmful effect on working memory. Second, in a more general sense, do emotional stimuli selectively impact the encoding, maintenance, and retrieval phases of working memory? Next, is there a differential effect on spatial vs. object working memory? With this question, we hypothesize that due to the nature of the distractor, we will have more of an effect with object working memory. Finally, is there an association with personality variables?

Methods

Fifty-nine undergraduate participants, 42 females and 17 males, were recruited from the psychology subject pool at Vanderbilt University. Participants received course credit in introductory psychology for their one-hour of participation in this experiment. All participants completed written informed consent approved by the Vanderbilt Institutional Review Board.

The n-back test as well as the distractor-rating program was run using the E-prime (PST software, Pittsburgh) program on a Dell computer. Participants were left alone in a room with this computer performing the various tasks of the experiment. In addition, the personality survey was taken with a pen and paper and distributed directly after the informed consent document was signed and before the two computer-based tasks.

A twenty question personality survey was administered measuring attentional control. The Attentional Control scale was created by Derryberry to measure what he defines as “a general capacity to control attention in relation to positive as well as negative reactions” (Derryberry & Reed, 2002). It has 20 items with each item scored on a 4-point system. Participants were instructed to respond with their true perception of themselves. Following this, verbal and written detailed directions were given regarding the n-back task to measure working memory. All subjects were warned prior to signing up as well as at the start of the experiment that the distractor images were of erotic or unpleasant content including bloody and gory images. Most of these distractor images were taken from the International Affective Picture System supplemented by additional pictures used in previous experiments to enhance the image collection. During the instructions of the n-back task, participants were told that the images were there solely to serve as a distraction and they had no task-relevance. They were instructed to ignore these images to the best of their ability.

There were two versions of the experiment measuring different types of working memory. One version tested object working memory while another tested spatial working memory which addressed both the central executive and the visuo-spatial sketchpad, two core components of Baddeley’s working memory model. Half of the subjects participated in the object working memory experiment while the other half participated in the spatial working memory version. No subjects participated in both versions. The distractor images were presented in the same order with both versions.

With both versions of the experiment, two experimental designs were used. They were alternated with half of the subjects seeing design “A” first and the other half beginning with design “B” (see Appendix 1). In the version of the experiment testing object memory, both designs involved subjects responding to an odd-shaped object that was displayed on the screen for two seconds. An odd-shaped object cannot be easily recognized or associated with a word. The task was to determine if the odd-shaped object was the same object as was displayed two objects previously. This was a basic 2-back working memory task. In design “A”, targeting distraction in the maintenance phase of working memory, the object was presented for 2 seconds, then a 1.5 second blank white inter-stimulus interval screen followed by the distractor image displayed for 2 seconds then another 1.5 second white ISI screen. This led to a total interstimulus interval of 5 seconds, including the time of the distractor image. The 2 seconds for the odd-shaped object and the five-second ISI was designed as a “trial”. In design “B”, the odd-shaped object was presented at the same time as the distractor image thus targeting the encoding and retrieval phases of working memory. They were presented side by side horizontally; the side in which the odd-shaped object was presented was alternated randomly. Then a 5 second ISI consisting only of a blank white screen was presented. Both designs had a total trial time of 7 seconds. Subjects were required to respond within the two seconds that the odd-shaped object was on the screen. Responses were detected using the “y” for yes or “n” for no keys on the keyboard. One short practice block was given with each design. Participants were not allowed to continue on with the experiment until they successfully completed the practice blocks. In the scored experiment, two blocks of 50 trials with design “A” and two blocks of 50 trials with design “B” were given interchangeably to each subject. The total time spent on this, not including optional breaks in between each block was 23.3 minutes. In addition, in a limited number of subjects, a shorter block of 20 trials was given with no distractor images at all in order to provide a baseline score. This allowed for differentiation between the effect of the distractor images and task difficulty.

The purpose of the two different designs was to differentiate phases of working memory. Design “A” revealed distraction during the maintenance phase of working memory. With design “B”, distraction during the encoding and retrieval phase was determined. In addition, within each block, there were three types of distractor images presented. In groupings of six consecutive images per type, neutral, negative, and erotic images were presented. The images were not duplicated within the experiment. Six consecutive neutral images were followed by six consecutive negative images concluding with six erotic images with this cycle repeating throughout the task.

