THE INFLUENCE OF CONTEXT AND PERCEPTUAL LOAD ON OBJECT RECOGNITION

by

Mohammed F. Islam

A Dissertation Submitted to the Faculty of

Charles E. Schmidt College of Science

In Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

Florida Atlantic University

Boca Raton, FL

August 2019

THE INFLUENCE OF CONTEXT AND ATTENTIONAL LOAD ON OBJECT RECOGNITION

by

Mohammed F. Islam

This dissertation was prepared under the direction of the candidate's dissertation advisor, Dr. Elan Barenholtz, Department of Psychology, and has been approved by all members of the supervisory committee. It was submitted to the faculty of the Charles E. Schmidt College of Science and was accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

SUPERVISORY COMMITTEE:

Elan Barenholtz, Ph.D.
Dissertation Advisor

Howard Hock, Ph.D.

Sang Wook Hong, Ph.D.

Summer Sheremata, Ph.D.

Thomas Sanocki, Ph.D.

Teresa Wilcox, Ph.D.
Chair, Department of Psychology

Ata Sarajedini, Ph.D.
Dean, Charles E. Schmidt College of Science

Robert Stackman, Jr. Ph.D.
Dean, Graduate College

June 21, 2019
Date

ACKNOWLEDGEMENTS

I wish to express my gratitude towards Howard Hock, Sang Wook Hong, Summer Sheremata, and Thomas Sanocki for their guidance and support. I would also like express my deepest thanks to Elan Barenholtz for his continuous advising.

ABSTRACT

Author: Mohammed F. Islam

Title: The Influence of Context and Perceptual Load on Object Recognition

Institution: Florida Atlantic University

Thesis Advisor: Dr. Elan Barenholtz

Degree: Doctor of Philosophy

Year: 2019

Forster and Lavie (2008) and Lavie, Lin, Zokaei and Thoma (2009) have demonstrated that meaningful stimuli, such as objects, are ignored under conditions of high perceptual load but not low. However, objects are seldom presented without context in the real world. Given that context can reduce the threshold for object recognition (Barenholtz, 2013), is it possible for context to reduce the processing load of objects such that they can be processed under high load? In the first experiment, I attempted to obtain similar findings of the aforementioned studies by replicating their paradigm with photographs of real-world objects. The findings of the experiment suggested that objects can cause distractor interference under high load conditions, but not low load conditions. These findings are opposite of what the perceptual literature suggests (e.g., Lavie, 1995). However, these findings are aligned with a two-stage dilution model of attention in which information is first processed in parallel and then selectively (Wilson, Muroi, and MacLeod, 2011). Experiment 2 assessed if this effect was specific to semantic objects by

introducing meaningless, abstract objects. The results suggest that the dilution effect was not due to the semantic features of objects. The third experiment assessed the influence of context on objects under load. The results of the experiment found an elimination of all interference effects in both the high and low load conditions. Comparisons between scene-object congruency revealed no influence of semantic information from scenes. It appears that the presentation of a visual stimuli prior to the flanker task diluted attention such that the distractor effects previously observed in the high load condition were minimized. Thus, it does not appear that context reduced the threshold for object recognition under load. All three experiments have demonstrated strong evidence for the dilution approach of attention over perceptual load models.

THE INFLUENCE OF CONTEXT AND PERCEPTUAL LOAD ON OBJECT RECOGNITION

FIGURES

INTRODUCTION

Humans are inundated with more sensory information than is possible to process (James, 1980). To effectively process such large quantities of information, attentional mechanisms are employed to filter and prioritize certain data (for review, see Kinchla, 1992). Yet, attentional capacity is also limited (Kahneman, 1973). Thus, the attentional system must select and filter out certain types of information in lieu of others. Therefore, selective attention is the ability to focus on relevant information (e.g., target) while ignoring irrelevant ones (e.g., distractors). The types of information and the stage at when selective attention is implemented have been widely debated.

One of the earliest models of attentional filter was proposed by Broadbent (1958). The researcher hypothesized that attention was a perceptual filter, sorting information based on physical characteristics (e.g., sensory data). Additionally, limited attentional capacity (i.e., resources) yielded the necessity for the rejection of irrelevant information prior to full analyses of the content. In this model, unattended information was discarded—preventing any further analyses (i.e., semantic processing). Relative to other models, Broadbent (1958) hypothesized that the locus of attention occurred early in attention. Numerous studies supported Broadbent's model by demonstrating that participants cannot respond to unattended stimuli (i.e., information; e.g., Broadbent, 1954). Indeed, much of the work on the locus of attention were derived from studies that utilized a dichotic listening paradigm in which participants were presented with two different auditory stimuli independently to both ears and were tasked to attend to one stimulus while ignoring the other (Cherry, 1953). Treisman and Geffen (1967) used this paradigm to assess if limited capacity in selective attention arose from limits in perception or biases in response. That is, were people capable of identifying incoming words or were they only able to organize and respond to a memory organization of a message? In their study, participants' primary task was to shadow the message of one ear. However, participants' secondary task was to make a tapped response in the presence of a target word from either ear. The researchers reasoned that if capacity limits were perceptual, then differences in efficiency between the secondary responses and the primary responses to either messages would arise. However, if capacity limits were response biased, interferences between primary and secondary responses would arise to the target words in the shadowed message. The authors found differences in tapping responses to the to be primary (to be shadowed) and secondary messages, implicating that capacity limits were perceptual. The findings of Treisman and Geffen (1967) were overwhelmingly in support of Broadbent's (1958) model. Neisser and Becklen (1975) extended these findings across modality. In their study, participants were presented with a *dichoptic* task in which participants were presented with two videos playing to both eyes independently. Participants were tasked to hit a switch if a target action (different for each video) occurred. The researchers found the performance in the dichoptic video condition to be like the performance of a single video. Furthermore, the researchers found that participants were unable to process both types of information (e.g., the videos) and were filtering information based on the type of video. The authors supported Broadbent's (1958) early selection model and demonstrated that the mechanism for attention generalized across modality. Utilizing overlapping shapes, similar findings were observed by Rock and Gutman (1981) in which the authors found that participants failed to perceive unattended shape stimulus, even if the stimulus was familiar to the participant.

While a variety of studies have supported Broadbent's (1958) early filter model, there remained findings in dichotic listening studies that failed to support the model. For instance, Corteen and Wood (1972) had participants associate electrical shocks with the names of different cities. Participants then performed a dichotic listening task in which participants were instructed to shadow one ear. The researchers found that when the shock-associated city names were presented in the unattended ear, participants exhibited an enhanced galvanic response, even though participants were tasked to ignore stimuli from that ear. More importantly, shadowing of the target ear remained unimpaired. This provided evidence against Broadbent's (1958) initial hypothesis. Studies such as this demonstrated two things: first, information is not solely based on physical characteristic. Second, unattended information was not simply discarded at an earlier stage of attention and was further processed than what was hypothesized by Broadbent (1958).

Treisman (1960) went on to suggest that unattended information may not be simply discarded, rather, the information was *attenuated.* That is, the signal strength of the information was reduced; however, not eliminated. The attenuated information can then be monitored by higher level processes and the weakened signal of the ignored information can be enhanced by top-down influences. For instance, in her study, participants would sometimes respond to a word in an unattended stream if the said word was contextually relevant to the attended audio stream. The context enhanced a weakened ignored stimulus (e.g., the unattended word). Treisman's (1960) idea is well exemplified by the phenomena of the "cocktail party effect" in which peoples' attention is guided towards the audition of their name amongst other noisy signals (e.g., Deutsch & Deutsch, 1963). This was well demonstrated in an experiment by Moray (1959) in which the researchers found that participants sometimes heard their name in an audio stream they were tasked to ignore. Nonetheless, stronger evidence of the attenuation model came from Treisman (1964) in which the author assessed the monitoring and storage of ignored messages during selective attention. Participants were tasked with shadowing a message to their right ear while ignoring a distractor auditory stream on their left ear. Half of all participants heard the distracter stream leading the relevant messages in time. The other half of participants heard the distracter stream lagging in time. Moreover, the auditory streams in both ears, at one point, became identical. The researchers waited for participants to notice the identical stream. That is, they waited for the participants' attention to shift from the relevant to the irrelevant stimuli. To do so, the to-be-ignored stimuli would gradually become identical to the target stimuli. In other conditions, the to be ignored conditions could have been in different languages or reversed speech, amongst other manipulations. The researchers measured when participants—uninstructed—commented that the messages became identical. The researchers found the participants were able to recognize ignored stimuli identical to the main message when followed in time. This supported the notion that the to-be-ignored stimuli were not simply discarded; rather, it was attenuated and monitored until it was relevant.

Contrary to the previously mentioned "early selection" and "attenuation" models, proponents of "late selection" models hypothesized that the bottlenecks (i.e., locus) of attention occurred after all received sensory data have been identified. Furthermore, unlimited attentional resources allowed for the semantic processing of unattended information (e.g., Deutsch & Deutsch, 1963; Treisman, 1969; Tipper 1985). Support for late selection models comes from a variety of studies (e.g.; Gatti & Egeth, 1978). Eriksen and Hoffman (1972) suggested that stimuli spatially relevant to a target stimulus within one-degree of focus will always be processed. However, this may not be the case if the target is outside of this eccentricity. Gatti and Egeth (1978) examined this idea by having participants perform a Stroop task in which participants were instructed to name the color of a central patch while being flanked by the color name label in either 1-, 2-, or 5-degrees of focus. The researchers found that participants conveyed a slower reaction time for all three conditions when the label was incompatible to the color patch (as compared to a neutral label). The participants' inability to ignore the color labels based on a physical feature, such as space, supported late selection models in which *everything* in the visual field is processed. Interestingly, this effect was still observed even when participants were warned of the Stroop effect. Moreover, Shiffrin, Pisoni, and Castaneda-Mendez (1974) assessed the locus of attention during selective listening. Utilizing speech-like stimuli, the researchers had participants placed in one of two conditions: in the first "sequential" condition, participants were presented with a stimulus in one ear and then the other. During the other "simultaneous" condition, both stimuli was presented in both ears at the same time. In both conditions, participants were tasked to respond to a stimulus which would play (sometimes amidst distractors) in each interval. Differences between the conditions should indicate attentional effects associated with perceptual processing. However, the researchers found no differences in participant performance between the two conditions. The results of the study implicated the effects of attention to arise during short-term memory, after perceptual processing. The findings of the study give support to the late-selection model of attention. Additional support come from Driver and Tipper (1989). Before them, Francolini and Egeth (1980) found that noninterfering distractors in a Stroop task were ignored and, thus, unidentified. However, Driver and Tipper (1989) suggested that identification may not always produce interference, rather, noninterfering stimuli may produce negative priming. In their task, participants were required to count the number of red items amongst an array of both red and black digits. The researchers found that the black items produced a negative effect similar to the interferences effect from the red items. This implicated that both the red and the black digits were being processed, supporting late-selection models.

However, late-selection models are not without criticism. Pashler (1981) utilized a bar-probe task in which participants were presented with an array of characters coupled with a probe (of a bar or arrow) indicating what the participant had to identify. Accuracy of identification depicts measures visual persistence. Typically, participants were accurate to identify the probe; however, with increased time interval between probe and array, accuracy decreased (Averbach & Coriell, 1961). This should not be the case if identification, as many late selection models suggest, is cost-free and involuntary. Through a series of five experiments, Pashler (1981) found that, regardless of stimulus array preview time, participant performance was influenced by the visual quality of the probed item. That is, it appeared that selection preceded identification, giving support to early selection models. Nonetheless, the author noted that the evidence acquired from their experiment argue *strong* late selection models and not weaker models in which multiple elements (not all) are extracted in parallel. The author cautioned that weaker late selection models should be treated separately than stronger models. Weaker models often claim that parallel processing that locate items without localization of the items are viable with the results from Pashler's study. In short, Pashler called for the need for progression of ideas that converged early and late selection models.

Hybrid Models and Load Theory

Johnston and Heinz (1978) noted the discrepancies in the evidence between early and late selection models and attempted to quell the debate. To do so, they proposed a multimode theory of attention in which attention is hypothesized to be flexible with two modes: an early mode and a late mode. However, what are the different modes of attention? Johnston and Heinz posited that there are three stages of perceptual processing. In stage 1, sensory representations are constructed and inputted into the system. Stage 2 then takes these sensory representations and creates semantic representations. Finally, Stage 3 admits these representations into consciousness. Early selection models—or modes—can be depicted in Stage 1 while late modes can be depicted in Stage 2. However, it must be emphasized the early and late modes are not two distinct categories, rather, they lie on a continuum (of attention). Nonetheless, the authors proposed that attention consumes and requires capacity (i.e., resources). Furthermore, the amount of capacity consumed increases from earlier to later modes of attention. More importantly, Johnston and Heinz claimed that "as the system shifts from early to late modes of attention it loses selection efficacy but gains breadth of attention" (p. 423). Thus, the system is dynamic between previously stated theories of attention. Indeed, through a set of five experiments, the researchers found evidence that (1) capacity is required for attention and (2) the amount of capacity consumed increased as the modes of attention progress. This study may have been the first to set the groundwork to create a hybrid model of attention in which the locus of attention was not solidified in either early or late stages of attention, rather attention was flexible.

