INFLUENCES OF ABRUPT VS RAMPED STIMULUS PRESENTATION ON LOCATION-BASED INHIBITION OF RETURN

by

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(Under the Direction of James M. Brown)

ABSTRACT

Recent work has illustrated the importance of a sensory component to inhibition of return (IOR). A recent study exploring the contributions from the parvocellular (P) and magnocellular (M) pathways to location based IOR through bottom-up sensory (target spatial frequency) and top-down attentional (objects) manipulations (Brown & Guenther, 2008) suggests conditions favoring P/ventral relative to M/dorsal processing should produce greater IOR magnitude and vice versa. To further explore the roles of the P and M pathways to IOR, the present study used a different sensory manipulation presenting cues and targets either abruptly (producing a strong M response) or ramped on and off (producing a relatively weaker M response). Greater IOR was expected to ramped targets because of the weaker M response. Less IOR was expected to abrupt targets due to a greater M response. This particular sensory manipulation by itself was unable to produce differences in IOR; however, when combined with increased P/ventral activity due to the presence of objects (2-D or 3-D) differences in IOR between abrupt and ramped conditions emerged. The results highlight the importance of sensory factors on IOR and provide an example of how they can interact with other perceptual variables to influence IOR.

Index words: Attention, Location IOR, Object IOR, Parvocellular and Magnocellular Pathways, Ramped stimulus presentation

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CHAPTER 1

INTRODUCTION

Researchers studying visuo-spatial attention have often used a covert cuing paradigm to explore the allocation of attention in the environment. A covert cuing task usually involves a cue flashing on and off at a location in the periphery. After a pause, during which attention reorients back to fixation, a target is presented either at the cued or an uncued location. When the time between the cue and target is short (i.e, short stimulus onset asynchronies (SOAs)), facilitation is typically observed. Research by Posner and Cohen (1984) has shown, at longer SOAs, attention may be inhibited to return to locations previously attended. This reaction time inhibition (RTI), later termed inhibition of return (IOR) (Posner, Rafal, Choate, & Vaughan, 1985) has been explored using a variety of stimuli and methods. Differing from the common attentional account, Posner & Cohen (1984) originally described RTI as a sensory rather than an attentional phenomenon. It was with Posner et al. (1985) that the attentional account first emerged. Recent research has challenged a purely attentional account of IOR illustrating the importance of sensory effects on IOR (Bell, Fecteau, & Munoz, 2004; Brown & Guenther, 2008; Chica, Lupiáñez, & Bartolomeo, 2006). If there is a sensory component to IOR then it can be argued that sensory manipulations of relative processing along the parvocellular (P) and magnocellular (M) retino-geniculo-cortical visual streams can be used to explore the sensory effects of stimulus manipulations on IOR. Recently, the potency of manipulating stimulus (bottom-up) as well as attentional (top-down) variables to influence IOR was demonstrated by Brown and Guenther

(2008). The present research expands on their work by manipulating temporal stimulus characteristics to examine the relationship between P and M activity and IOR.

Previous studies exploring the relationship between attention and P and M activity (Roth & Hellige, 1998; Srinivasan & Brown, 2006; Yeshurun, 2004; Yeshurun & Carrasco, 1999; Yeshurun & Levy, 2003) have found evidence that attention may be related more to P than M activity. Of the different cell types in the retina, midget ganglion cells (P cells) project along the P pathway (Leventhal, Rodieck, & Dreher, 1981; Perry, Oehler, & Cowey, 1984), are smaller, have smaller receptive fields (Shapley & Perry, 1986), and dominate near the fovea (Dacey, 1993), compared to cells projecting along the M pathway. Thus, a characteristic feature differentiating the P and M pathways is their preferential processing of high and low spatial resolutions respectively (Breitmeyer & Ganz, 1976; Livingstone & Hubel, 1987, 1988). Utilizing this difference, Srinivasan and Brown (2007) endogenously cued targets that were either high spatial frequency (sharp-edged) or low spatial frequency (blurred) line segments. Typical cuing effects were found for both sharp-edged and blurred line segments in a simple detection task; however, typical cuing effects were only found for the sharp-edged target when the task involved target identification. Responses to blurred targets were not effected by whether they were validly (attended) or invalidly (unattended) cued. This suggests P activity may be more associated with attended processing while M activity may be more associated with unattended processing.

Further support of an attentional mechanism favoring P over M processing comes from studies by Yeshurun and colleagues exploring the influence of transient spatial attention on both spatial (Yeshurun & Carrasco, 1999) and temporal resolution (Yeshurun, 2004; Yeshurun & Levy, 2003). Consistent with the smaller receptive fields of P cells (and the notion of an attentional mechanism favoring P processing), Yeshurun and Carrasco (1999) found increases in spatial resolution at cued locations. Further work, by Yeshurun & Levy (2003), found that while spatial attention increases spatial resolution it also decreases temporal resolution which is consistent with the slower and longer response properties of P relative to M cells. To explain this, they proposed an attentional mechanism in which spatial attention facilitates P activity which in turn inhibits M activity at the same location. By using stimulus conditions favorable to P processing (reducing M activity), thereby reducing the ability for P on M inhibition to occur, Yeshurun (2004) found the decreased temporal resolution at the attended location was greatly reduced (e.g., isoluminant) or eliminated (e.g., red background).