The spatial working memory version of the experiment also had the same two designs for distinction between the phases of working memory. In this version, instead of the odd-shaped object, there were 8 boxes symmetrically surrounding the center of the screen. In every trial, one of the boxes contained an asterisk. The task objective was to determine whether the asterisk was in the same spatial box as it was in two displays previously. In the design measuring the encoding and retrieval phases of working memory, the distractor image was presented in the center between the boxes. In design “B”, the distractor image was in between the stimulus slide, identical to the object working memory design. The timing for the two versions of the experiment was identical. A two-second stimulus display was followed by a five-second ISI. Again, a limited number of subjects participated in a 20 trial block with no distractor images.

This part of the experiment proved to be extremely important in the implications that can be gained from the study.

Next, a distractor-rating program was administered on the same computer, also using E-prime. Subjects went through all of the distractor images that were presented in the n-back task and were asked to rate their reaction to these images based on two scales. Each image was presented on the screen for one second. They were then instructed to use the mouse to click on each scale where they felt best described their reaction to the image (Appendix 2). Participants were told that reaction time was again not being measured, however, they should respond as quickly and accurately as possibly in order to measure the initial reaction to each image. The first scale measured arousal; all images were presented with this scale first. Arousal refers to the overall feeling of excitement or physiological response that is elicited by the image. Arousal, which can be due to pleasant or unpleasant stimuli, varies on a continuum from neutral to most arousing imaginable. Next, all images were presented with the Empirical Valence Scale (EVS) empirically demonstrated to be a valid and reliable rating scale (Lishner, Cooter, Zald, 2007). This scale ranges from most unpleasant imaginable and most pleasant imaginable with neutral being the midpoint. Measurements were taken based on spatial location clicked with the mouse using E-prime's data collection. Upon completion, all subjects were debriefed on the purpose of the study.

Results

Two measures of performance were recorded, accuracy, defined as percent correct, and reaction time; however, for these analyses, we only examined accuracy in order to allow participants to concentrate on that dimension of performance.

Object Working Memory

During the object working memory task, we found main effects for phase of working memory ($F(1, 28) = 9.370$, $p<.005$) such that participants' accuracy decreased when confronted with distractors in the encode/retrieve phase ($m = .797$, $SEM = .027$) relative to the maintenance phase ($m = .858$, $SEM = .017$). (Figure 1.) In addition, we found a main effect for type of distractor ($F(2, 27) = 8.917$, $p<.001$) such that participants demonstrated poorer performance for erotic distractors relative to neutral distractors ($p < .001$, paired t-test) and negative distractors ($p<.001$, paired t-test). Performance was not significantly different for negative and neutral distractors ($p=.347$, paired t-test). (Erotic: $m = .793$, $SEM = .025$; Neutral: $m = .842$, $SEM = .020$; Negative: $m = .883$, $SEM = .021$) Finally, there was no significant interaction effect between distrator type and phase of working memory for the object working memory trials ($p = .319$).

Spatial Working Memory

During the spatial working memory task, we found no main effect for phase of working memory ($F(1, 29) = 1.783$, $p = .192$). (Figure 1.) We also found no main effect for type of distractor ($F(2, 28) = 2.167$, $p = .133$). Performance did not differ between erotic and neutral images ($p = .196$, paired t-test), erotic and negative images ($p = .076$, paired t-test), nor neutral and negative images ($p = .256$, paired t-test). (Erotic: $m = .910$, $SEM = .017$; Neutral: $m = .920$, $SEM = .016$; Negative: $m = .930$, $SEM = .017$). Similar to object working memory, we found no interaction effect between distractor type and phase of working memory in spatial working memory trials ($p = .538$).

Working Memory Type: Interactions with Time of Distractor and Type of Distractor

Next, in order to look at significant differences and interactions, we performed this additional analysis. We found a significant main effect for type of working memory (F (1, 57) = 15.143, p < .001) such that participants demonstrated greater accuracy for the spatial working memory task (m = .920, SEM = .017) compared to the object working memory task (m = .823, SEM = .018) as compared to spatial working memory.