Additional support for a hybrid model came from Yantis and Johnston (1990) who argued that there was no clear locus of attention (e.g., early and late stage), rather, the locus of attention was dynamic and required a hybrid model to explain it. The researchers found that congruently related to-be-ignored stimuli had no effect (e.g., facilitative) on the discrimination of a target stimuli. Similarly, incongruent to-be-ignored stimuli had minimal interference effects on the target. In essence, the authors found that selective-attention was too efficient for either facilitative or interference effects. This lends support to early selection models (e.g., Broadbent, 1958). The authors reconciled prior evidence of late-stage models with their findings by proposing a "multiple locus" or "variable locus" model. The authors noted that though their results suggest weak support for divided attention even though a great amount of literature still existed that demonstrated the strength of divided attention. The researchers then posited that focused attention occurs early in attention while divided attention occurs later. Moreover, people can utilize either early-stage, late-stage, or both stages of attention based on task demands.

Lavie and Tsal (1994) refined this model by proposing that early selection was a result of limited resources and selection is required to allocate said resources. Importantly, these resources were flexible and did not occur in a specific stage of attention. More importantly, these resources can be utilized within or between tasks.

Thus, resources can be focused (selective attention) or spread (divided attention). Nonetheless, Lavie and Tsal's (1994) novel contribution to the understanding of the locus of attention arose when they asked, "when the demand of processing is *below* the upper limit of available resources, can the perceiver withhold the allocation of the spare resources left by relevant (primary processing) to the irrelevant processing?" (p. 184). Their hypothesized answer to this question was that one cannot allocate less than the total capacity available, rather, capacity proceeds automatically until it is exhausted. Therefore, if a task was underwhelming, spare attentional resource would have spread to other variables.

Lavie (1995) aimed to provide the first set of strong evidence for a hybrid model of attention. Like early stage models, Lavie posited that perception is limited in capacity and that selection is automatic until attentional resources have been exhausted. However, Lavie (1995) also hypothesized that attention becomes selective once the upper limits have been achieved. This makes the locus and the selectivity of attention dynamic, varying by the "perceptual load" presented to a person. Perceptual load is the amount of perceptual information (e.g., features) given, typically operationalized by either the number of different items presented, alteration of task demands, or the complexity of a stimulus (e.g., conjunctive features; Lavie, 1995; Lavie, Lin, Zokaei, & Thoma, 2009; Murphy, Groeger, & Greene, 2016). That is, all attentional resources will be deployed and distributed amongst the visual field. Lavie (1995) suggested that if an attended-to-stimulus is simple in its features (e.g., low perceptual load) and does not utilize all available attentional resources, the remaining resources will spill over to other irrelevant stimuli. Conversely, if a target stimulus is complex, indicating high perceptual load, then the stimuli will consume more attentional resources, yielding little-to-no spillover for other irrelevant stimuli. Using an Eriksen flanker paradigm (Eriksen & Eriksen, 1974), Lavie (1995) demonstrated that flanker effect was more prevalent under conditions of low load. Over three main experiments, Lavie manipulated load in three critical ways (e.g., set size, stimulus color and shape). All three manipulations of load lead to converging evidence in which interference effects from distractors were observed in low load conditions but not in high load conditions. This implicated the processing of irrelevant stimuli; that is, attentional resources had spilled over from target stimuli to distractors in low load conditions. Moreover, Lavie suggested that perceptual load played a "causal role" in the efficiency of selective attention.

Perceptual load has been well documented in the literature (e.g., Lavie, 2005, 2006; for review, see; Murphy, Groeger, & Greene, 2016). For instance, Lavie and Fox (2000) found that negative priming from distractors depended on the set size (i.e., perceptual load) and that it decreased as load increased. Thus, exhausting attentional resources reduced the processing of irrelevant processing. Carmel, Rees, and Lavie (2007) found that perceptual load modulated conscious perception of temporal patterns. That is, participants in their study perceived physical light flickers as "fused" under a high load condition, but less so in a low load condition. Macdonald and Lavie (2008) found that manipulations in perceptual load lead to changes in detection sensitivity in which participants were unable to detect the presence of a stimuli in high perceptual load, implicating the impact of perceptual load on conscious experience. Finally, Forster and Lavie (2007) generalized findings of perceptual load to real-world application by assessing perceptual load and individual differences. The researchers found that participants who reported high levels of distractibility (based on the Cognitive Failures Questionnaire) were more prone to interference effects in a flanker paradigm than participants who reported lower distractibility. This was, of course, not a surprise—however, this finding was only true in low load conditions. Interestingly, participants with high distractibility exhibited lower interference effects under high load.

Nevertheless, many studies assessing perceptual load utilized arguably simple stimuli (e.g., letters and shapes). How does perceptual load theory generalize to more complex and meaningful stimuli such as real-world objects? This issue was addressed by Forster and Lavie (2008). The researchers presented participants with a flanker array of random letters in which participants were instructed to look for a target letter. Sometimes, a distracter letter (congruent or incongruent to a target) would appear outside of the circular array. More rarely (approximately 10% of trials), a distractor image of a famous cartoon character (e.g., "Spongebob Squarepants") would appear outside of the array. The cartoon characters were irrelevant to both the letter stimuli and the assigned task. Though participants were told to ignore all distractor stimuli (both letter and cartoon), the researchers found evidence of interference effects from the cartoon characters. This effect was especially present when the array conveyed low perceptual load (in low load conditions, the distractor letters in the array were replaced by outlines of small circles). However, interference effects from the cartoon stimuli were significantly lower in higher load conditions. The findings further supported the notion that attentional resources "spill over" in low load conditions. Forster and Lavie (2008) demonstrated two things: first, semantically rich stimuli are highly distracting, even when tasked to ignore them. Second, even meaningful stimuli are susceptible to perceptual load effects. Nonetheless, Forster and Lavie did not measure to the what extent the cartoon stimuli were processed (e.g., identified). Rather, the cartoon stimuli could have been distracting due to low-level and physical features (e.g., saliency).

Previous work on perceptual load has observed behavioral interference from perceptual load regarding irrelevant distractors (e.g., Forster & Lavie, 2008; Lavie, Ro, & Russell, 2003; Lavie, 2006, Yi et al., 2004). However, Lavie, Lin, Zokaei, and Thoma (2009) have made the criticism that these studies utilized a small set of distracters that were both easy to identify and repeated multiple times—making it easier to process distractor stimuli. This potentially allows for multiple objects to be recognized before attentional resources are depleted. Interestingly, multiple stimuli can be processed regardless of intent (e.g., objects will be processed involuntarily if resources are available). Thus, if perceptual load is high enough, only the most task relevant objects will be processed. Lavie, Lin, Zokaei, and Thoma (2009) aimed to assess object recognition under different perceptual loads. Moreover, the researchers examined if object representations were view dependent or invariant. In their study, participants were first presented with a priming array containing a target object, a distractor object, and two non-object stimuli. Target objects were presented at, above, or below fixation. Distractor objects were presented either to the left or right of the column in which the target object appeared. In low load conditions, non-objects were simple circle outlines. However, in the high perceptual load condition, the non-objects were scrambled objects (see Figure 1). Participants were initially tasked with vocally identifying the target object. Afterwards, participants were presented with a probe object (either target or distractor). Participants were again instructed to vocally identify the probe object. Consistent with perceptual load theory, the researchers predicted that in low load conditions, participants would be quicker to identify the distractor objects compared to high load conditions. Indeed, the researchers found that distractor stimuli were often and quickly recognized under low, but not high, perceptual load. Interestingly, the authors suggested that the objects processed under the different load conditions were represented independent of viewpoint. This finding has been suggested previously by others (e.g., Hummel, 2001).

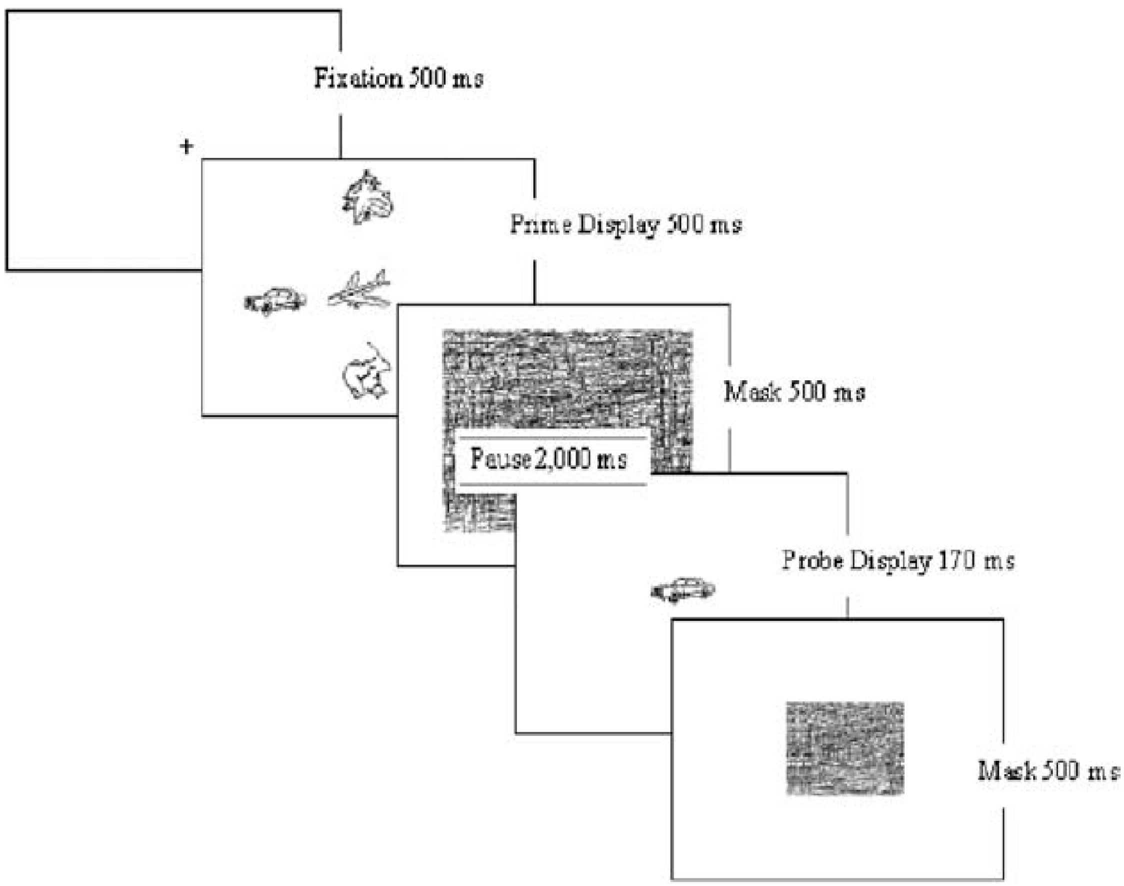

Figure 1. Sample schematic of trials and stimuli from Lavie, Lin, Zokaei, & Thoma (2009).

Alternative to Perceptual Load: Dilution

However, as dominant as the traditional pattern of perceptual load effects may appear, there many studies have found confounding results. For instance, Eltiti, Wallace and Fox (2005) found that the selectivity of attention is more greatly influenced by the saliency of the distractor as opposed to the load. In their study, the researchers produced interference effects in both the high and low load conditions. This pattern in which the distractor stimuli creates interference across various loads can be found in other studies (e.g., Paquet & Craig, 1997; Cosman & Vecera, 2012). More striking, many researchers have found the opposite effect of perceptual load: interference in high load settings but not in low load.

Dubbed the "reversed load effect," this pattern of results has been well demonstrated by the opposing camp of perceptual load theory (e.g., Tsal & Benoni, 2010; Benoni & Tsal, 2013; Wilson, Muroi, & MacLeod, 2011; Chen & Cave, 2013). The opposing view to perceptual load theory states that widely observed effects of load are not due to the exhaustion of resources, but the diluted representation of information (Benoni & Tsal, 2013). This "dilution" account of attention explains that traditionally, in the literature, perceptual load increases are often conveyed by an increase in set size (e.g., Lavie & Tsal, 1994). The increase in set size in turn "dilutes" attention across all items that are presented which in turn weakens the representation of non-target items. Therefore, distractors are too diluted in traditional high-load conditions (e.g., Lavie, 1995) to be properly represented. Evidence for dilution is compelling. Benoni and Tsal (2010) manipulated both perceptual load and dilution. In their experiment, the researchers presented three conditions using colored letters. In the first condition, a green target letter was presented in isolation—this was known as the “low load, low dilution” condition. In the second condition, a green target letter was presented amongst other green distractors—this was known as the “high load, high dilution” condition. Results for these two conditions implicated traditional perceptual load effects: distractor interference on the “low load, low dilution” condition and minimal interference on the “high load, high dilution” condition. However, in a third condition, a green target letter was presented amongst distractor letters of different colors—this conveyed a low perceptual load because the target letter was easily distinguished from the distractors, but this also conveyed high dilution because of the number of irrelevant information. The researchers found no interference in this “low load, high dilution” condition, results akin to traditional high load conditions (e.g., Lavie & Tsal, 1994). Nonetheless, Benoni and Tsal (2010) did not find the “reversed load effect” that was mentioned earlier. However, Wilson, Muroi, and MacLeod (2011) found that if dilution is controlled for, distractor interference actually increases with perceptual load. Moreover, the authors proposed a two-stage model of dilution to help explain the reverse load effect.

In their study, Wilson, Muroi, and MacLeod (2011) manipulated display set size and cue set size (i.e., the number of possible locations for a target to appear). The researchers found that as set sizes increased, reaction time increased implicating an increase in task difficulty. However, if cue set size increased, interference from distractors increased. The researchers posited a two-stage model to explain this. Based on Neisser (1987), Hoffman (1979), and Hoffman et al. (1983), the authors proposed that the first stage of their model includes parallel search in which attention inputs multiple information to locate a target based on probable locations. The second stage involves focused attention, in which the item is selected and actively processed. Nonetheless, the authors stated that as cue set size increased, so does the number of probable locations of a target. This in turn increases the uncertainty of the target (i.e., noise in decision making). The hesitation that is created increases the amount of time spent in the first stage which then allows for more information, including distractors, to be processed, allowing for interference effects.