Most relevant to the present study is evidence showing a relationship between location IOR magnitude and activity along the P/ventral and M/dorsal streams through manipulations of stimulus spatial frequency and the presence or absence of objects (Brown & Guenther, 2008). IOR magnitude was less for low spatial frequency stimuli expected to favor M pathway processing and greater for high spatial frequency stimuli expected to favor P pathway processing. Object processing should be related more to P compared to M processing since the perception and identification of objects is controlled primarily by activity along the ventral stream (Baizer, Ungerleider, & Desimone, 1991; Goodale & Milner, 1992; Livingstone & Hubel, 1987) which, receives dominant input from the P pathway (Baizer et al., 1991; Previc, 1990), (also see, Goodale & Milner, 1992; Nassi & Callaway, 2006; Nassi, Lyon, & Callaway, 2006). Consistent with research on object- and location-based effects in IOR (Jordan & Tipper, 1998; Leek, Rippa, & Tipper, 2003; McAuliffe, Pratt, & O'Donnell, 2001; Tipper, Weaver, Jerreat, & Burak, 1994) IOR magnitudes increased with 3-D objects compared to without objects (however, see below). Additional findings, consistent with proposed influences of spatial frequency and visual field

(VF) processing (see Previc, 1990), indicated IOR magnitude was influenced by whether targets appeared in the P dominant upper VF or in the M dominant lower VF dependent on its spatial frequency. The finding of greatest interest was the conditions with the most M bias (low spatial frequency, no-objects, lower VF) yielded the least IOR (or no IOR in one case) with greater IOR found when one or more condition favored P processing.

The current study expands upon Brown & Guenther's (2008) work by manipulating relative P and M activity in a different way to explore their role in visuo-spatial attention. The primary manipulation was whether stimuli were presented abruptly (on/off) or ramped (gradual/ramped increase/decrease in luminance). It is important to note (as with the Brown & Guenther study) that manipulations of P and M activity are not absolute and the specific magnitude of activity along each pathway is unknown. It is assumed all stimuli generate both P and M responses. The P pathway would process both gradual and abrupt stimulus onsets well, while the M pathway would respond more strongly to abrupt compared to gradual onsets (Breitmeyer, 1984). From the perspective proposed here, relative to a standard, or a baseline balance of activity, any manipulation increasing P (or decreasing M) activity can be thought of as shifting the balance towards a relatively greater P response. Likewise, any manipulation increasing M (or decreasing P) activity can be thought of as shifting the balance towards a relatively greater M response. In the context of the present experiments, relatively less M activity would be expected to ramped/gradual compared to abrupt stimulus onsets with P activity less affected. Based on Brown and Guenther's (2008) results, ramped onsets (favoring P processing) were expected to result in greater IOR magnitudes than abrupt onsets (favoring M processing).

In addition to the influence of spatial frequency (bottom-up, sensory), Brown & Guenther (2008) found the presence or absence of 3-D objects (top-down, attentional) contributed to P/ventral and M/dorsal based influences on location-based IOR. Therefore, the present experiment also tested whether location-based IOR is influenced by the presence or absence of objects as well as whether the objects were 2-D or 3-D. Stimuli were presented either against a blank grey background or within the boundaries of two-dimensional, outline squares or three-dimensional, cube-shaped objects (see Figure 1). There is evidence of increased IOR with objects (Jordan & Tipper, 2003; Leek et al., 2003; Tipper et al., 1994) but, McAuliffe et al (2001) did not find object related increases in IOR (for 10 out of 12 conditions) when comparing 2-D square object (i.e., placeholders) and no-object conditions both in a blocked (Experiment 2) and randomized (Experiment 3) design. They did however; find object related increases in IOR when the targets could appear in locations within or outside objects in the same display. We might interpret this as locations within the objects having relatively increased P/ventral processing compared to locations outside of the objects. For the present study this may suggest objects will interact with presentation mode to influence IOR. Using 3-D object and no object conditions, Brown & Guenther (2008) found a general increase in IOR when the objects were present. Of particular interest was the way objects interacted with the manipulation of target SF, holding their greatest influence on IOR magnitude in the condition that most favored M processing (low SF, lower visual field). The increase of P/ventral processing by the addition of the objects, in their study, had a strong effect on the low SF target in the lower VF causing large increases in IOR magnitude. These results suggest the influences of objects on IOR may be related to how they shift or alter the balance of P/ventral and M/dorsal activity and how they interact with stimulus variables. The 2-D display (and blocked design) used in the present experiment is similar to that used by McAuliffe et al (2001) so general increases in IOR magnitude with the presence of objects in the display may not be found; however, the objects were expected to influence the relative balance of P/ventral and M/dorsal activity. If so the interaction between the top-down, attentional effects related to object perception and the bottom-up, sensory effects related to stimulus presentation may influence any observed IOR effects. The final factor of interest was the VF of stimulus presentation. Our previous study (Brown & Guenther, 2008) suggests IOR magnitude may be influenced when stimuli are presented in the P dominant upper or M dominant lower VF (see Previc, 1990). Brown and Guenther's (2008) VF effects were most evident in the way they interacted with other stimulus variables expected to produce a more M/dorsal dominant scenario (low spatial frequency target, no-objects, lower VF). Similar VF effects may be found in the present experiment; however, since the manipulation of stimulus presentation type generates separate conditions through a stronger M response to abrupt compared to ramped targets (i.e., the level of P activity may be unaffected) manipulating the temporal nature of the stimuli may not be as effective a sensory manipulation as spatial frequency. The present experiment also presented stimuli in the left and right VFs. While Previc (1990) proposed the upper and lower VFs receive relatively larger P and M contributions respectively, P and M contributions to left and right hemispheres are not well defined thus no clear predictions were made but any observed differences may be informative.