In aggregating spatial and object working memory, we found a significant main effect of phase of working memory (F (1, 57) = 11.127, p < .01) such that participants performed better during the maintenance phase (m = .887, SEM = .011) than the encoding and retrieval phases (m = .855, SEM = .015). We found a significant main effect of type of distractor (F (2, 56) = 11.188, p < .001) as participants demonstrated lower accuracy for the erotic distractors as compared to the the neutral and negative distractors. (Erotic: m = .851, SEM = .015; Neutral: m = .882, SEM = .012; Negative: m = .881, SEM = .012). The interaction between type of distractor and type of working memory was significant (F (2, 56) = 3.994, p < .05). The interaction between phase of working memory and type of working memory was marginally significant (F (1, 57) = 3.77, p = .057). There was also a marginally significant interaction effect between phase of working memory and type of distractor (F (2, 56) = 2.984, p = .059).

Individual Differences

With the results of the distractor rating program, we found no significant effect on valence with performance on the working memory task (p > .1, correlation). We also found no main effect of arousal with performance on the working memory task (p > .1, correlation). Interestingly, there was no effect of gender on any specific type of distractor (p > .1, ANOVA).

Finally, we found an interaction effect between phase of working memory and the attentional control personality measure (F (30, 28) = 2.405, p = .011). In a correlation analysis, we found a significant correlation with attentional control and neutral images in the maintenance phase ($p < .05$) and marginally significant correlation between attentional control and erotic images in the maintenance phase ($p = .053$). All other data yielded null results ($p > .1$). This finding is interesting in that it suggests that lowered attentional control may not impact the ability to encode or retrieve information as much as the ability to hold a representation on-line. The internal representation may be degraded or dropped when the person is presented with a new stimulus. Interestingly, this does not appear to be due to any selective distratction resulting from emotionally valenced stimuli, since the association was actually strongest for neutral stimuli.

Discussion

The present study demonstrated a significant effect of distractor type and working memory phase on performance on an n-back task. All effects were stronger in object working memory as compared to spatial working memory. A stronger effect of type of distractor and working memory phase in object working memory in comparison with spatial working memory can be attributed to the type of distractor used in this experiment. All distractors were pictures of people or objects presented in one specific location. As such, they conveyed object information, but no unique spatial information. They would thus be predicted to interfere more with an object task than with a spatial task. Tresch, Sinnamon, Seaman (1993) have showed that object and spatial memory respond to different distracters, as has been demonstrated here. This study has elaborated on this functional dissociation between object and spatial memory processing to include other interactions between phase of working memory and type of distractor. These effects with phase and type of distractor were not as strong with spatial working memory task due to the domain specificity of working memory. This suggests that spatial working memory is resistant to the types of visual emotional distractors that are used in psychological research when no spatial information is being conveyed by the distractor.

These results demonstrate the effect of working memory phase as well as type of distractor on working memory interference. Erotic images have a stronger interference effect than negative and neutral images. The erotic distractor results are consistent with previous findings with attention; however, the null effect of negative images is in contrast with the effect seen in interference of attention. Theories of emotion often emphasize threat and negativity, characterized by the aversive images in this study. Contrary to an emphasis on threat, stimuli that most participants value as positive, such as erotica, are more potent than truly aversive distractors in disrupting object working memory..

The timing of distraction is a significant factor in interference. During the encoding and retrieval phases, participants' performed worse due to the strong influence of distractors. There are many possible explanations as to why this is the case. Possibly because the encode and retrieval phases were not isolated, distractors were present during both the encode and retrieval phases, in contrast to one distractor in the maintenance phase. Also, participants were forced to pay closer attention during the encode and retrieve phases because this is where the memory cue was presented. Considering all the participants were told that the distractor images had no task relevance, it is possible that participants did not pay as much attention to the distractor during the maintenance phase.

It has been known that attention and working memory involve different cognitive processes; however, they also have many similarities. Sources of interference to attention also cause reductions in the performance of working memory, as is evident in the significant effect of erotic images. The temporal aspect of paradigms evaluating attention and working memory offers possible explanations for the differences in results. Attentional blink paradigms present stimuli in rapid succession such that a stimulus can capture attention and block perception of subsequent stimuli. In the current working memory paradigm, stimuli are presented for substantially longer, so there is no risk that they will fail to detect the stimulus. The attentional control survey showed that performance during the maintenance phase was most strongly correlated with attentional control survey results. The internal representations of the stimuli are likely less stable during the maintenance phase, allowing these representations to be more easily disrupted. In addition, the null results with type of distractor and attentional control survey results showed that attention and working memory involve different cognitive processes with respect to interference.