Dilution; however, has not been demonstrated with real-world or meaningful stimuli such as objects. Thus, the only studies that have utilized meaningful stimuli under load are researchers in favor of perceptual load (Forster & Lavie, 2008; Lavie, Lin, Zokaei, & Thoma, 2009). Nonetheless, objects in the real world are seldom present in isolation. Rather, they are typically accompanied by a form of context (e.g., visual scene or environment). The influence of context has been repeatedly demonstrated in object recognition. For instance, semantically congruent and familiar contexts enable for the accurate identification of objects with less information (e.g., spatial frequency) than an incongruent or unfamiliar environment (e.g., Barenholtz, 2013). Therefore, how does context influence objects under load? Surprisingly, to my knowledge, this question has not been appropriately addressed in the literature. Nonetheless, before assessing this question, one must understand how context effects object recognition.

Context Effects on Object Recognition

The effects of top-down factors on object recognition has been widely demonstrated (e.g., Bugelski & Alampay, 1961; Balcetis & Dale, 2003, 2007). Perhaps one of the strongest types of top-down influences in contextual scenes. Classic studies in visual perception have already demonstrated that context facilitates object recognition, even if the context was presented prior to the object (e.g., Henderson & Hollingworth, 1999; Bar, 2004; Davenport, 2007; for review, see Oliva & Torralba, 2007). Nonetheless, *how* does context influence object recognition? This is a debated question; however, three types of models have emerged in the literature (Henderson & Hollingworth, 1999). One model of object recognition posits that object recognition is independent of scene knowledge. More specifically, *functional isolation models* propose that bottom-up signals are enough for recognition (Hollingworth & Henderson, 1998). This implicates that contextual scenes do not affect object identification. Conversely, other models of object recognition posit that scenes greatly influence object recognition. However, for scene effects to occur, scenes must first be quickly identified. Previous research has found that scenes can be categorized and identified as quickly as 45-135 msec. (e.g., Potter, 1975; Schyns & Oliva, 1994; Oliva & Schyns, 1997). This is possible due to rapid extraction of global information via low-spatial frequencies (Schyns & Oliva, 1994). Henderson and Hollingworth (1999) proposed that analyses of scenes involve the translation of retinal images into low-level "primitives," (e.g., features). These primitives then combine to create structures or "object tokens." The structures are compared to representations stored in long-term memory. The matching of such structures to representations in memory is where recognition may occur. This matching of a scene to a preexisting representation would also entail matching of consistent object tokens. Nonetheless, exactly when and how does this matching occur?

Many types of object recognition models state that expectations are derived from scene knowledge. Furthermore, these expectations interact bidirectionally with physical descriptions of the scenes. As mentioned prior, objects are typically accompanied by a scene, these scenes serve as a contextual frame for the object in focus (e.g., Biederman et al., 1974; Palmer, 1975; Bar & Ullman, 1996). For instance, *perceptual schema models* state that expectations of certain objects, derived from preexisting representations or schema, are extracted very early in object recognition. The locus of matching representations occurs at a perceptual level (e.g., Biederman, 1981). However, *priming models* state that the locus of matching occurs at a cognitive level. Like perceptual schema models, priming models assert that expectations of the scene are derived and are constrained based on perceptual information (Ullman, 1995; Bar & Ullman, 1996; Bar, 2004). Activation of scene schema primes semantically congruent object representations. Additionally, this prime shift the criterion for the perceptual information needed to facilitate an object representation to recognition. Objects consistent with a schema are then facilitated in recognition—whereas objects inconsistent are inhibited (Palmer, 1975; Biederman, Mezzanotte, & Rabinowitz, 1982). A more recent version of this models suggests that a scene representation activate multiple object representations that are then constrained, filtered, and eventually selected for object recognition (Bar, 2004; 2006).

Nonetheless, Barenholtz (2013) has provided a strong case for the priming model. The researcher demonstrated that context greatly reduced the amount of information needed to identify an object. In his study, participants were tasked to identify a pixelated object primed by a given scene. The scene could have been semantically congruent or incongruent to the target object. Furthermore, the scene could have been familiar to the participants (e.g., their own bedroom or their personal kitchen). The results of the study indicated that participants needed less pixels (i.e., resolution) to identify an object primed by a semantically congruent context. Furthermore, participants needed even less pixels to identify objects primed by a scene that the participant was personally familiar with. This raises the following concern: if context reduces the amount of information needed to identify an object, how does perceptual load influence object recognition when a context is provided? More generally, how does perceptual load influence context effects on object recognition? Can context prime an object such that the attentional resources required to process the object can be minimized? However, the semantic priming an object by a scene only provides so much contextual information that in turn can only minimize the attentional needs of an object by so much.

Current Study

Previous studies have demonstrated that the effects of perceptual load extend beyond simple, low-level stimuli (e.g., letters and numbers) into meaningful and complex stimuli such as objects (e.g., Lavie, Lin, Zokaei, & Thoma, 2009). However, to truly assess the effects of perceptual load on object recognition, one should consider how perceptual load affects object recognition with the presence of context, since objects are seldom unaccompanied by context. The initial concerns of the current study were as follows:

1. What is the effect of perceptual load on object recognition?
2. How does semantic context influences object recognition under load?

To assess these concerns, I adopted the paradigm of Forster and Lavie (2008), and Lavie, Lin, Zokaei, and Thoma (2009) and utilized photographs of real-world objects and natural scenes. In alignment with the aforementioned studies, it was initially predicted that objects would cause distractor interference effects under low load conditions but not high load conditions due to resources being exhausted. Moreover, it was predicted that context could reduce the threshold for objects such that objects would be processed under high load conditions, causing interference (e.g., Barenholtz, 2013). However, if the alternative view of dilution was correct, the effects would be reversed; objects would cause interference in high load conditions and not low; moreover, this interference would be minimized with priming of context (e.g., Wilson, Muroi, and MacLeod, 2011).

EXPERIMENT 1: THE EFFECTS OF PERCEPTUAL LOAD ON OBJECT RECOGNITION

A primary goal of the first experiment was to assess the effects of perceptual load on object recognition. Forster and Lavie (2008) have already found that meaningful stimuli caused interference effects on a flanker task within low perceptual load settings; however, not for high load conditions. Nonetheless, the experimenters did not use meaningful objects, rather, the researchers used drawings of famous cartoon characters (e.g., “Spongebob Squarepants”). This issue was quelled by Lavie, Lin, Zokaei, and Thoma (2009) when they used cartoon drawings of common objects. However, the stimuli used in the aforementioned study were simple line drawings. In addition to replicating the findings of the previous study, the current experiment aimed to do so by using more realistic stimuli, that is, by using photographs of real-world objects. Participants in the current experiment performed a modified version of the flanker paradigm. On rare occasion, participants also encountered an object. The objects were expected to produce interfering effects on the flanker in low load conditions, but not in high load conditions.

Method

Participants

Eighty-six undergraduate students from Florida Atlantic University were recruited through the university participant pool or undergraduate psychology courses. Participants received course credit for their participation. Additionally, participants must have had normal-to-corrected vision.

Stimuli

Flanker. The current experiment utilized a central Eriksen-flanker paradigm. Forster and Lavie (2008) utilized a radial circle for their flanker task; however, for simplicity, a simple linear array was used in the current experiment. This flanker array consisted of five letters: four distractor letters and one target letter. The target letter could have been either the letter "X" or the letter "N." On low attentional-load conditions, the target appeared amongst lower-case "o's." Conversely, in high-load conditions, the target was flanked by the randomly selected capital-cased distractor letters. Distractor letters were "H, K, M, Z, V, or W." In both low- and high-load conditions, the target never appeared all the way to the left or right. That is, the target only appeared in the three middle letters. Additionally, no letters repeated within the array. See Figure 2 for sample low- and high-load flankers.

Low Load	**High Load**
oXooo	KMZNW
ooNoo	WXKMZ
oooXo	VWHXM

Figure 2. Sample flanker arrays conveying low and high perceptual load. The target letter "X" or "N" was flanked by potential distractor letters, "H, K, M, Z, V, or W." The target letters never appeared all the way to the right or to the left in the letter array.

Object Images. As mentioned prior, the current study differentiated itself from previous studies (e.g., Forster & Lavie, 2008; Lavie, Lin, Zokaei, & Thoma, 2009) by using more realistic stimuli, that is, photograph images of real-world objects. All object images were not filtered through any means and were displayed in full color, 250 x 250-pixel resolution. The objects in the images were presented in isolation; in front of a white background. Twenty-eight unique object images were used in the first experiment. The object images were gathered through various databases. See Figure 3 for sample images of the objects.

Figure 3. Sample stimuli of object images. All images were presented in 250 x 250-pixel resolution. Furthermore, all images were presented in isolation, in front of a white background. Objects from left to right: hard hat, ornament, and power drill.

Procedure

After completing their informed consent, participants were taken to a well-lit room. Participants sat 2-ft. in front of a computer screen where the experiment took place. All trials began with a 500-msec. presentation of a cross-shaped fixation point in center of the screen. Afterwards, participants encountered a flanker array conveying either high or low perceptual load. The flanker array will stay onscreen for 100-msec.[1], afterwards, a blank screen appeared. Participants' task was to indicate which target letter was present in the letter array. If the target letter "X" appeared on the screen, participants were to respond using the "X" key on the keyboard. Similarly, if the target letter "N" appeared onscreen, participants were instructed to indicate using the "N" key on the keyboard. The blank screen stayed onscreen until participants made a response. Afterwards, a new trial began. On rare occasion (approximately 10% of all trials), an object image was presented either above or below the flanker array. Participants were instructed to ignore the objects. All object images appeared twice, once accompanied by a low load flanker and once with a high load flanker. The position of the images in relation to the flanker were counterbalanced (i.e., all objects appeared above the flanker array once, and again below the flanker array). See Figure 4 for schematic representation of a sample trial. Prior to beginning experimental trials, participants completed ten training trials, one of which contained the presence of an object. There were approximately 1100 trials per participants. Participants had the opportunity to take a break in between blocks of trials.

[1] In Forster and Lavie's (2008) original first experiment, the central flanker task did not contain a 100-msec. time constraint. Rather, the flanker stayed onscreen until participants made a response. In that experiment, the researchers found that their meaningful stimuli caused interference effects in both low and high load conditions—these findings were inconsistent with the general findings of the perceptual load literature (e.g., Lavie, 1995). The researchers attributed the findings to eye movements. Indeed, my own pilot study has found that photographs of real-world objects create interference effects on both high and low perceptual load conditions without a time constraint. Forster and Lavie (2008) attempted to control for eye movements by creating a second experiment in which their imposed the 100-msec. time constraint—the findings from their new experiment were consistent with their general findings. Thus, a 100-msec. time constraint was used in the current experiment. See Appendix A for Pilot Experiment A for overview of a pilot experiment without time constraints.

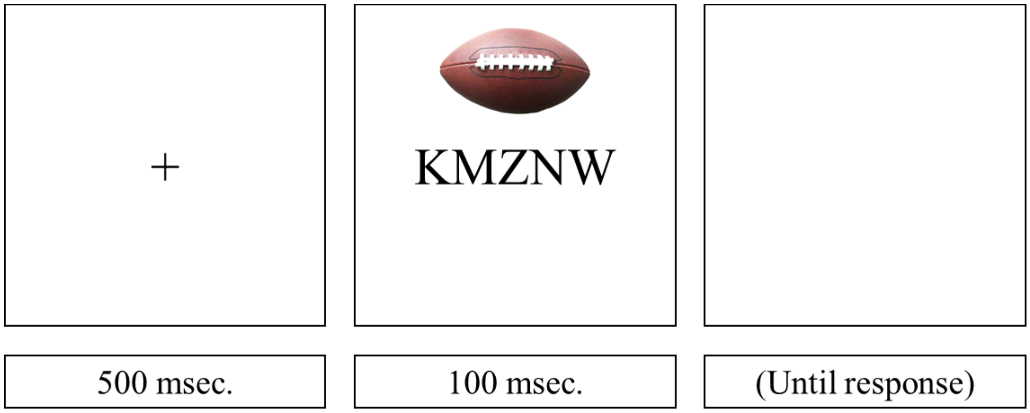

Figure 4. Schematic representation of trials for Experiment 1. All trials began with a 500-msec. presentation of a fixation point. Afterwards, a flanker array appeared for 100-msec. On rare occasion (approximately 10% of trials), an object appeared either above or below the flanker array. A blank screen then proceeded the flanker presentation and remained on screen until participants made a response. A new trial began immediately afterwards.

Results

For both measures of accuracy and reaction times, a repeated measures analysis of variance (ANOVA) was conducted between perceptual load (low, high) and object presence (absent, present). Post-hoc analyses were conducted using paired-sample *t*-tests.

Accuracy. A main effect of load was detected, $F(1, 85) = 127.020$, $p < .001$, $\eta_p^2 = 0.599$: participants were more accurate in low perceptual load conditions ($M = 0.951$, $SEM = 0.006$) than high perceptual load conditions ($M = 0.866$, $SEM = 0.008$), $t(85) = 11.270$, $p < 0.001$, $SEM = 0.008$. Interestingly, no main effect of object presence was found, $F(1, 85) = 2.677$, $p =$ n.s., $\eta_p^2 = 0.031$. That is, there was no difference between object absent ($M = 0.913$, $SEM = 0.005$) and object present ($M = 0.904$, $SEM = 0.008$),

$t(85) = 1.636$, p = n.s., $SEM = 0.006$. Finally, there was no interaction between load and object type, $F(1, 85) = 0.244$, p = n.s., $\eta_p^2 = 0.003$. See Figure 5 for mean scores for accuracy.