CHAPTER 2

METHOD

Participants

Two hundred forty-three undergraduates participated for course credit. All participants had normal or corrected to normal vision, and were classified as right handed according to the Annett Handedness Scale.

Stimuli and apparatus

Stimuli were presented and data collected using E-Prime software running on a PC computer using a color monitor running at 85 Hz. Responses were collected from a standard QWERTY keyboard. Participants sat in a darkened room 191.8 cm from the monitor using a chin rest.

Stimuli were presented on a gray background (mean luminance 13 cd/m^2). Cues and targets were square shaped subtending 0.4° and 0.6° respectively and were centered 2.1° from the fixation point which consisted of a 0.1° dot presented at center screen. Cues and targets either appeared alone (no-objects) or within the boundaries of 2-D objects or 3-D objects. 2-D objects (outline squares) subtended 0.8° and were defined by a 0.03° thick line. The cube shaped, 3-D objects (see Figure 1) were presented against a light gray background (mean luminance 39 cd/m^2) and were made up of three different shades of gray (top = 27 cd/m^2, side = 7 cd/m^2, front = 13 cd/m^2). The front of the cube was a square subtending 0.8°. The top and side of the cube subtended 0.2° perpendicularly from the edge. The fixation point was placed on a similar object using a 0.5° x 0.8° bar (instead of a square) for the front surface. Objects were centered surrounding 2.1° from the fixation dot and cues and targets were presented in the center of the objects (which were the same respective locations when objects were absent).

Cues and targets were either presented abruptly or ramped depending on the condition of the experiment. Abrupt cues and targets had a mean luminance of 66 cd/m^2 and ramped cues and targets appeared as a rapid progression of 10 stimuli of increasing luminance from 13 cd/m^2 (local background luminance) to the full intensity of 66 cd/m^2 (with the 10^{th} step representing full luminance intensity) over 106 ms (sequence: 18, 23, 29, 34, 40, 45, 50, 55, 61, 66 cd/m^2). Each frame in this progression was matched to the refresh rate of the monitor (11.76 ms/frame) and the cue then remained at full intensity for 388 ms before disappearing in 10 decreasing steps over 106 ms. Cue duration was 600 ms for both abrupt and ramped conditions.

One issue that arises when using a ramped stimulus presentation is the question of when the stimulus becomes visible enough for participants to begin a response. To address this issue a control experiment was conducted in which cues were presented as in the ramped conditions and the targets were presented as in the abrupt condition. Targets had a luminance of 18 cd/m^2 (step 1) or 40 cd/m^2 (step 5) depending on the condition. If there are no differences between the RTs to these two targets (or to the final, step 10) then RT data between abrupt and ramped conditions could be directly compared.

Design

The experiment was set up in a 2 (stimulus presentation: abrupt vs. ramped) x 2 (location: cued vs. uncued) x 2 (direction of shift: left/right vs. upper/lower) x 3 (objects: no objects, 2-D objects, or 3-D objects) design. Direction of shift and object conditions were between-subjects variables (creating six groups) while all other variables were within-subjects. The control experiment was set up in a 2 (target intensity: 18 vs. 40 cd/m^2) x 2 (Location: cued vs. uncued) x 2 (target position: left vs. right) within-subjects design.

Procedure

Each session consisted of two blocks, one block for each method of stimulus presentation (abrupt vs. ramped or 18 vs. 40 cd/m^2 for the control experiment). The order of block presentation was counterbalanced across participants. Each block consisted of 10 practice trials followed by 100 randomly presented experimental trials. There was a short break between blocks. The within-subjects factors created a design generating 4 conditions, each receiving 20 trials. Twenty catch trials, in which no target was presented, were included in each block.

