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Covert Visual Spatial Attention: Effects Of Voluntary And Involuntary Attention On Channel Enhancement And Channel Selection

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COVERT VISUAL SPATIAL ATTENTION: EFFECTS OF VOLUNTARY AND
INVOLUNTARY ATTENTION ON CHANNEL ENHANCEMENT AND CHANNEL
SELECTION

A Thesis

Presented to

The Faculty of the Department of Psychology

San José State University

In Partial Fulfillment

of the Requirement for the Degree

Master of Arts

By

Rocio Luna

May 2014

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The Designated Thesis Committee Approves the Thesis Titled

COVERT VISUAL SPATIAL ATTENTION: EFFECTS OF VOLUNTARY AND
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SELECTION

by

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APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

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May 2014

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ABSTRACT

COVERT VISUAL SPATIAL ATTENTION: EFFECTS OF VOLUNTARY AND INVOLUNTARY ATTENTION ON CHANNEL ENHANCEMENT AND CHANNEL SELECTION

by Rocio Luna

The ability to fixate ones eyes on one object while attending to another object is known as covert visual attention. The present study investigated the effects of covert visual attention on reaction time (RT) and accuracy while manipulating cue types (i.e., informative and non-informative) and validity (i.e., valid and invalid) in two experiments. The results of the RT experiment revealed a main effect of validity and an interaction between cue types and cue validity. However, there was no main effect of attention type. The results of the Accuracy experiment were very similar; there was a main effect of validity but none for attention type, and there was an interaction of the two variables. These results provide evidence that voluntary attention may be causing channel enhancement. Some claim that involuntary attention may lead to channel selection, but this was not supported in the results. Further research should be conducted to better determine the process that occurs with involuntary attention.

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Introduction

Some of our visual tasks involve fixating on one object in our environment while attending to another object. For example, in the classroom, students may fixate on the professor but deploy their attention to the clock, or a parent may be looking at a magazine while attending to the children in the pool. Posner (1980) described attention as a spotlight, suggesting that attention can be linked to a spotlight. This may enhance the efficiency of detecting a target when influenced by information. The ability to fixate one's eyes on one object while attending to another object is known as *covert visual attention* (Posner, 1980). This is different from overt attention in that attention is not focused on the fixation object. Covert visual attention has been investigated extensively for many years and continues to be a dominant topic in vision research.

Humans and animals depend on covert visual attention for survival purposes, such as the ability to locate and avoid predators or environmental dangers while fixating on another object. For example, humans use covert visual attention while driving to avoid collisions with other vehicles. When driving, individuals stare ahead to avoid collisions in front of them while also attending to their surroundings at the same time without moving their eyes. Specifically, individuals may be looking straight ahead, but they may still be attending to cars or objects to the left or right of them without moving their eyes. Without covert visual attention, simple tasks such as driving can pose great risks to the drivers as well as those around them. Covert visual attention is also essential for the survival of animals. Animals use this skill to avoid predators that threaten their existence.

For example, deer may be fixating on food while still attending to their peripheral vision for predators, such as wolves or mountain lions.

Many researchers have studied covert visual attention over the years. Posner (1980) suggested that covert attention could be measured with the same amount of precision as overt attention. In general, covert visual attention is studied by using the spatial cueing paradigm originally developed by Michael Posner (Posner, 1980). Participants in this task perform target detection or target identification. Typically, this task involves a cue followed by a target display with a predetermined target (see Figure 1). The cue is used to potentially drive attention towards (i.e., valid cues) or away (i.e., invalid cues) from a target location, which will be discussed in more detail later. For example, participants must identify if they saw the letter “F” or “T” in the target display, while being potentially influenced by the cue. In valid trials, the cue identifies the correct target location. During invalid trials, the cue does not correctly identify the target location.

Figure 1. Spatial Cueing Paradigm. This is a typical spatial cueing paradigm seen in Gibson and Davis (2011). Participants must identify if they see an “F” or “T” in the target display. This cue is invalid in that it does not accurately cue the target location.

In general, if a stimulus is cued by a valid cue, also known as a *predictive cue*, the valid cue will first attract attention to the cued stimulus, which is accompanied by decreased attention to the non-cued stimuli. On the other hand, invalid cues, also known as *non-predictive cues*, do not attract attention to any particular stimulus. Results typically show that target detection reaction times (RTs) are faster on valid trials than on invalid trials (i.e., non-predictive), known as the *cue-validity effect* (Gibson & Kingstone, 2006; Qian, Shinomori, & Song, 2012). These findings suggest that participants are capable of shifting their attention to the cued location prior to the appearance of the target without moving their eyes from the fixation point (Posner, 1980). Also, invalid information has been found to produce slower RTs and poorer accuracy (Jonides, 1981). These effects are often taken as a “signature that attention had been oriented to the cued location” (Gibson & Kingstone, 2006, p. 622). The spatial cueing paradigm has become the standard method used when studying covert visual attention.

In the visual attention literature, two types of covert visual attention have been identified, voluntary and involuntary attention. In general, voluntary attention is the ability to control visual attention. For example, if an individual is looking for his family in the airport and knows they will be coming out of the terminal on the right, then the individual would focus their attention on the terminal to the right. Involuntary attention is generally thought of as the opposite of voluntary attention: the inability to control attention. Involuntary attention is when attention is shifted without intention. For example, if the individual is attending to the terminal on the right side and notice people walking out of the terminal on the left side, the individual may automatically turn their

attention to the people (even though he knows his family will not be coming out of that terminal), triggering involuntary attention. Voluntary attention is thought of as the *ability* to control attention, and involuntary attention is thought of as the *inability* to control attention (Posner, 1980).