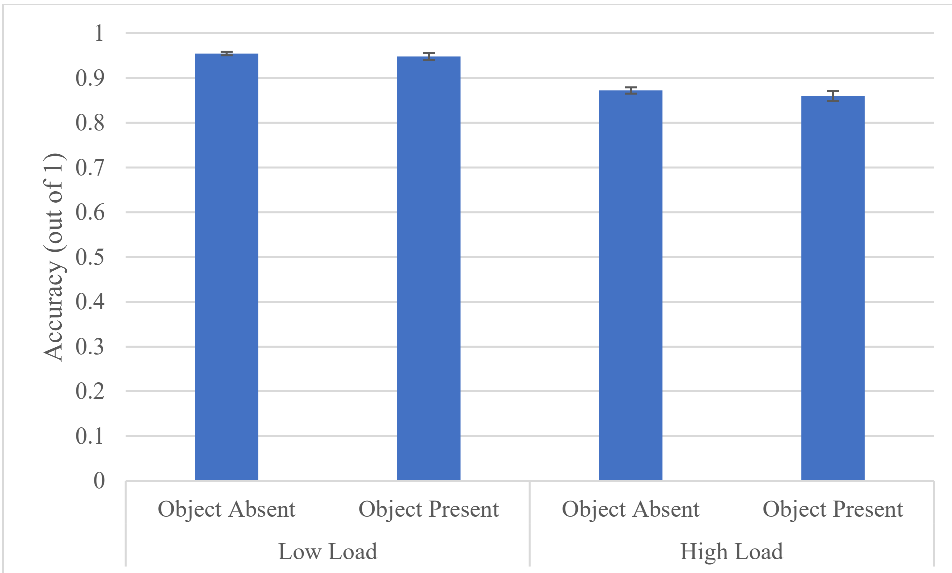

Figure 5. Accuracy across perceptual load and object presence for Experiment 1. Participants were significantly more accurate in low load trials as compared to high load trials. There were no effects of object presence nor were there any interactions. Error bars represent SEM.

Reaction Time. For reaction times, only trials in which participants were accurate were analyzed. A main effect of load was observed, $F(1, 85) = 326.407$, $p < .001$, $\eta_p^2 = 0.793$. Low perceptual load ($M = 0.648$, $SEM = 0.006$) was faster than high perceptual load ($M = 0.796$, $SEM = 0.008$), $t(85) = 18.067$, $p < 0.001$, $SEM = 0.008$. Moreover, a main effect of object presence was found, $F(1, 85) = 5.351$, $p = 0.023$, $\eta_p^2 = 0.059$. Reaction times for object absent trials ($M = 0.715$, $SEM = 0.005$) was faster than object present trials ($M = 0.729$, $SEM = 0.007$), $t(85) = 2.31$, $p = 0.023$, $SEM = 0.006$.

Interestingly, an interaction between perceptual load and object presence was also observed, $F(1, 85) = 5.195$, $p = 0.025$, $\eta_p^2 = 0.058$. *t*-tests confirmed that there was no difference between object absent ($M = 0.646$, $SEM = 0.005$) and object present ($M = 0.650$, $SEM = 0.008$), $t(85) = 0.490$, p = n.s., $SEM = 0.008$. However, within high perceptual load, object absent ($M = 0.784$, $SEM = 0.007$) was faster than object present ($M = 0.807$, $SEM = 0.010$), $t(85) = 3.481$, $p = 0.001$, $SEM = 0.007$. Thus, effects of object presentation were specific to high perceptual load trials. See Figure 6 for mean reaction times across perceptual load and object type.

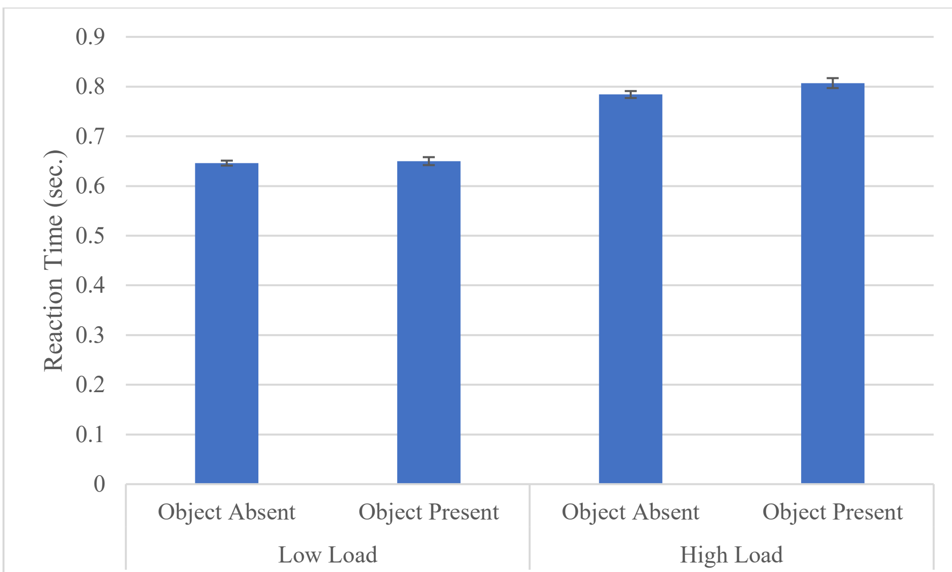

Figure 6. Reaction time across perceptual load and object presence for Experiment 1. There was a main effect of perceptual load in which reaction time for low load conditions were faster than high load condition. Moreover, there was an effect of object presence in which participants were quicker in object absent trials than object present trials. However, this effect was qualified with an interaction in which the object presence effect was specific to high load trials. Therefore, there was no interference from objects in low load conditions, but in high load conditions. Error bars represent SEM.

Discussion

General analyses of reaction time revealed that low perceptual load trials were performed quicker than high perceptual load trials; these results are consistent with most experiments that have been conducted on perceptual load (e.g., Lavie, 1995). However, contrary to the much of the literature, distractor objects created interference effects in the high perceptual load condition and not the low perceptual load condition. This finding is in stark contrast to the findings of Forster and Lavie (2008), and Lavie, Lin, Zokaei, and Thoma (2009). The pattern of result found in the current study is the “reversed load effect” that was mentioned earlier. Again, this pattern has been consistently demonstrated by researchers in favor of the dilution model of attention (e.g., Tsal & Benoni, 2010; Benoni & Tsal, 2013; Chen & Cave, 2013). More specifically, the current data shares a strong resemblance to the findings of Wilson, Muroi, & MacLeod (2011). The researchers proposed a two-stage model of attention. In the first stage, information is processed in parallel in an attempt to find a target based on relevant information. In the second stage, attention becomes focused and information is actively processed. Nonetheless, what is important of note is the first stage. The authors state that as task demand or load become greater, so does the amount of time needed to spend on the first stage. This increase in processing time allows for irrelevant information, such as distractors, to become processed—causing interference. Wilson, Muroi, and MacLeod’s (2011) two-stage model best fits the data of the current experiment. In my low load condition, decision making for the target may have been minimal as the “X” or “N” stands out from the lower case “o’s.” Therefore, the parallel processing in the first stage was quick and decisive. However, in my high load condition, the target was flanked by other capital distractor letters, decision making required more information and the time of processing is increased, allowing for distractors to confound the target. This then raises the question—are these effects specific to semantic objects or are these findings due to the general presentation of a visual stimuli?

EXPERIMENT 2: THE EFFECTS OF PERCEPTUAL LOAD ON SEMANTIC AND ABSTRACT OBJECTS

The results of the first experiment indicated findings that are opposite to those of Lavie, Lin, Zokaei, and Thoma (2009). Again, in their study, in alignment with much of the literature, found that objects were distracting by creating an interfering effect in low load condition—but not in high load conditions. This contradicts the results of my first experiment in which objects created an interfering effect in the high load condition, but not the low load. These effects may be due to the semantic nature of the objects used in the current study. However, the effects may also be due to the simple presentation of a general distractor stimuli. Thus, a second experiment was built upon the first experiment by introducing a condition in which abstract objects were presented. These abstract images were meant to be physically similar to natural objects but without any semantic (i.e., identifiable) information.

Method

Participants

Eighteen undergraduate students from Florida Atlantic University were recruited through the university participant pool or undergraduate psychology courses. Participants received course credit for their involvement. Additionally, participants must have had normal-to-corrected vision.

Stimuli

Both the object and flanker stimuli that were used in Experiment 1 were used in the current experiment. However, Experiment 2 introduced "abstract objects" to the study. Abstract objects were abstract sculptures found through various databases. These abstract objects were presented unfiltered, in full color within a 250 x 250-pixel resolution (to match their semantic counterparts) and were presented in isolation. The sculptures used for abstract objects were not clearly related to any real-world objects. There were 28 unique abstract objects. See Figure 7 for sample images of abstract objects.

Figure 7. Sample stimuli of abstract object images. All images were presented in 250 x 250-pixel resolution. Furthermore, all images were presented in isolation, in front of a white background.

Procedure

The procedure and trials of the current experiment were similar to that of the first experiment. However, to reiterate, after completing their informed consent, participants were taken to a well-lit room. Participants sat 2-ft. in front of a computer screen where the experiment took place. All trials began with a 500-msec. presentation of a cross-shaped fixation placed in center of the screen. After the fixation point, participants were presented with a flanker array; the array conveyed either high or low perceptual load. The flanker stayed onscreen for 100-msec. Afterwards, a blank screen appeared in which participants were tasked to indicate which target letter was present in the flanker array using the corresponding key on the keyboard (e.g., press "X" on the keyboard if the target "X" was present). The blank screen stayed onscreen until participants made a response. Following a response, a new trial began immediately. On rare occasion, an object image was presented. The object image could have either been a semantic object (i.e., a real-world object) or an abstract object (i.e., an abstract sculpture). Each object image appeared twice, once accompanied by a low load flanker and once with a high load flanker. The position of images in relation to the flanker were counterbalanced (i.e., all objects appeared above the flanker array once, and again below the flanker array). See Figure 8 for schematic representation of a sample trial. Similar to the first experiment, participants completed ten training trials prior to the experiment, one of the trials contained a semantic object and another trial contained an abstract object. There were approximately 1100 trials per participants. Participants had the opportunity to take a break in between blocks of trials.

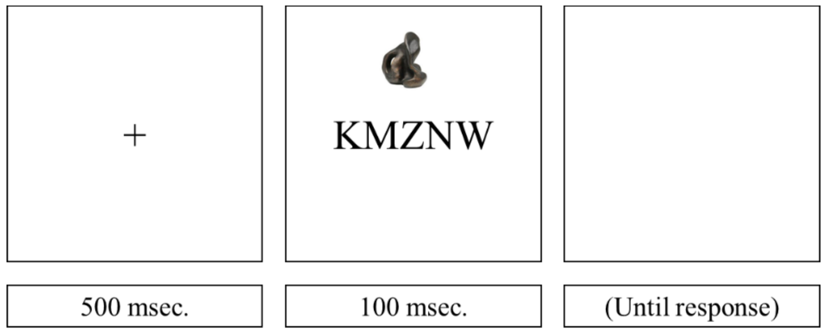

Figure 8. Schematic representation of trials for Experiment 2. All trials began with a 500-msec. presentation of a fixation point. Afterwards, a flanker array appeared for 100-msec. On rare occasion an object (semantic or abstract) appeared either above or below the flanker array. A blank screen then proceeded the flanker presentation and remained on screen until participants made a response. A new trial began immediately afterwards.

Results

For both measures of accuracy and reaction times, a repeated measures ANOVA was conducted between perceptual load (low, high) and type (no-object, semantic object, abstract object). Post-hoc analyses were conducted using paired-sample *t*-tests.

Accuracy. Interestingly, no main effect of perceptual load was detected, $F(1, 17) = 0.326$, p = n.s, $\eta_p^2 = 0.019$: low load ($M = 0.960$, $SEM = 0.008$) was no different than high load ($M = 0.966$, $SEM = 0.007$), $t(17) = 0.571$, p = n.s., $SEM = 0.009$. Additionally, there was no main effect of object type, $F(2, 34) = 0.264$, p = n.s, $\eta_p^2 = 0.015$. Specifically, no-objects ($M = 0.960$, $SEM = 0.005$) was no different than semantic objects ($M = 0.964$, $SEM = .012$), $t(17) = 0.352$, p = n.s., $SEM = 0.006$. Moreover, no-objects was no different than abstract objects ($M = 0.957$, $SEM = 0.012$). Additionally, semantic objects were no different than abstract objects, $t(17) = 0.352$, p = n.s., $SEM = 0.006$.

Finally, no interaction was observed, $F(2, 34) = 1.104$, p = n.s, $\eta_p^2 = 0.061$. See Figure 9 for accuracy across all conditions.