Due to the importance of spatiotemporal stimulus parameters for producing location-based IOR (Collie, Maruff, Yucel, & Currie, 2000; McAuliffe & Pratt, 2005; Pratt & Fischer, 2002; Pratt, Hillis, & Gold, 2001), we chose timing parameters (e.g., cue duration, cue-to-target interval) known to produce location-based IOR. Each trial began with the participant directing their gaze at the fixation stimulus in the center of the screen, starting each trial by pressing the space bar with their left hand. 1000 ms after the starting the trial, a cue appeared for 600 ms. In the ramped condition the luminance intensity was gradually increased and decreased whereas in the abrupt condition the cue simply appeared and disappeared. The stimulus onset asynchrony (SOA) was 800 ms with an interstimulus interval (ISI) of 200 ms. The target then appeared at full intensity (for the abrupt condition), low or medium intensity (control experiment), or gradually appeared (in the same manner as the cue) and the participant responded by pressing the '0/Ins' key on the keyboard with their right index finger. An empty, medium gray screen was presented for 750 ms between trials and the return of the fixation stimulus signaled that the next trial was ready to begin. If a participant responded during a catch trial an error message was presented at center screen.

CHAPTER 3

RESULTS

27 participants (11%) were excluded from data analysis due to excessive false alarms (FAs) (20% and above) on one or both blocks of trials, leaving a total of 216 participants (36 per condition). Trials in which RTs (measured from when the target first appears) were less than 150 ms and greater than 1000 ms were excluded prior to data analysis. Each participant's mean RTs were calculated for each condition. After FA exclusions and trimming, any participant whose means on one or more conditions (RT or IOR) were beyond 2.5 standard deviations of the mean were also excluded from data analysis. After this process of trimming outliers, the remaining number of participants were as follows. For the left/right direction of shift: no objects, 32 (15 female); 2-D objects, 32 (14 female); 3-D objects, 32 (16 female). For the upper/lower direction of shift: no objects, 33 (16 female); 2-D objects, 30 (15 female); 3-D objects, 33 (16 female). Mean FA rate for each condition was 6%. FA exclusion and trimming criteria applied to the control experiment resulted in 1 participant (5%) being excluded due to excessive FAs. After trimming outliers, 17 (13 female) participants remained with a mean false alarm rate of 6%

RT data for each condition were first submitted to separate 2 (location: cued vs. uncued) x 2 (position: left vs. right) repeated measures ANOVAs to determine if location-based IOR was present (i.e., RT at cued location greater than uncued RTs). These analyses revealed that all conditions produced location-based IOR (see Table 1).

Sensory manipulations influencing relative P and M activity should be evident in RT data with reduced RTs to more M based stimuli. Since the primary manipulation was of this nature, it would be informative if RTs between abrupt and ramped conditions could be directly compared. To determine if RTs could be directly compared between abrupt and ramped conditions, mean RT data from the two target luminances in the control condition were submitted to a paired-samples *t*-test revealing no differences between them (340 vs. 331 ms) t (16) = 1.62, $p > .12$, suggesting RTs between abrupt and ramping conditions can be directly compared. As an added measure, each of the conditions from the control experiment were also compared to a sample of data (matched for gender, 13 females and 4 males (without objects, left/right direction of shift)) with a full intensity target (i.e., step 10 in the ramped presentation) from the abrupt condition revealing no differences in RTs between targets with luminance values for step 1 (340 ms) and step 10 (334 ms) t (32) = .49, p >.62 or step 5 (331 ms) and step 10 (334 ms) t (32) = -.19, p >.85. These analyses indicate participants were able to see and initiate a response to the gradually presented stimulus from the start of the first frame of the ramp sequence. Therefore, RTs between abrupt and ramped conditions were directly compared by adding 106 ms to the mean RT data in the ramped condition for each participant. The reason for adding 106 ms was because responses in the ramped conditions were recorded from the start of the last frame of the ramp sequence, and the time between the start of the first frame and the start of the last frame was 106 ms.

The RT data from each between subject condition were submitted to 2 (presentation: abrupt vs. ramped) x 2 (position: upper vs. lower; left vs. right) x 2 (location: cued vs. uncued) repeated measures ANOVAs. These comparisons demonstrated (across all conditions) the sensory effects expected of reduced M activity (Breitmeyer, 1975) with increased RTs for ramped (P) compared to abrupt (M) conditions. Without objects, RTs in the ramped condition were 16 ms longer $F(1,31) = 23.94$, $\eta_2^2 = .45$, $p < .01$ in the left/right direction and 19 ms longer

$F(1,32) = 18.53$, $\eta_2^2 = .37$, $p < .01$ in the upper/lower direction. The increase in RTs to ramped stimuli with 2-D objects was 21 ms in both the left/right $F(1,31) = 25.94$, $\eta_2^2 = .46$, $p < .01$ and upper/lower $F(1,29) = 23.18$, $\eta_2^2 = .44$, $p < .01$ shift directions. With 3-D objects, the increase in RTs to ramped stimuli were 21 ms for left/right $F(1,31) = 12.39$, $\eta_2^2 = .29$, $p < .01$ and 20 ms for upper/lower $F(1,32) = 14.94$, $\eta_2^2 = .32$, $p < .01$. RT analyses, collapsed over abrupt and ramped, also revealed main effects of position with increased RTs for stimuli presented in the left VF for no object $F(1,31) = 10.93$, $\eta_2^2 = .26$, $p < .01$, 2-D object $F(1,31) = 10.55$, $\eta_2^2 = .25$, $p < .01$, and 3-D object $F(1,31) = 10.89$, $\eta_2^2 = .26$, $p < .01$ conditions. However, without objects, these position effects were only found in the ramped condition, 14 ms $t(31) = 4.09$, $p < .01$ (no difference in abrupt condition $p > .28$).