This research is limited in the lack of differentiation between the encoding and retrieval phases. However, despite this limitation, in a pilot study for this experiment, 8 participants participated in a differentiated phase n-back task. There was a significant trend for accuracy to be higher in the maintenance phase as compared to the average of the retrieval and encoding phase separately ($t = -1.978$, $p = .089$). There was also no significant difference with distractors in two phases, such as both encode and maintenance, as compared to only one phase ($t = -.1$, $p = .923$). This lead to our study of the encoding and retrieve phase differentiated from the maintenance phase. Considering the limited number of participants in the pilot experiment, this could still be a limitation in this study.

The between subjects experimental design of object and spatial working memory imposes another limitation on the conclusions from this study. A design in which all participants complete the object working memory task as well as the spatial working memory task will allow for stronger inferences to be made.

Future research on this topic should include a similar analysis for spatial working memory to test for consistency across types of working memory. Presenting emotional stimuli at different spatial locations could allow one to observe an emotional distraction in spatial working memory. This area is worth pursuing in the future to allow for a more complete understanding of working memory interference. In addition, differentiating the encoding and retrieval phases in working memory could provide further detail on the interactions between distractors and working memory performance. This study used recognition as the test for working memory retrieval, it is possible that free recall could produce even stronger interference effects. This is another area of research that could expand upon the results found in this study.

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Figure 1. Overall performance separated by working memory type: E-R = Encode and Retrieval phases; Maint = Maintenance phase. X-axis: mean percent correct; Y-axis: Type of distractor/Working memory phase.