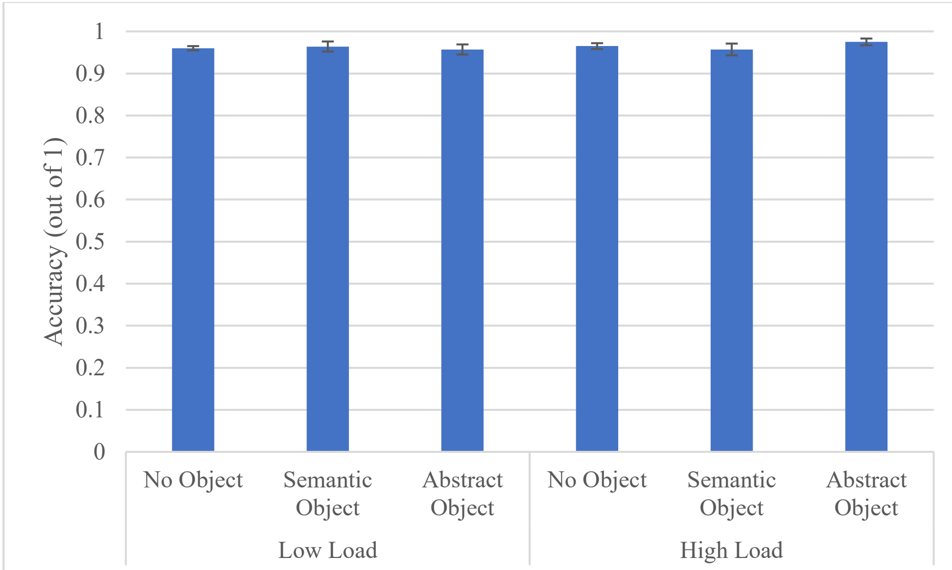

Figure 9. Accuracy across perceptual load and object types for Experiment 2. There were no effects of perceptual load or object type. Moreover, there were no interactions.

Reaction Time. Only accurate trials were analyzed for reaction time. A main effect of perceptual load was observed for reaction time, $F(1, 17) = 307.208$, $p < 0.001$, $\eta_p^2 = 0.948$: low load ($M = 0.584$, $SEM = 0.015$) was faster than high load ($M = 0.889$, $SEM = 0.029$), $t(17) = 17.527$, $p < 0.001$, $SEM = 0.017$. There was also a main effect of object type, $F(2, 34) = 8.253$, $p = 0.001$, ηp2 = 0.327. No-objects ($M = 0.704$, $SEM = 0.019$) was faster than semantic objects ($M = 0.755$, $SEM = 0.027$), $t(17) = 3.73$, $p = 0.004$, $SEM = 0.015$. Additionally, no-objects was faster than abstract objects ($M = 0.752$, $SEM = 0.027$), $t(17) = 3.325$, $p = 0.004$, $SEM = 0.014$. Lastly, there was no differences between semantic and abstract objects, $t(17) = 0.288$, p = n.s., $SEM = 0.054$. More interestingly, there was an interaction, $F(2, 34) = 4.612$, $p = 0.017$, $\eta_p^2 = 0.21$. Within low perceptual load, there were no differences amongst the object types: no objects (*M* = 0.567, *SEM* = 0.015) was no different than semantic objects (*M* = 0.589, *SEM* = 0.0222), *t*(17) = 1.731, *p* = n.s., *SEM* = 0.013; no objects was no different than abstract objects (*M* = 0.597, *SEM* = 0.023), *t*(17) = 2.030, *p* = n.s., *SEM* = 0.015; and there was no differences between semantic and abstract objects, *t*(17) = 0.825, *p* = n.s., *SEM* = 0.009. However, within high perceptual load, no-objects were significantly faster than semantic and abstract object types: no objects (*M* = 0.840, *SEM* = 0.025) was faster than semantic objects (*M* = 0.921, *SEM* = 0.034), *t*(17) = 3.821, *p* = 0.001, *SEM* = 0.021; No objects were significantly faster than abstract objects (*M* = 0.907, *SEM* = 0.035), *t*(17) = 3.261, *p* = 0.005, *SEM* = 0.020; and there was no significant differences between semantic and abstract objects, *t*(17) = 0.688, *p* = n.s., *SEM* = 0.021. See Figure 10 for mean reaction times across all conditions.

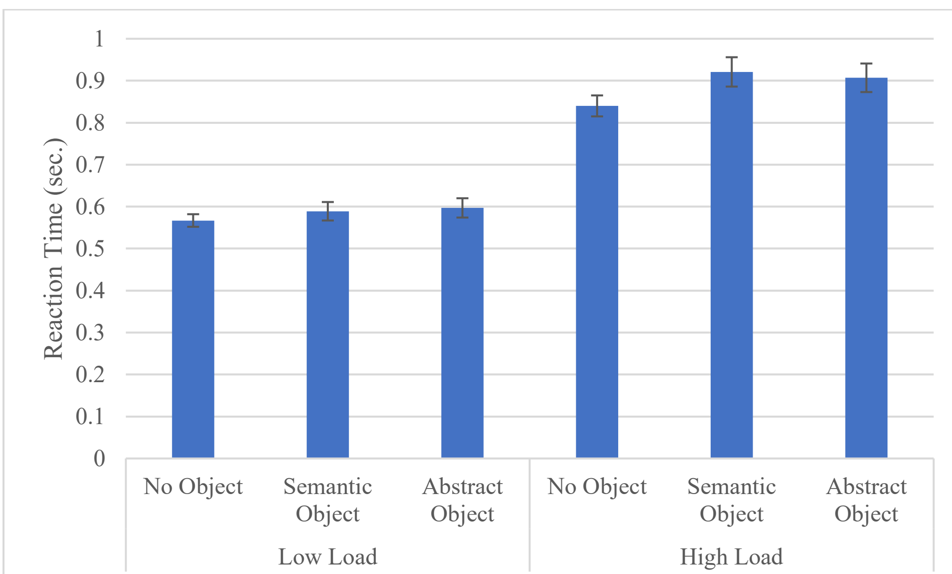

Figure 10. Reaction time across perceptual load and object type for Experiment 2. There was a main effect of perceptual load in which low load trials were faster. There was also an effect of object type in which no-object trials were significantly faster than both

semantic and abstract objects; however, there was no difference between the semantic and abstract objects. Interestingly, this object effect was qualified by an interaction in which these effects were presented under the high load condition, but not the low load condition.

Discussion

The results of Experiment 2 replicate the findings of the first experiment in which objects (both semantic and abstract) cause interference in high load conditions, but not in low load conditions. Again, this is the opposite of what perceptual load theory suggests (e.g., Lavie, 1995). The use of abstract sculptures eliminated the possibility that the obtained results were due to the semantic nature of the objects used in the first experiment. Thus, it appears that the current results are due to the simple presentation of a visual stimuli. As with the first experiment, the explanation that best fits the data for the second experiment is Wilson, Muroi, and MacLeod's (2011) two-stage model of attention in which attention works in a parallel fashion in the first stage and then selectively in the second. It again appears that within the low load condition, the decision-making for a target in the first stage was quick and decisive. However, the decision-making process for the first stage was delayed within the high load condition, allowing for distractors to be processed. Again, the first two experiments demonstrate support for dilution models of attention. Nonetheless, how does context influence these effects?

EXPERIMENT 3: PERCEPTUAL LOAD EFFECTS WITH CONTEXT

The initial purpose of the current study was to assess how context influences object recognition under load. Therefore, a third experiment was conducted to observe the influence of context on objects under load. A variety of studies have already demonstrated the strong influence of context on object recognition (e.g., Biederman, Messanotte, & Rabinowitz, 1982; Henderson & Hollingworth, 1999; Bar, 2004; Davenport, 2007). Without context, perception of an object should be difficult when attention is allocated elsewhere, especially when perceptual load is high. However, priming models of object recognition (see Henderson and Hollingworth, 1999) have suggested that context may significantly reduce the threshold of object recognition (e.g., Barenholtz, 2013). Therefore, it may be the case that context can reduce the threshold of an object so much so, that the object is able to be selected into attention with whatever attentional resources are left over (i.e., in high attentional settings). However, given the results of the previous set of experiments, the opposite may be predicted: context may allow objects to distract in a low load setting.

Method

Participants

Twenty-nine undergraduate students from Florida Atlantic University were recruited through the university participant pool or undergraduate psychology courses. Participants received course credit for their involvement. Additionally, participants must have had normal-to-corrected vision.

Stimuli

Both the object and flanker stimuli that will be used in Experiment 1 will be used in the current experiment. However, Experiment 3 introduced context to the study in the form of visual scenes. These scene images were presented unfiltered, in full color within an 800 x 800-pixel resolution. Additionally, scenes contained minimal number of objects and, more importantly, did not contain any target objects used in the current experiment. There were 28 unique scenes. See Figure 11 for sample scenes.

Figure 11. Sample scene images used in Experiment 3. All scenes will be presented in 800 x 800-pixel resolution. Scenes from left to right: beach, baseball field, and bathroom.

Procedure

Like the first two experiment, Experiment 3 will take place in a well-lit room in which participants were seated 2-ft. in front of a 26-in. computer screen. All trials began with a 1000-msec. presentation of a cross-shaped fixation point in middle of the screen. Proceeding the fixation point was a 1000-msec. presentation of a scene image. Afterwards, a flanker array conveying either high or low perceptual load appeared in center of the screen for 100-msec. Following the flanker array, participants encountered a blank screen. Participants were instructed to indicate which target letter (an “X” or an “N”) was present in the encountered letter array using the appropriate key on the keyboard. On rare occasion, an object image appeared above or below the flanker array.

The object may have been semantically congruent or incongruent to the preceding scene image. Additionally, all object-scene pairs were presented once alongside a low perceptual load condition and once again alongside a high perceptual load condition. Nonetheless, participants were forewarned about the images and were instructed to ignore them. A new trial began immediately after the participant makes a response. See Figure 12 for schematic representation of trials. Prior to beginning experimental trials, participants completed ten training trials, one of which will contain the presence of an object. Participants had the opportunity to take a break in between blocks of trials.

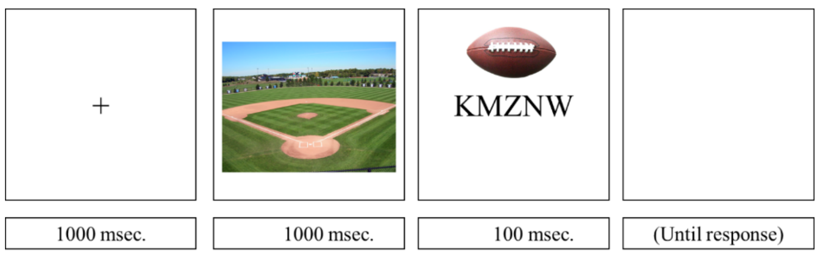

Figure 12. Schematic for sample trials for Experiment 3. All trials began with a 1000-msec. presentation followed by a 1000-msec. presentation of a scene. Afterwards, a flanker array appeared for 100-msec. On rare occasion, an object (congruent or incongruent) to the scene appeared above or below the flanker array. A blank screen proceeded the flanker array and stayed on the screen until participant made a response. A new trial began immediately afterwards.

Results

For both measures of accuracy and reaction times, a repeated measures ANOVA was conducted between perceptual load (low, high) and scene-object relationship (no object, congruent object, incongruent object). Post-hoc analyses were conducted using a paired-sample *t*-tests.

Accuracy. There was a main effect of perceptual load, $F(1, 28) = 59.075$, $p < 0.001$, $\eta_p^2 = 0.678$: accuracy was higher in low perceptual load ($M = 0.967$, $SEM = 0.009$) than high perceptual load ($M = 0.851$, $SEM = 0.018$), $t(28) = 7.686$, $p < 0.001$, $SEM = 0.015$. There was no effect of object type, $F(2, 56) = 1.577$, $p =$ n.s., $\eta_p^2 = 0.053$. No difference in accuracy between no-objects ($M = 0.922$, $SEM = 0.008$) and congruent object ($M = 0.896$, $SEM = 0.020$), $t(2) = 1.763$, $p =$ n.s., $SEM = 0.015$. Additionally, no difference between no-objects and incongruent objects ($M = 0.910$, $SEM = 0.013$), $t(28) = 1.137$, $p =$ n.s., $SEM = 0.011$. Moreover, there was no significant difference between congruent and incongruent objects, $t(28) = 0.780$, $p =$ n.s., $SEM = 0.017$. Lastly, there was no interaction, $F(2, 56) = 1.236$, $p =$ n.s., $\eta_p^2 = 0.042$. See Figure 13 for visual representation for accuracy across all conditions.

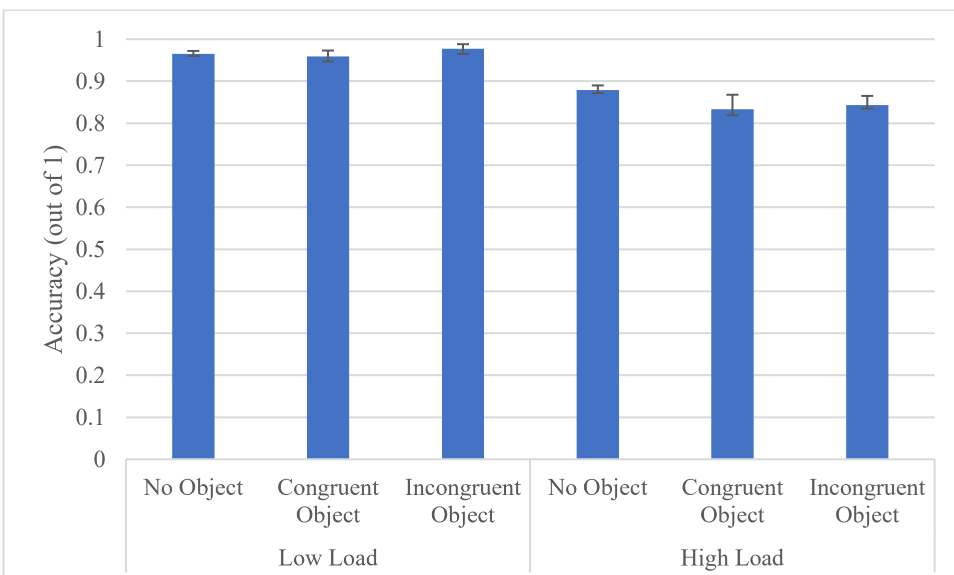

Figure 13. Accuracy across perceptual load and scene-object congruency for Experiment 3. There was a main effect of perceptual load in which low load trials were performed more accurately than high load trials. There were no effects of scene-object congruency nor were there any interactions.