Mean IOR values were then calculated for each participant by subtracting the RT at a location when it was cued from when it was uncued. IOR data from each between subject condition were submitted to 2 (presentation: abrupt vs. ramped) x 2 (position: upper vs. lower; left vs. right) repeated measures ANOVAs. IOR analyses revealed no effect of ramping in the no object condition with a left/right direction of shift ($p > .3$) and a near significant effect for the upper/lower direction $F(1,32) = 4.01$, $\eta_2^2 = .11$, $p = .054$. Probing the results from the upper/lower direction of shift (no object condition) indicates that there was a 17 ms increase in IOR magnitude to the ramped target which only occurred in the lower visual field $t(32) = -3.08$, $p < .01$.

When 2-D objects were present IOR magnitude was 11 ms greater in the ramped condition in the left/right $F(1,31) = 4.82$, $\eta_2^2 = .14$, $p < .05$ and 17 ms in the upper/lower $F(1,29) = 7.27$, $\eta_2^2 = .20$, $p < .05$ directions of shift. When 3-D objects were present IOR magnitude was

14 ms greater for the ramped condition in the left/right $F(1,31) = 7.31$, $\eta_2^2 = .19$, $p < .05$ and 12 ms greater in the upper/lower $F(1,32) = 6.99$, $\eta_2^2 = .18$, $p < .05$ directions of shift. The type of objects used (2-D box outline or 3-D cube) did not result in any differences.

There were no influences of VF in the left/right shift direction. In the upper/lower shift direction VF had an affect for the no-object condition with a 10 ms increase in IOR magnitude in the lower VF $F(1,32) = 4.51$, $\eta_2^2 = .12$, $p < .05$ and for the 2-D object condition with an 11 ms increase $F(1,29) = 5.12$, $\eta_2^2 = .15$, $p < .05$. The fact that these VF effects did not interact with the type of presentation, and were not found in the 3-D object condition makes it difficult to interpret and relate these results to Brown & Guenther’s (2008) study where the VF effects had a clear interaction with the presence of 3-D objects and target SF.

CHAPTER 4

GENERAL DISCUSSION

Previous research by Brown & Guenther (2008) manipulated the relative balance of P and M activity finding relatively greater P activity to be associated with increased IOR and relatively greater M activity to be associated with decreased IOR. To further examine the roles of the P and M pathways in location-based IOR, the present research employed abrupt versus ramped stimulus presentations to manipulate the relative balance of P and M activity. It was predicted that since ramped stimuli would be processed less efficiently by the M system, ramped and abrupt stimuli would represent conditions of relatively less M (i.e., greater P) and relatively greater M activity respectively.

One characteristic difference between ramped and abrupt stimulus presentations is that the appearance of a ramped stimulus is modulated over time (in the present case: a rapid increase in luminance). As a result of this difference, and noting the ability to detect and respond to a stimulus is related to its duration, Breitmeyer & Julesz (1974) questioned how the duration of a ramped stimulus can be defined. Similarly we questioned the ability to directly compare RTs between ramped and abrupt conditions; however, due to the importance of RT analyses for demonstrating the sensory effect on RTs from relative differences in P and M processing this issue was addressed with a control experiment. The lack of RT differences within control conditions and between the control and abrupt condition provided justification for direct RT comparisons between abrupt and ramped conditions. These comparisons demonstrated (across all conditions) the sensory effects expected of reduced M activity (Breitmeyer, 1975) with increased RTs for ramped (reduced M) compared to abrupt (M) conditions. Importantly this confirmed the ramping manipulation had the desired sensory effect creating two conditions differing in their levels of M activity. Further examinations of the RT data showed increases in RT to targets presented in the left visual field (a right visual field advantage (VFA)). Although some other studies, using simple detection RTs, report left VFAs (Davidoff, 1977; Umilta, Salmaso, Bagnara, & Simion, 1979) results in the literature have been mixed (see Christman & Niebauer, 1977 for a review).

Earlier work suggests IOR is influenced by sensory variables (Bell, et al, 2004; Brown & Guenther, 2008; Chica, et al , 2006; Posner & Cohen, 1984), thus the sensory manipulation of ramping was predicted to influence IOR. However, IOR analyses on the no object conditions failed to demonstrate a main effect of ramping on IOR (near significant effect in the upper/lower VF). Using manipulations of stimulus spatial frequency combined with the presence or absence of objects, Brown & Guenther (2008) created conditions expected to increase P/ventral processing (presence of objects, high SF targets) and one condition expected to strongly favor M/dorsal processing (no objects, low SF targets, lower VF). The stimuli used in the present experiment would have contained a broad range of spatial frequencies with no particular condition strongly favoring M/dorsal processing. Thus, the absence of a ramping effect in the no object condition may simply be a result of a weaker sensory manipulation of P and M activity (even though RT analyses confirmed the presence of a sensory effect). This is supported by the emergence of ramping related differences when other variables (objects) were added to further manipulate the relative levels of P/ventral and M/dorsal activity.