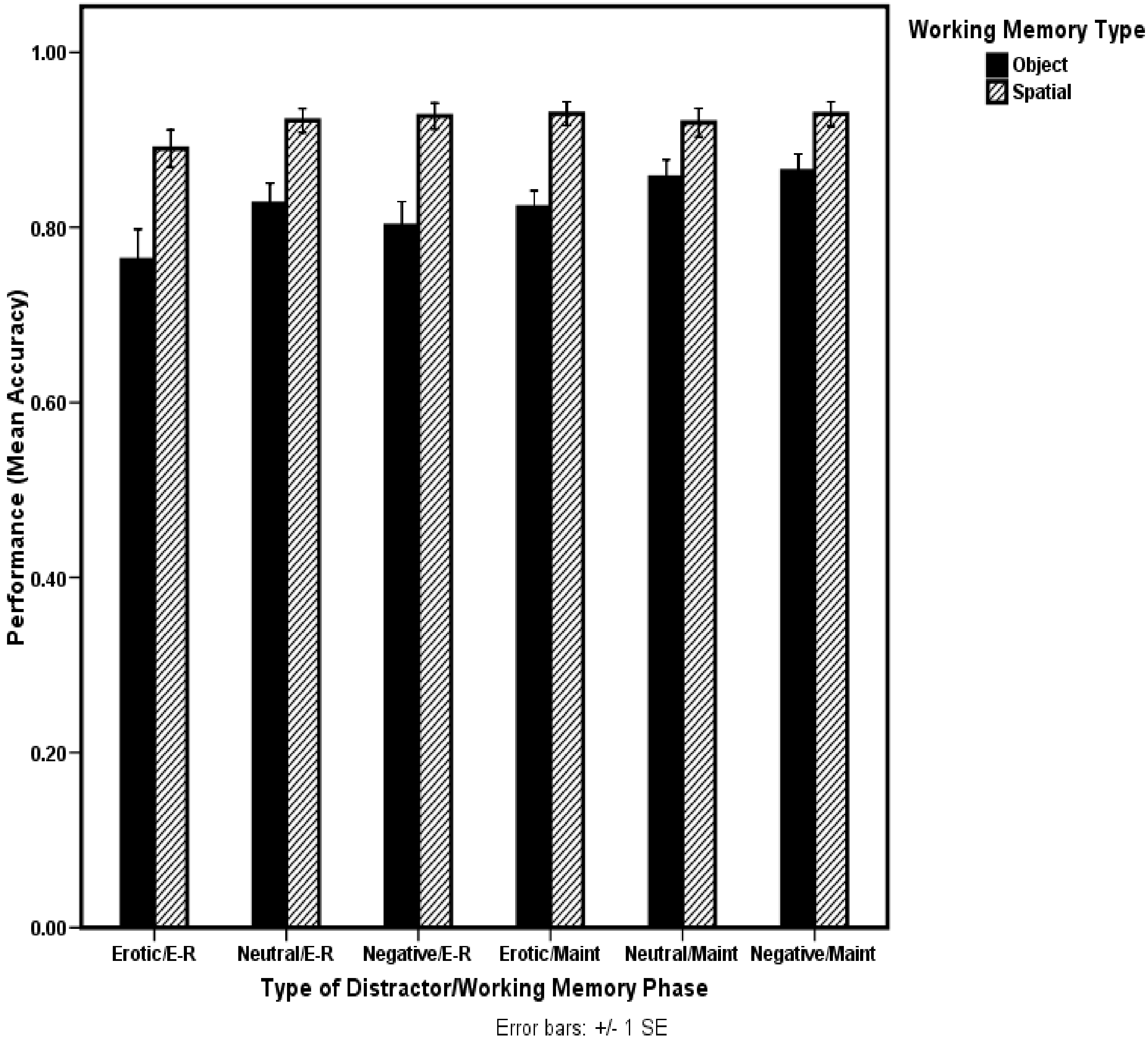
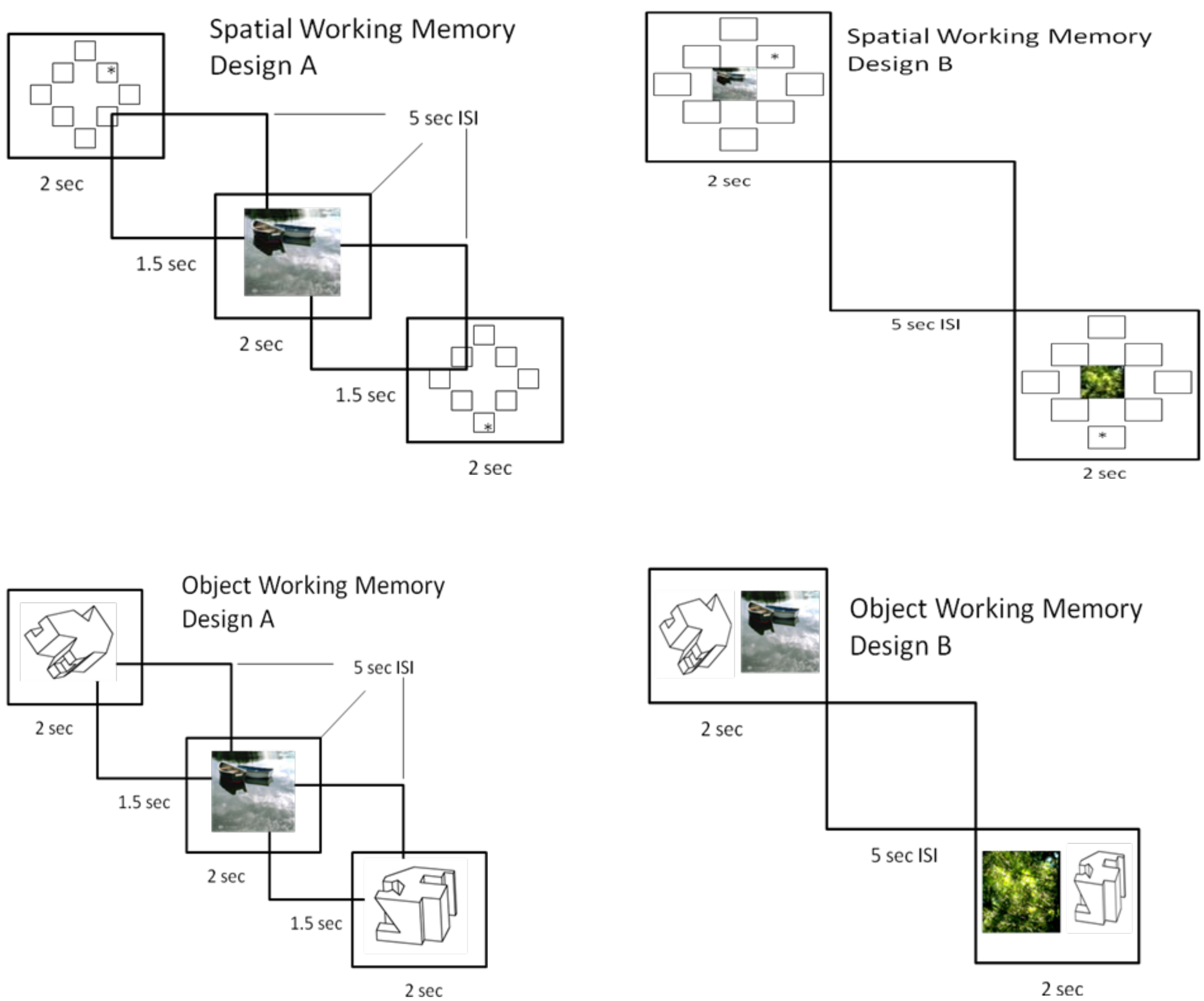
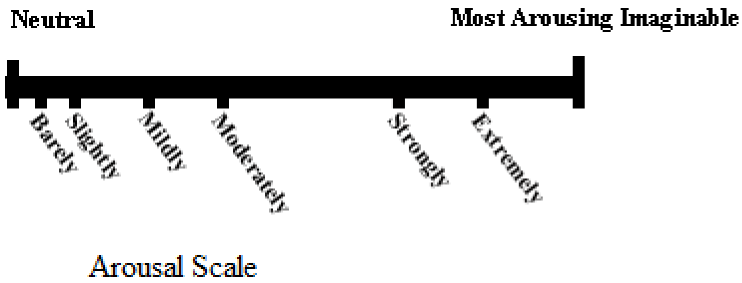
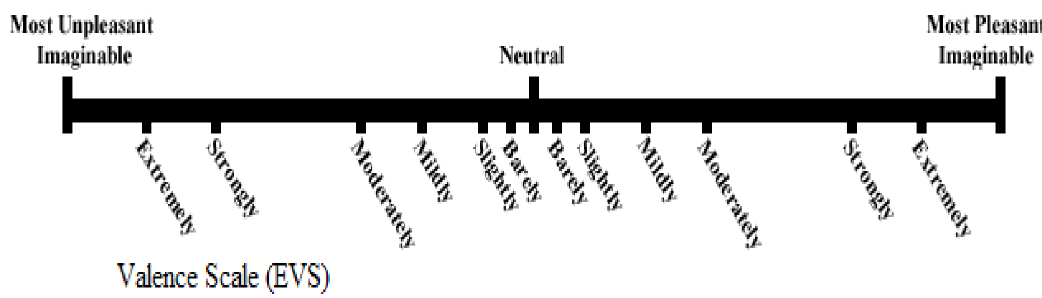