Reaction Time. Only accurate trials were analyzed for reaction time. There was a main effect of perceptual load, $F(1, 28) = 129.978$, $p < 0.001$, $\eta_p^2 = 0.823$: reaction times were quicker for the load perceptual load condition (*M* = 0.663, *SEM* = 0.023) than high perceptual load (*M* = 0.887, *SEM* = 0.024), $t(28) = 11.401$, $p < 0.001$, *SEM* = 0.020. There was also no main effect of object type, $F(2, 56) = 1.570$, *p* = n.s., $\eta_p^2 = 0.053$. Specifically, there was no significant differences between no-object (*M* = 0.762, *SEM* = 0.020) and congruent object conditions (M = 0.771, SEM = 0.024), t(28) = 0.656, *p* = n.s., *SEM* = 0.014. Similarly, there was no significant differences between no-object and incongruent objects (*M* = 0.791, *SEM* = 0.027), $t(28) = 1.842$, *p* = n.s., *SEM* = 0.016. Additionally, there were no differences found between the congruent and incongruent conditions, $t(28) = 0.992$, *p* = n.s., *SEM* = 0.020. Finally, there was no interaction, $F(2, 56) = 0.426$, *p* = n.s., $\eta_p^2 = 0.015$. See Figure 14 for mean reaction times across all conditions.

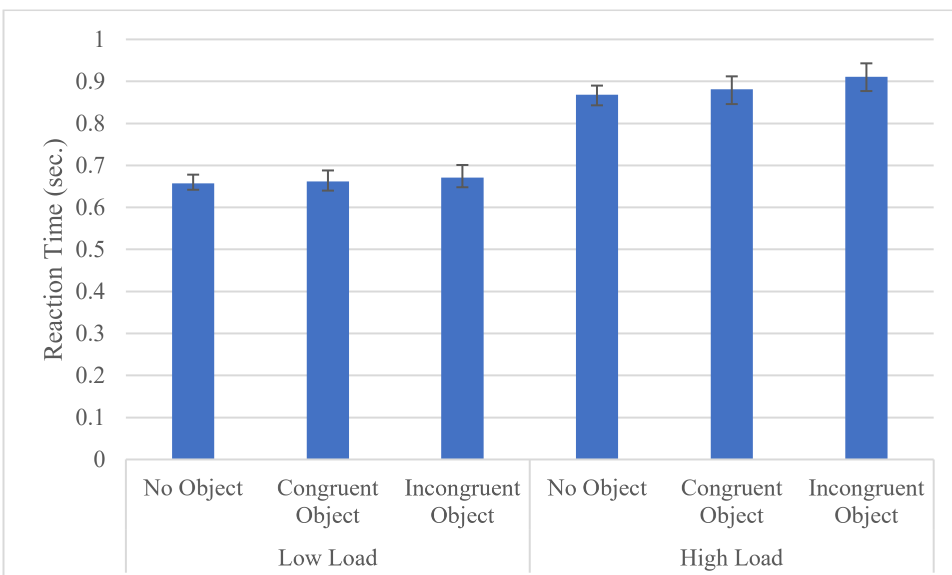

Figure 14. Reaction time across perceptual load and scene-object congruency for Experiment 3. There was a main effect of perceptual load in which low load trials were

performed quicker than high load trials. There was no effect of scene-object congruency nor were there any interactions.

Discussion

The results of the third experiment suggest that context has eliminated the interference effect that was initially observed in the high load condition which was consistently found in the first two experiments. Thus, *how* did the scenes influence attention? Given that the natural scenes had no differentiating effects on either congruent or incongruent objects, it may be assumed that the meaning of the scene (i.e., contextual information) did not influence attention at all. Rather, it may be that the initial presentation of the scene diluted attention prior to the presentation of the flanker. Therefore, when the flanker array was presented with an object, the distractor was too diluted to be sufficiently represented. However, refer back to the original question: can context influence object recognition such that the object can be processed under load? The answer appears to be “no”—in fact, it appears that contextual information does not get processed.

GENERAL DISCUSSION

The initial aim of the current study was to observe the influence of context on object recognition under load. It was originally hypothesized that objects would be processed in low load settings and not in high load settings (e.g., Forster & Lavie, 2008; Lavie, Lin, Zokaei, & Thoma, 2009). Moreover, the introduction of context was hypothesized to prime semantically consistent objects so the threshold for recognition would be low enough to be processed even within a high perceptual load setting (Barenholtz, 2013). However, results of the current study not only failed to replicate traditional findings of perceptual load but have demonstrated support for the alternative dilution model of attention (e.g., Tsal & Benoni, 2010; Benoni & Tsal, 2013). The results of the first two experiments suggested that, in contrast to perceptual load models, increase in perceptual load produced increased distractor interference. This reverse load effect has been demonstrated by proponents of dilution models (e.g., Wilson, Muroi, & MacLeod, 2011; Chen & Cave, 2013). Specifically, the findings of the current study support the two-stage model of attention by Wilson, Muroi, and MacLeod, 2011). To reiterate, information is processed in parallel fashion in the first stage and then selectively in the second stage. Increased load creates a delay in the first stage, allowing more time for distractors to be processed. Interestingly, results of the third experiment suggest that scenes eliminate interference effects of distractors. Given that performance between trials with congruent objects and incongruent objects were statistically similar, it can be assumed that the effect of the scenes was not due to contextual information. Rather, it appears that the effects of the natural scenes were low-level: the simple presentation of a visual stimuli produced the effect. It can be argued that the lack of distractor interference after the presentation of a scene was due the scene image diluting attention prior to the presentation of the flanker task. Thus, when objects were presented, attention was too diluted to sufficiently represent distractors. This is, of course, speculation. More research is needed to test this notion.

There lies a discrepancy yet to be addressed. The data derived from the current experiments fit the dilution approach to attention; however, this same data was derived from a paradigm that supports the findings of perceptual load models. The question then becomes, why is it that Lavie, Lin, Zokaei, and Thoma (2009) found perceptual load effects whereas the current study found the reverse effect? There were two differences between the current study and the aforementioned study. First, my study used a linear flanker array whereas Lavie, Lin, Zokaei, and Thoma's (2009) used a radial array. However, to my knowledge, both types of flankers should produce the same effect. Though, it may be argued that spatial characteristics of a radial flanker are different from a linear one. Nonetheless, it must be noted that original studies conducted on perceptual load utilized a linear flanker array (e.g., Lavie, 1995). Regardless, future research is needed to replicate the current study using a radial flanker. However, and more importantly, the second difference between the two studies is that the current experiment utilized more realistic stimuli that were presented in full color. Nonetheless, Wei and Zhou (2006) have found that adding dimensions to a distractor, such as color, should not affect the perceptual load effect—however, the researchers used letter stimuli in their study. Future studies need to compare the effects of object-images and drawings of objects under load. In addition to supporting the dilution approach of attention, the current study failed to replicate perceptual load using the paradigms of load theory. To further test replication, I conducted a second pilot experiment (see Appendix B) using an Eriksen flanker paradigm and letter distractors. The results of that study failed to replicate the traditional perceptual load effect.

Nonetheless, the current study has found support for a two-stage approach to attention in which parallel processing is proceeded by selective focus (Experiment 1; Wilson, Muroi, & MacLeod, 2011). Moreover, it appears that this process is not influenced by either semantic information (Experiment 2) or contextual information (Experiment 3). Ultimately, the study suggests the minimal influence semantic information under load.

APPENDICES

APPENDIX A. Pilot Experiment A: The Effects of Perceptual load on Objects without Time Constraint

The methods of the current study were in part adopted from Lavie, Lin, Zokaei, and Thoma (2009). In the aforementioned study, participants were shown an Eriksen flanker array which was, in rare occasion, accompanied by a meaningful stimulus above or below the flanker array. Additionally, the flanker could have conveyed either high or low perceptual load. In their first experiment, the flanker and distractor stayed onscreen until participants made a response. Their findings indicated an interference effect in both the high and low load condition. These findings are inconsistent with the general pattern of results typically observed in a perceptual load paradigm (e.g., Lavie, 1995). They attributed their findings to eye movements. Thus, their experiments proceeded with a 100-msec. constraint on the flanker task. With the addition of the time constraint, the authors observed the familiar perceptual load effect (interference in the low load but not the high load). Nonetheless, I initially ran a study utilizing the paradigm of the current study without a time constraint. The findings of my study were consistent with the findings of Forster and Lavie's (2008) initial experiments (without time constraints). This is the only time my experiments have been consistent with Forster and Lavie's (2008) finding. Nevertheless, my experiment without a time constraint is presented below.

METHOD

Participants

Thirty-four undergraduate students from Florida Atlantic University were recruited through the university participant pool or undergraduate psychology courses. Participants received course credit for their participation. Additionally, participants must have had normal-to-corrected vision.

Stimuli

The pilot experiment used the same Eriksen flanker arrays and object images used in the Experiment 1.

Procedure

The procedure and trials of the pilot experiment were identical to Experiment 1 with the exception of the time constraint on the flanker task. To reiterate, participants first filled out informed consent and then were seated in a well-lit room, approximately 2-ft in front of a computer. All trials began with a 500-msec. presentation of a cross-shaped fixation point in center of the screen. Afterwards, a flanker array conveying either high or low perceptual load appeared on the screen. Participants were tasked to identify a target letter (“X” or “N”) using the appropriate key on the keyboard. On rare occasion, the flanker array would be accompanied by an object image above or below the flanker. The flanker array stayed onscreen until participants made a response. Participants were instructed to ignore the object stimuli. All objects were presented twice, once accompanied by a low load flanker and once with a high load flanker. The position of the images in relation to the flanker were counterbalanced. A new trial began immediately after a participant’s response. See Figure 15 for schematic representation of all trials.

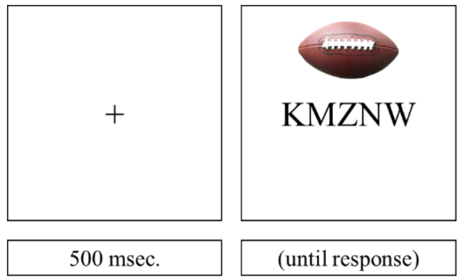

Figure 15. Schematic representation of trials in the pilot experiment. Participants first encountered a fixation point for 500 msec. Afterwards, a flanker array appeared in center of the screen. On rare occasion, an object would accompany the flanker array. The flanker array (and sometimes the object) stayed onscreen until participants made a response. A new trial began immediately after.

RESULTS

For both measures of accuracy and reaction times, a repeated measures ANOVA was conducted between perceptual load (low, high) and object presence (absent, present). Post-hoc analyses were conducted using a paired-sample *t*-test.

Accuracy. There was no main effect of perceptual load, $F(1, 33) = 0.029$, p = n.s., $\eta_p^2 = 0.001$: the low load condition ($M = 0.941$, $SEM = 0.009$) was statistically similar to the high load condition ($M = 0.941$, $SEM = 0.118$), $t(33) = 0.070$, p = n.s., $SEM = 0.006$. Moreover, there was no effect of object presence, $F(1, 33) = 0.005$ p = n.s., $\eta_p^2 < 0.001$; there was no difference between object-absent trials ($M = 0.942$, $SEM = 0.010$) and object-present trials ($M = 0.941$, $SEM = 0.011$), $t(33) = 0.169$, p = n.s., $SEM = 0.006$.

Finally, there were no interactions, $F(1, 33) = 0.498$, p = n.s., $\eta_p^2 = 0.015$. See Figure 16 for accuracy across all conditions.

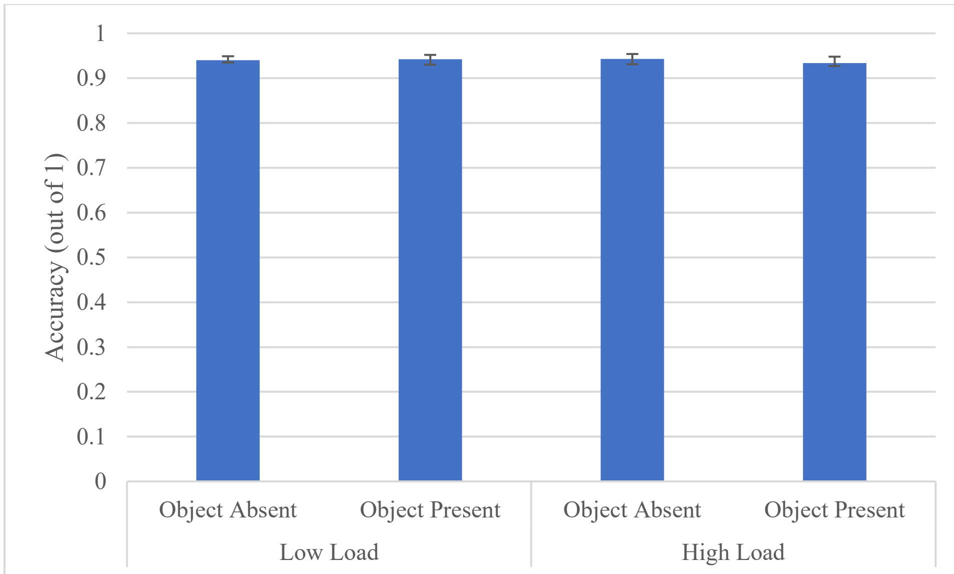

Figure 16. Accuracy across perceptual load and object presence for Pilot Experiment A. There was no effect of either perceptual load or object presence. Furthermore, there was no interaction.