In addition to the influence of spatial frequency, Brown & Guenther (2008) found the presence or absence of 3-D objects contributed to P and M based influences on location-based

IOR. Their results suggest top-down stimulus manipulations (such as objects) may interact with bottom-up stimulus variables, together altering the balance of P/ventral and M/dorsal activity thereby influencing IOR magnitude. Since the present experiment used a blocked design similar to McAuliffe et al (2001), general increases in IOR magnitude with the presence of 2-D objects was not expected; however, the addition of objects did influence the relative balance of P/ventral and M/dorsal activity (e.g., objects should create relatively greater P/ventral activity) interacting with the ramping manipulation such that ramping based effects on IOR were observed when objects were present. Overall IOR magnitudes did not increase with objects, indicating the objects did not directly influence IOR. Instead they interacted with the temporal aspects of the stimuli increasing IOR for ramped (weaker M) compared to abrupt (M) conditions. Whether the objects were 2-D or 3-D produced the same results.

Using strong stimulus manipulations to influence relative P and M processing, Brown & Guenther (2008) found a relationship between location-based IOR and the balance of P and M activity with greater P activity associated with increased IOR and greater M activity associated with decreased IOR. The present study used a similar design (stimulus and display dimensions), and offers additional support for the relationship between relative P activity and greater IOR and greater M activity with less IOR through the use of a different manipulation of relative P and M activity. When objects were present, conditions predicted to favor P/ventral processing (ramped) resulted in increased IOR compared to conditions expected to favor M/dorsal processing (abrupt).

Although the present experiment succeeds in producing a sensory manipulation of relative P and M activity (influencing IOR) it suggests that ramping versus abrupt stimulus presentation alone may not be an optimal way to explore P/ventral and M/dorsal based influences on IOR. One important difference between this study and Brown & Guenther's (2008) is that the SF manipulation was able to produce conditions with strong relative preferences for P and M processing while the present experiment produced conditions primarily favoring stronger M and weaker M (i.e., relatively more P) responses.

The present results ultimately supports the literature indicating an attentional system relatively more associated with P than M processing (Brown & Guenther, 2008; Srinivasan & Brown, 2006; Yeshurun, 2004; Yeshurun & Carrasco, 1999; Yeshurun & Levy, 2003) and illustrates the importance of sensory information in the IOR effect (Bell, et al, 2004; Brown & Guenther, 2008; Chica, et al , 2006; Posner & Cohen, 1984). The present research (combined with Brown & Guenther, 2008) provides an interesting perspective from which IOR research can be viewed. For example research on object-based effects on IOR has debated the mechanism through which objects hold their influence. Objects have often been found to increase the magnitude of observed IOR effects (Jordan & Tipper, 1998; Leek, et al., 2003; McAuliffe, et al., 2001; Tipper, et al., 1994), while experiments using static displays (Leek, et al., 2003; Jordan & Tipper, 1998) have often found IOR magnitudes that are greater than those observed in moving displays (Tipper, et al., 1994). If reduced IOR magnitudes are associated with relative increases in M over P processing then an alternate explanation for the differences between static and moving displays could be related to the increased dorsal processing associated with the movement of the stimulus across the visual field.

Posner & Cohen (1984) attributed the origins of the IOR effect (or RTI as it was then called) to changes in stimulus energy at the cued location. Shortly thereafter, the more common "attentional" account of IOR emerged. From this, a great deal of research has been conducted elucidating many forms and varieties of IOR providing a wealth of information about what IOR is, how it can be observed, and how it can be created (for a review, see Klein, 2000; Lupiáñez, Klein, & Bartolomeo, 2006). For example, IOR has also been found for non-spatial attributes such as shape (Riggio, Patteri, & Umiltà, 2004), color (Law, Pratt, & Abrams, 1995), and line length (Francis & Milliken, 2003). Additionally, IOR has also been found both with exogenous and endogenous cuing as well as in detection and discrimination tasks (e.g., Pratt & Abrams, 1999; Lupiáñez, Milán, Tornay, Madrid, & Tudela, 1997, also see Lupiáñez et al., 2006). Another line of research has focused on determining the temporal nature (or time course) of IOR (for a review, see Samuel & Kat, 2003) indicating the stability of IOR across a large timeframe. In returning to sensory variables, the present work (also see: Brown & Guenther, 2008; Sumner, Nachev, Vora, Husain, & Kennard, 2004) uses psychophysical techniques to increase understanding of how this phenomenon occurs. For example, many studies have explored collicular and cortical mechanisms of IOR (see Berlucchi, 2006; Lupiáñez et al., 2006). Through the use of S cone stimuli (which are not processed by the superior colliculus), Sumner and colleagues (2004) used a simple psychophysical manipulation and offered strong evidence for separate collicular and cortical IOR mechanisms. Along with Brown & Guenther (2008), the present work again uses a simple psychophysical manipulation and offers evidence for differences in IOR magnitude related to relative P/ventral and M/dorsal processing as well as indicating the importance of both sensory and attentional variables on IOR. Future studies will need to continue considering the importance of stimulus variables to IOR and how they can be manipulated to further our understanding of the mechanisms behind IOR.