Working Memory Type
Object
Spatial
Performance (Mean Accuracy)
1.00
0.80
0.60
0.40
0.20
0.00
Erotic/E-R
Neutral/E-R
Negative/E-R
Erotic/Maint
Neutral/Maint
Negative/Maint
Type of Distractor/Working Memory Phase
Error bars: +/- 1 SE

Figure 1.



Appendix 1. Study designs.





Appendix 2: Arousal and valence scales used in the distractor rating program.

Directions: Please read each item carefully and rate each statement to best describe yourself. There are no right or wrong answers so please be honest and open in your responses. The rating scale is as follows:

1= The statement **almost never** describes you.

2= The statement **sometimes** describes you.

3= The statement **often** describes you.

4= The statement **always** describes you.

It's very hard for me to concentrate on a difficult task when there are noises around. ___

When I need to concentrate and solve a problem, I have trouble focusing my attention. ___

When I am working hard on something, I still get distracted by events around me. ___

My concentration is good even if there is music in the room around me. ___

When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me. ___

When I am reading or studying, I am easily distracted if there are people talking in the same room. ___

When trying to focus my attention on something, I have difficulty blocking out distracting thoughts. ___

I have a hard time concentrating when I'm excited about something. ___

When concentrating I ignore feelings of hunger or thirst. ___

I can quickly switch from one task to another. ___

It takes me a while to get really involved in a new task. ___

It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures. ___

I can become interested in a new topic very quickly when I need to. ___

It is easy for me to read or write while I'm also talking on the phone. ___

I have trouble carrying on two conversations at once. ___

I have a hard time coming up with new ideas quickly. ___

After being interrupted or distracted, I can easily shift my attention back to what I was doing before. ___

When a distracting thought comes to mind, it is easy for me to shift my attention away from it. ___

It is easy for me to alternate between two different tasks. ___

It is hard for me to break from one way of thinking about something and look at it from another point of view. ___

Appendix 3. Attentional control survey (Derryberry, 2002).