Reaction time. Reaction time for only accurate trials were analyzed. There was a main effect of perceptual load, $F(1, 33) = 426.592$, $p < 0.001$, $\eta_p^2 = .928$: low perceptual load trials ($M = 0.536$, $SEM = 0.008$) were faster than high load trials ($M = 0.812$, $SEM = 0.017$), $t(33) = 20.654$, $p < 0.001$, $SEM = 0.133$. There was also a main effect of object presence, $F(1, 33) = 59.466$, $p < 0.001$, $\eta_p^2 = 0.643$; in which, object absent trials ($M = 0.652$, $SEM = 0.011$) were performed quicker than object present trials ($M = 0.697$, $SEM = 0.124$), $t(33) = 7.711$, $p < 0.001$, $SEM = 0.006$. There was also an interaction between perceptual load and object presence, $F(1, 33) = 15.354$, $p < 0.001$, $\eta_p^2 = 0.318$. Within low perceptual load, object absent trials ($M = 0.525$, $SEM = 0.008$) were performed faster than object present trials (*M* = 0.547, *SEM* = 0.009), *t*(33) = 4.628, *p* < 0.001, *SEM* = 0.005. Similar results were obtained for high perceptual load trials; object absent trials (*M* = 0.778, *SEM* = 0.015) were faster than object present trials (*M* = 0.846, *SEM* = 0.019), *t*(33) = 6.318, *p* < 0.001, *SEM* = 0.011. See Figure 17 for visual representation of reaction time across all conditions.

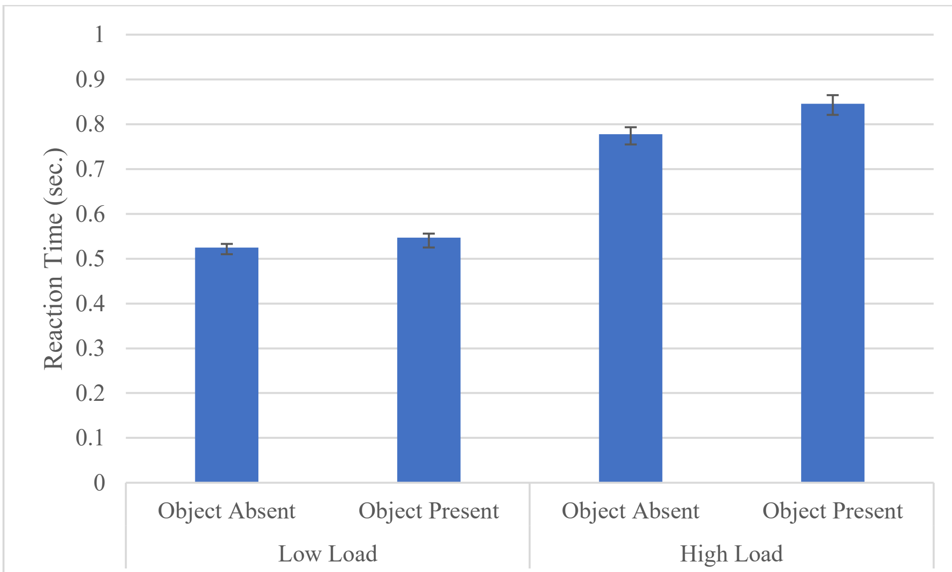

Figure 17. Reaction time across perceptual load and object presence for Pilot Experiment A. Low load conditions were performed faster than high load conditions. Moreover, object absent trials displayed quicker reaction time than object present trials. Finally, there was an interaction between load and object presence.

The finding in which there was an effect of object presence in both the high and low load was replicable to Forster and Lavie (2008). Nonetheless, these findings are inconsistent with the traditional findings of perceptual load (e.g., Lavie, 1995). Forster and Lavie (2008) attributed this discrepancy to potential eye-movements. Thus, they introduced a 100-msec. time-constraint to their paradigm. The change in presentation time produced effects that were more consistent with the literature. Thus, the experiments of the current study have adopted the time-constraint.

APPENDIX B. Pilot Experiment B: Replication of Perceptual Load with Letter Distractors

The first two experiments not only demonstrated a failure to replicate perceptual load but found results that were opposite to Forster and Lavie (2008); and Lavie, Lin, Zokaei, and Thoma (2009). Both experiments then raise the need for a more bare-bones replication of perceptual load—without pictures of objects. Thus, the purpose of the current pilot experiment was to replicate perceptual load using the Eriksen flanker task and non-object distractors (i.e., letters). In this experiment, flanker arrays were, in rare occurrence, accompanied by a letter that was congruent or incongruent to the target letter.

METHOD

Participants

Twenty-three undergraduate students from Florida Atlantic University were recruited through the university participant pool or undergraduate psychology courses. Participants received course credit for their involvement. Additionally, participants must have had normal-to-corrected vision.

Stimuli

The Eriksen flanker stimuli that has been used in all of the prior studies were used in the current experiment. Rather than distractor stimuli being object images, the distractor stimuli for the current experiments were either the letter “X” or the letter “N.”

Procedure

The procedure and trials of the current experiment were similar to the first experiment with the exception of the presence of a letter distractor instead of an object. After completing their informed consent, participants were taken to a well-lit room and placed 2-ft. in front of a computer screen where the experiment took place. All trials began with a 500-msec. presentation of a cross-shaped fixation point followed by the presentation of a flanker array. The array conveyed either high or low perceptual load. The flanker stayed onscreen for 100-msec. Afterwards, a blank screen appeared in which participants were tasked to indicate which target letter was present using the corresponding key on the keyboard (e.g., press "N" if the target "N" was present inside the flanker array). The blank screen stayed onscreen until participants made a response. A new trial began immediately after participants made a response. On rare occasion, a congruent or incongruent letter ("X" or "N") appeared above or below the flanker array. The position of the distractor letter, perceptual load, and distractor congruency were all counterbalanced. See Figure 18 for schematic representation of a sample trial. There were approximately 1100 trials per participants. Participants had the opportunity to take a break in between blocks of trials.

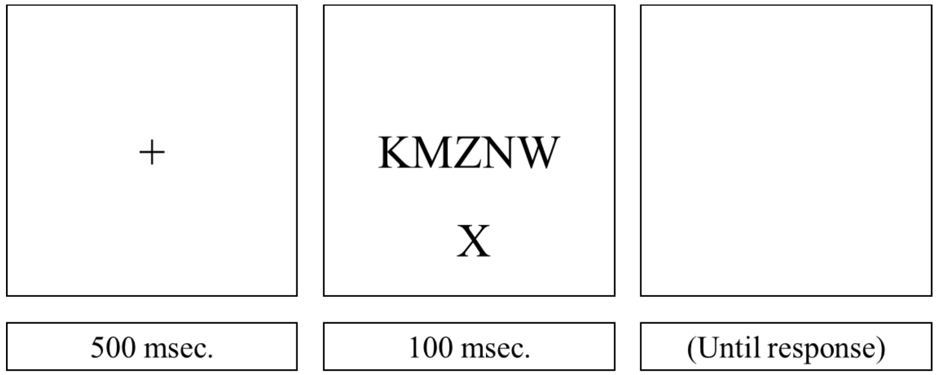

Figure 18. Schematic representation of trials for Pilot Experiment B. All trials began with a 500-msec. presentation of a fixation point. Afterwards, a flanker array appeared for 100-msec. On rare occasion letter distractor (congruent or incongruent) appeared either above or below the flanker array. A blank screen then proceeded the flanker presentation and remained on screen until participants made a response. A new trial began immediately afterwards.

RESULTS

For both measures of accuracy and reaction times, a repeated measures ANOVA was conducted between perceptual load (low, high) and distractor congruency (no distractor, congruent, incongruent). Post-hoc analyses were conducted using a pair-samples *t*-test.

Accuracy. There was a main effect of perceptual load, $F(1, 22) = 10.297$, $p = 0.004$, $\eta_p^2 = 0.319$: low load conditions ($M = 0.924$, $SEM = 0.011$) was significantly more accurate than high load conditions ($M = 0.889$, $SEM = 0.015$), $t(22) = 3.209$, $p = 0.004$, $SEM = 0.011$. There was also an effect of distractor congruency, $F(2, 44) = 8.919$, $p = 0.001$, $\eta_p^2 = 0.288$. There was no difference between trials with no distractors ($M = 0.914$, $SEM = 0.013$) and congruent distractors ($M = 0.931$, $SEM = 0.010$), $t(22) = 1.512$, $p =$

n.s., *SEM* = 0.012. However, trials without a distractor was more accurate than incongruent trials (*M* = 0.874, *SEM* = 0.018), $t(22) = 3.041$, $p = 0.006$, *SEM* = 0.013. Similarly, congruent trials were more accurate than incongruent trials, $t(22) = 3.465$, $p = 0.002$, *SEM* = 0.017. Finally, there was a trending; however, insignificant interaction, $F(2, 44) = 3.170$, p = n.s., $\eta_p^2 = 0.126$. See Figure 19 for visual representations of accuracies across all conditions.

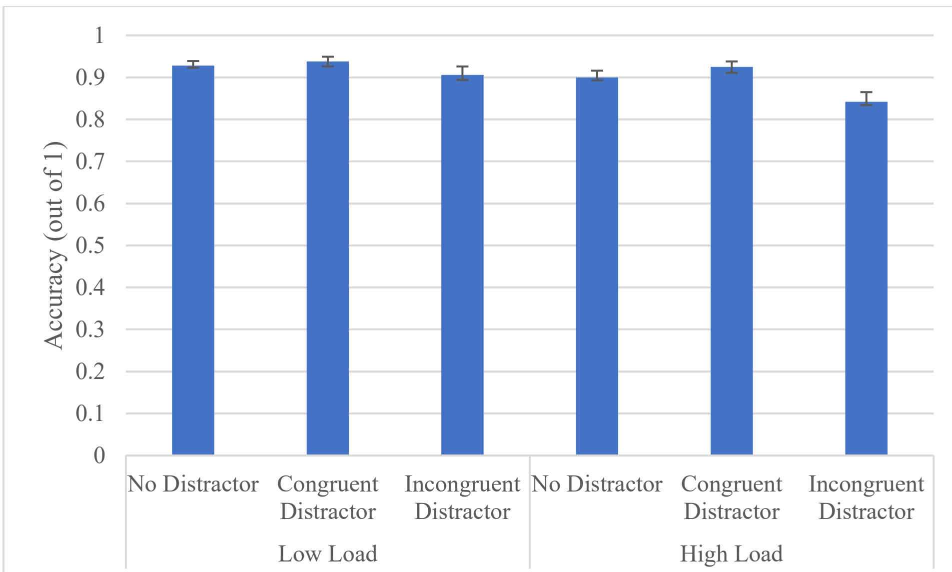

Figure 19. Accuracy across perceptual load and distractor congruency for Pilot Experiment B. Low load trials were performed more accurately than high load trials. There was also an effect of distractor congruency in which the incongruent condition was less accurate than both congruent trials and trials without a distractor—there was no difference between congruent trials and no-distractor trials. Finally, there was no interaction. Error bars represent the SEM.

Reaction Time. Reaction time was analyzed for accurate trials only. A main effect of perceptual load was found, $F(1, 22) = 157.829$, $p < 0.001$, $\eta_p^2 = 0.878$: Reaction times for low perceptual load (*M* = 0.602, *SEM* = 0.029) was significantly faster than high perceptual load (*M* = 0.808, *SEM* = 0.026), $t(22) = 12.563$, $p < 0.001$, *SEM* = 0.016. A second main effect for distractor congruency was observed, $F(2, 44) = 9.691$, $p < 0.001$, $\eta_p^2 = 0.306$. Trials with no distractors (*M* = 0.680, *SEM* = 0.024) was similar in response time to congruent distractors (*M* = 0.704, *SEM* = 0.031), $t(22) = 2.056$, *p* = n.s., *SEM* = 0.057. However, incongruent trials (*M* = 0.730, *SEM* = 0.026) was significantly slower than trials with no distractors, $t(22) = 5.021$, $p < 0.001$, *SEM* = 0.010. Similarly, incongruent trials were significantly slower than congruent trials, $t(22) = 2.111$, $p = 0.046$, *SEM* = 0.012. Finally, no interaction was observed, $F(2, 44) = 0.697$, *p* = n.s., $\eta_p^2 = 0.031$. See Figure 20 for visual representations of reaction time across perceptual load and distractor congruency.