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Figure 1: Example of stimuli used in 3-D object conditions

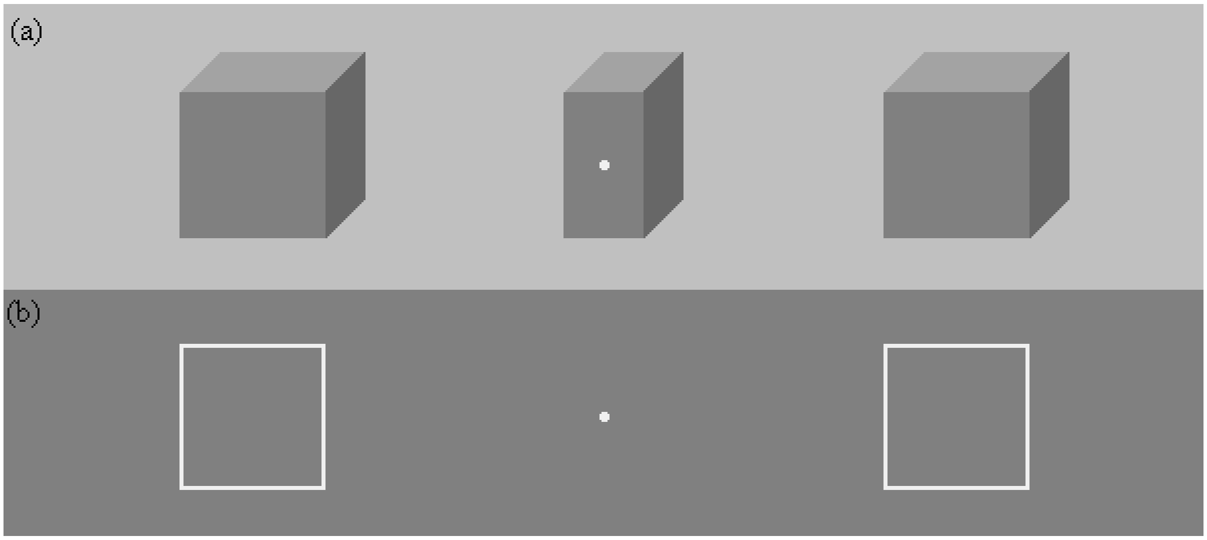

Figure 2: Mean IOR values for the left/right shift direction

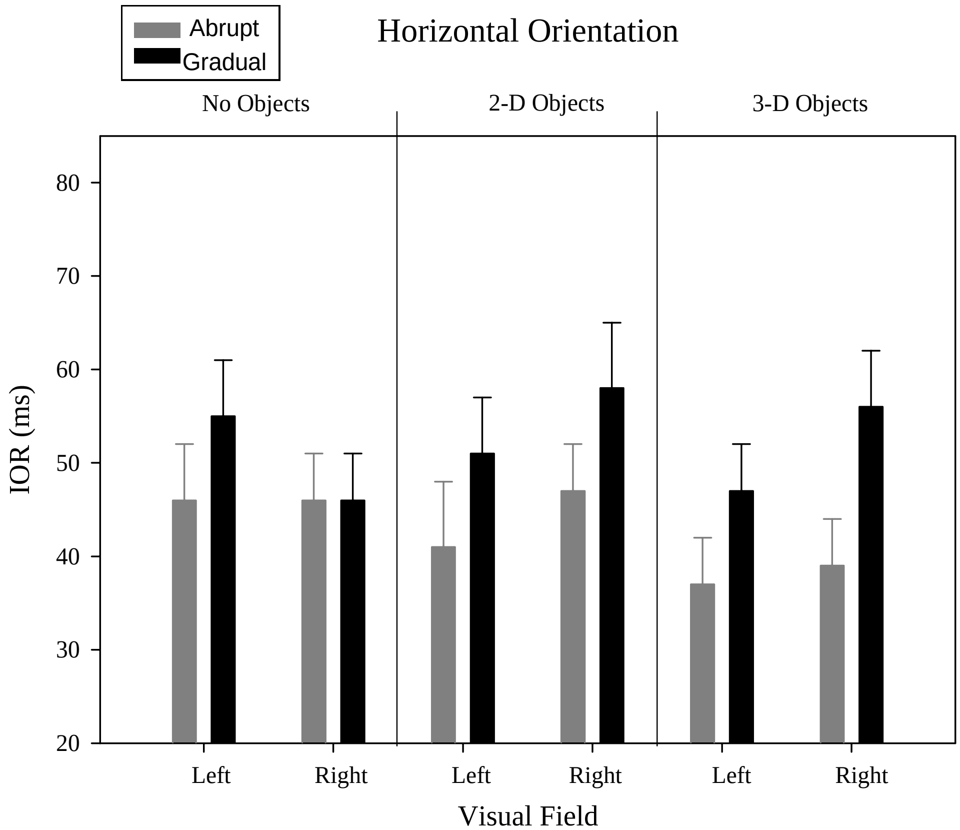

Figure 3: Mean IOR values for the upper/lower shift direction

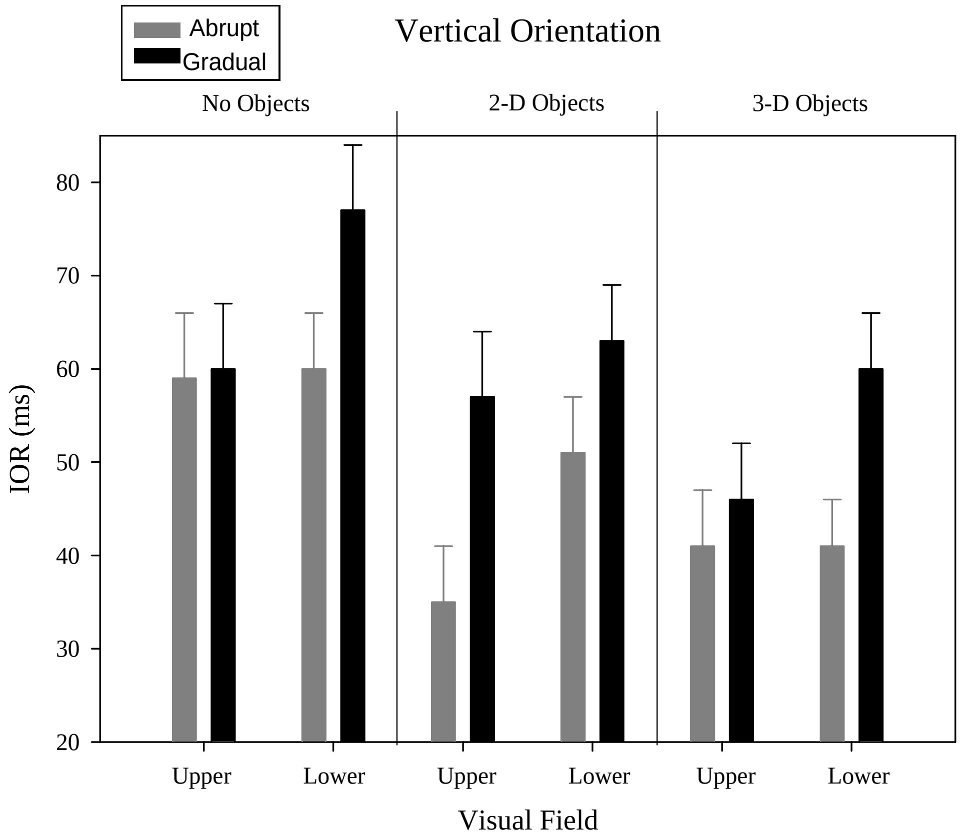

Table 1: Mean RT data indicating the presence of location based IOR

			Cued RT (ms)	Uncued RT (ms)	***IOR*** (ms)	($p < .01$)
No Objects	Horizontal	Abrupt	336	290	***46***	$F(1,31) = 94.43$, $\eta_2^2 = .75$
		Gradual	354	304	***20***	$F(1,31) = 110.90$, $\eta_2^2 = .78$
	Vertical	Abrupt	344	285	***59***	$F(1,32) = 115.17$, $\eta_2^2 = .78$
		Gradual	368	299	***69***	$F(1,32) = 121.89$, $\eta_2^2 = .79$
2-D Objects	Horizontal	Abrupt	324	280	***44***	$F(1,31) = 98.05$, $\eta_2^2 = .76$
		Gradual	351	296	***55***	$F(1,31) = 75.96$, $\eta_2^2 = .71$
	Vertical	Abrupt	327	284	***43***	$F(1,29) = 93.36$, $\eta_2^2 = .76$
		Gradual	357	297	***60***	$F(1,29) = 110.36$, $\eta_2^2 = .79$
3-D Objects	Horizontal	Abrupt	333	296	***37***	$F(1,31) = 72.57$, $\eta_2^2 = .71$
		Gradual	359	311	***48***	$F(1,31) = 77.39$, $\eta_2^2 = .71$
	Vertical	Abrupt	335	294	***41***	$F(1,32) = 88.84$, $\eta_2^2 = .74$
		Gradual	361	308	***53***	$F(1,32) = 108.30$, $\eta_2^2 = .77$

* Statistical analyses determining the presence/absence of location based IOR on RT data for each condition was conducted on the original raw data. Here, for ease of comparison, RT data for the gradual presentation conditions are presented in their adjusted form (raw + 106 ms).