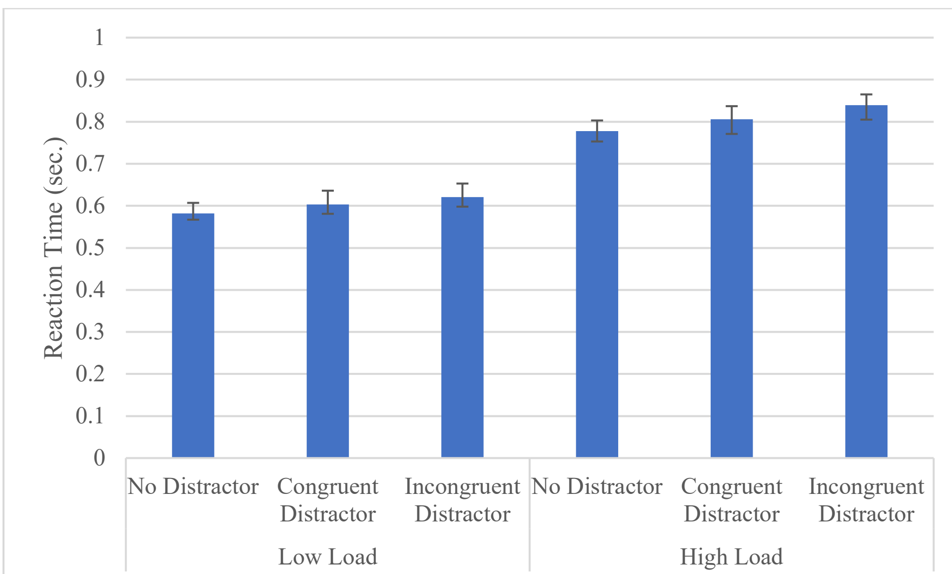

Figure 20. Reaction time across perceptual load and distractor congruency for Pilot Experiment B. There was a main effect of perceptual load in which the low load condition was performed quicker than the high load condition. There was also an effect of distractor congruency in which the incongruent condition displayed longer reaction times than both the congruent condition and no-distractor condition. There was no

difference between congruent trials and trials without a distractor. Finally, there was no interaction. Error bars represent the SEM.

The results of the current experiment show that interference effect was found in both high and low load conditions. This is a failure to replicate perceptual load effects (e.g., Lavie, 1995).

REFERENCES

Alho, K., Woods, D. L., Algazi, A., & Naatanen, R. (1992). Intermodal selective attention. II. Effects of perceptual load on processing of auditory and visual stimuli in central space. *Electroencephalography and Clinical Neurophysiology, 82*(1992), 356-368.

Averbach, E., & Coriell, A. S. (1961). Short-term memory in vision. *Bell System Technical Journal, 40,* 309-328.

Balcetis, E., & Dunning, D. (2006). See what you want to see: Motivational influences on visual perception. *Journal of Personality and Social Psychology*, *91*(4), 612-625.

Balcetis, E., & Dale, R. (2007). Conceptual set as a top-down constraint on visual object identification. *Perception*, *36*(4), 581-595.

Bar, M. (2004). Visual objects in context. *Nature Reviews Neuroscience*, *5*(8), 617-629.

Bar, M., & Ullman S. (1996) Spatial context in recognition. *Perception*, 25(3), 343-352.

Barenholtz, E. (2013). Quantifying the role of context in visual object recognition. *Visual Cognition, 22*(1), 30-56.

Benoni, H., & Tsal, Y. (2010). Where have we gone wrong? Perceptual load does not affect selective attention. *Vision Research, 50*(2012), 1292-1298.

Benoni, H., & Tsal, Y. (2012). Controlling for dilution while manipulating load: Perceptual and sensory are just two aspects of task difficulty. *Psychonomics Bulletin Review, 19,* 631-638.

Benoni, H. & Tsal, Y. (2013). Conceptual and methodological concerns in the theory of perceptual load. *Frontiers in Psychology, 4*, 522.

Biederman, I. (1972). Perceiving real-world scenes. *Science, 177*, 77-80.

Biederman, I., Mezzanotte, R., & Rabinowitz, J. (1982). Scene perception: Detecting and judging objects undergoing relational violations. *Cognitive Psychology*, *14*(2), 143-177.

Biederman, I., Rabinowitz, J., Glass, A., & Stacy, E. (1974). On the information extracted from a glance at a scene. *Experimental Psychology*, *103*(3), 597-600.

Broadbent, D. (1954). The role of auditory localization in attention and memory span. *Experimental Psychology, 47,* 191-196.

Broadbent, D. (1958). *Perception and communication.* Oxford: Oxford University Press.

Bugelski, B., & Alampay, D. (1961). The role of frequencies in developing perceptual sets. *Canadian Journal of Psychology/Revue Canadienne de Psychologie*, *15*(4), 205-211.

Carmel, D. V., Rees, G., & Lavie, N. (2007). Perceptual load modulates conscious flicker perception. *Vision, 7,* 1–13.

Cosman, J. D., & Vecera, S. P. (2012). Object-based attention overrides perceptual load to modulate visual distraction. *Experiment Psychology: Human Perception and Performance, 38*, 576-579.

Chen, Z., & Cave, K. R. (2013). Perceptual load vs. dilution: the roles of attentional focus, stimulus category, and target predictability. *Frontiers in Cognition, 4*(327), 1-14.

Chun, M. M., & Jiang, Y. (1999). Top-down attentional guidance based on implicit learning on visual covariation. *Psychological Sciences, 10*, 360-365.

Davenport, J. (2007). Consistency effects between objects in scenes. *Memory & Cognition*, *35*(3), 393-401.

Deutsch, J. A., & Deutsch, D. (1963). Attention: Some theoretical considerations. *Psychological Review, 87,* 272–300.

Driver, J. A., & Tipper, S. P. (1989). On the nonselectivity of “selective” seeing: Contrasts between interference and priming in selective attention. *Experimental Psychology: Human Perception and Performance, 15*, 304-314.

Eltiti, S., Wallace, D., & Fox, E. (2005). Selective target processing: perceptual load or distractor salience. *Perception and Psychophysics, 67*, 876-886.

Eriksen, C. W., & Hoffman, J. E. (1972). Temoporal and spatial characteristics of selective encoding from visual displays. *Perception and Psychophysics, 12*, 201 204.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in nonsearch task. *Perception & Psychophysics, 16*(1), 143-149.

Forster, S., & Lavie, N. (2007). High perceptual load makes everybody equal: Eliminating individual differences in distractibility with load. *Psychological Science, 18,* 377–382.

Forster, S., Lavie, N. (2008). High perceptual load makes everybody equal: Eliminating individual differences in distractibility with load. *Psychological Sciences*.

Francikubu, C. M., & Egeth, H. E. (1980). On the nonautomaticity of "automatic" activation: Evidence of selective seeing. *Perception & Psychophysics, 27,* 331-342).

Francolini, C. M., & & Egeth, H. E. (1980). On the nonautomaticity of "automatic" activation: Evidence of selective seeing. *Perception and Psychophysics, 27,* 433-443.

Gatti, S. W., & Egeth, H. (1978). Failure of spatial selectivity in vision. *Bulletin of the Psychonomic Society, 11,* 181–184.

Gronau, N., Neta, M., & Bar, M. (2008). Integrated contextual representation for objects' identities and their locations. *Cognitive Neuroscience*, *20*(3), 372-388.

Henderson, J., & Hollingworth, A. (1999). High-level scene perception. *Annual Review of Psychology*, *5,* 243-271.

Hoffman, J. E. (1979). A two-stage model of visual search. *Perception & Psychophysics, 25,* 319-327.

Hoffman, J. E., Nelson, B., & Houck, M. R. (1983). The role of attentional resources in automatic detection. *Cognitive Psychology, 15*, 379-410.

Hollingworth, A., & Henderson, J. M. (1998). Does consistent scene context facilitate object perception? *Experimental Psychology: General, 127*(4), 398-415.

Hummel, J. E (2001). Complementary solutions to the binding problem in vision: Implications for shape perception and object recognition. *Visual Cognition, 8,* 489-517.

Johnston, W. A., & Heinz, S. P. (1978). Flexibility and capacity demands of attention. *Experimental Psychology: General*, *107*, 420-435.

Jovicich, J., Peters, R. J., Braun, J., Chang, L., & Ernst, T. (2001). Brain areas specific for perceptual load in a motion-tracking task. *Cognitive Neuroscience, 13*(8), 1048-1058.

Kinchla, R. A. (1992). Attention. *Annual Review Psychology, 43*, 711-742.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Experimental Psychology: Human Perception and Performance, 21,* 451–468.

Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in Cognitive Sciences, 9,* 75–82.

Lavie, N. (2006). The role of perceptual load in visual awareness. *Brain Research, 1080,* 91-100.

Lavie, N., & Fox, E. (2000). The role of perceptual load in negative priming. *Experimental Psychology: Human Perception and Performance, 26,* 1038–1052.

Lavie, N. (2010). Attention, distraction, and cognitive control under load. *Current Directions in Psych Science, 19*(3), 143-148.

Lavie, N., Lin, Z., Zokaei, N., & Thoma, V. (2009). The role of perceptual load in object recognition. *Experimental Psychology: Human Perception and Performance, 35*(5), 1346-138.

Lavie, N., Ro, T., & Russell, C. (2003). The role of perceptual load in processing distracter faces. *Psychological Science, 14,* 510–515.

Lavie, N., & Tsal, Y. (1994). Perceptual load as a major determinant of the locus of selection in visual attention. *Perception & Psychophysics, 56*, 183-197.

Lemaitre, G., Houix, O., Misdariis, N., & Susini, P. (2010). Listener expertise and sound identification influence the categorization of environmental sounds. *Experimental Psychology: Applied, 16*(1), 16-32.

Macdonald, J., & Lavie, N. (2008). Load induced blindness. *Experimental Psychology: HumanPerception and Performance, 34,* 1078–1091.

Moray, N. (1959). Attention in dichotic listening: affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology, 11*, 56-60.

Naatanen, R. (1990). The role of attention in auditory information processing as revealed by event-related potentials and other brain measures of cognitive science. *Behavioral Brain Science, 12*, 201-288.

Neisser, U. (1967). *Cognitive psychology*. New York: Appleton-Century-Crofts.

Neisser, U., & Becklen, R. (1975). Selective looking: Attending to visually specified events. *Cognitive Psychology, 7*, 480-494.

Oliva, A., & Schyns, P. G. (1997). Coarse blobs or fine edges? Evidence that information diagnosticity changes the perception of complex visual stimuli. *Cognitive Pyschology, 34*, 72-107.

Oliva, A., & Torralba, A. (2007). The role of context in object recognition. *TRENDS in Cognitive Sciences, 11*(12), 520-527.

Palmer, S. (1975). The effects of contextual scenes on the identification of objects. *Memory & Cognition*, *3*(5), 519-526.

Paquet, L. & Craig, G. L. (1997). Evidence for selective target processing with a low perceptual load flanker task. *Memory and Cognition, 25*, 182-189.

Pashler, H. (1984). Evidence against late selection: Stimulus quality effects in previewed displays. *Experimental Psychology: Human Perception and Performance, 75*, 522-536.

Peltonen, V. T. K., Eronen, A. J., Parvianen, M. P., & Klapuri, A.P. (2001). Recognition of everyday auditory scenes: potentials, latencies, and cues. Convention paper 5404. 110th Auditory Engineering Society Convention; *Amsterdam, the Netherlands.*

Potter, M. C. (1975). Meaning in visual scenes. *Science, 187,* 964-967.

Rock, I., & Gutman, D. (1981). The effect of inattention on form perception. *Experimental Psychology: Human Perception and Performance, 7,* 275-285.

Schwartz, S., Vuilleumier, P., Hutton, C., Maravita, A., Dolan, R. J., & Driver, J. (2005) Perceptual load and sensory competition in human vision: Modulation of fMRI responses by load at fixation during task-irrelevant stimulation in peripheral visual field. *Cerebral Cortex, 15,* 770-786.

Shcyns, P. G., & Oliva, A. (1994). From blobs to boundary edges: evidence for time and spatial scare dependent scene recognition. *Psychological Science, 5*, 195-200.

Shiffrin, R. M., Pisoni, D. B., & Castaneda-Mendez, K. (1974). Is attention shared between the ears? *Cognitive Psychology, 6*(2), 190-215.

Swallow, K. M., & Jiang, Y. V. (2013). Perceptual load and attentional boost: a review of data and theory. *Frontiers in Psychology, 4*:274.

Tipper, S. P. (1985). The negative priming effect: Inhibitory effects of ignored primes. *Quarterly Experimental Psychology, 37A,* 571–590.

Treisman, A. (1960). Contextual cues in selective listening. *Quarterly Journal of Experimental Psychology, 12,* 242-248.

Treisman, A. (1964). Monitoring and storage of irrelevant messages in selective attention. *Verbal Learning and Verbal Behavior, 3*, 449-459.

Treisman, A. (1969). Strategies and models of selective attention. *Psychological Review, 76*, 282-299.

Treisman, A., & Geffen, G. (1967). Selective attention: Perception or response? *Quarterly Experimental Psychology, 19*, 1-18.

Tsal, Y., & Benoni, H. (2010). Diluting the burden of load: Perceptual load effects are simply dilution effects. *Experimental Psychology: Human Perception and Performance, 36,* 1645-1656.

Ullman, S. (1995). Sequence seeking and counter streams: A computational model for bidirectional information flow in the visual cortex. *Cerebral Cortex, 1,* 1–11.

Wei, P., & Zhou, X. (2006). Processing multidimensional objects under different perceptual loads: The priority of bottom-up perceptual saliency. *Brain Research, 1114*(1), 113-124.

Wilson, D. E., Muroi, M., & MacLeod, C. M. (2011). Dilution, not load, affects distractor processing. *Experiment Psychology: Human Perception and Performance, 37*, 319-335.

Yantis, S., & Johnston, J. C. (1990). On the locus of visual selection Evidence from focused attention tasks. *Experimental Psychology, 16*(1), 135-149.

Yi, D. J., Woodman, G. F., Widders, D., Marois, R., & Chun, M. M. (2004). Neural fate of ignored stimuli: Dissociable effects of perceptual and working memory load. *Nature Neuroscience,* 7, 992–996.