Previously, voluntary attention had been associated with central cues, and involuntary attention had been associated with peripheral cues (Prinzmetal, McCool, & Park, 2005a). In general, central cues are cues that appear in the center of a target display, and peripheral cues appear in the periphery of a target display (see Figure 2). Peripheral cues, such as abrupt-onset cues, have been found to have a robust effect on visual attention (Logan, 1995) and were thought to only trigger involuntary attention. This was assumed because peripheral cues stimulated an automatic response versus a controlled response. Central cues, such as arrow cues, were thought to require cognitive interpretation before directing attention (Logan, 1995), which was thought to involve voluntary attention. In general, peripheral cues were thought to produce a stronger cueing effect because the cognitive interpretation process was avoided. More importantly, central cues were thought to involve only voluntary attention because cueing effects were initially observed with only informative cues (Hsu et al., 2011), which was originally associated with voluntary attention. However, much has changed since researchers proposed that central cues trigger voluntary attention, and peripheral cues trigger involuntary attention. This view must be modified given that involuntary attention has been found to occur with both peripheral cues and central cues (Friesen & Kingstone, 1998; Tipples, 2002).

Figure 2. Cues. Central cues are located in the center of a target display while periphery cues are located in the periphery of a target display.

More recently, voluntary attention has been operationally defined as resulting from informative cues (see Figure 3) and not specifically associated with central cues due to the above finding that involuntary attention has been found to occur with both peripheral cues and central cues. Informative cues have non-chance cue validity (e.g., above or below 25%) on trials with four-stimulus locations (Hsu et al., 2011; Jonides 1980; Prinzmetal et al. 2005a, Prinzmetal, Zvinyatskovskiy, Gutierrez, & Dilem, 2009). For example, if the cued location has a cue validity of above chance (i.e., 50%) in a four-stimulus locations then this is informative in that the target is likely to be at the cued location. In general, if a cue has above chance validity, it tells participants that the correct target is likely to be in the cued location, motivating participants to attend to the cue. A cue is informative even if the cued location has a below chance cue validity (e.g., 20%) in four-stimulus locations because it provides information that the target is highly unlikely to be in the cued location. In situations in which a cue has above chance validity or below chance validity, the cue works as a strong incentive motivating participants to

attend or avoid the cued location because it is informative, benefiting accuracy or a faster response. Note that it is strategically advantageous to attend (i.e., above chance validity) or avoid (i.e., below chance validity) informative cues because they assist when locating the target (Prinzmetal et al. 2005a).

Figure 3. Cue Type. Voluntary attention had informative cues (above or below chance validity), while involuntary attention had non-informative cues (chance validity).

Conversely, involuntary attention has been operationally defined as involving non-informative cues (see Figure 3) and is not specifically associated with peripheral cues due to the above finding stating that involuntary attention has been found to occur with both peripheral cues and central cues. Non-informative cues have chance validity (i.e., 25% validity) or occur at random on trials where there are four-stimulus locations (Hsu et al., 2011; Jonides 1980; Prinzmetal et al. 2005a, Prinzmetal et al. 2009). Cues with chance validity are considered non-informative because they do not provide any target location information. For example, if a cue has chance validity (i.e., 25%), then the target is likely to randomly appear in any of the four-target locations, and an

advantage of target localization will not be provided by the cue. Thus, the cue does not help predict the target location better than chance, making the cue non-informative.

Participants with non-informative cues tend to ignore the cue because they do not have enough incentive to attend to the cued location. Thus, it would not be strategically advantageous to attend to involuntary attention cues because they do not accurately identify the correct target object better than chance and are non-predictive.

Voluntary and Involuntary Attention Process

Recent debates have investigated whether voluntary attention (i.e., informative cues) and involuntary attention (i.e., non-informative cues) are controlled by the same mechanism or by different mechanisms. Wilhelm Wundt (1897) first proposed that the factors driving voluntary and involuntary attention differ, but the same mechanism is responsible for these forms of attention. However, Prinzmetal et al. (2005a) argued that voluntary attention and involuntary attention serve different functions and may be controlled by different mechanisms. Specifically, voluntary attention affects a process termed *channel enhancement*, whereas involuntary attention affects a process termed *channel selection* (see Figure 4).

Figure 4. Processes Among Attention Types. Voluntary attention reflects channel enhancement, while involuntary attention reflects channel election.

Channel enhancement changes the perceptual representation of an object to the extent that individuals have a more faithful representation of the stimulus they are attending to, due to more perceptual resources allocated to that object. For example, if an individual is fixating ahead but knows that the correct target object will be on the left (i.e., informative cue), then that individual will deploy more of his or her attention to the object on the left. Thus, the individual will have a better perceptual representation of the object to the left than the object to the right, which occurs during voluntary attention. On the contrary, channel selection does not enhance perceptual representation for any object but does divide attention equally among target objects. For example, if an individual is looking ahead and does not know if the target will be to the right, left, above, or below (i.e., non-informative cue), then that individual is likely to divide his or her attention equally among the four-locations. Thus, no target object has an enhanced perception; the objects have equal attention deployment. Note that object perception is less precise with

involuntary attention when compared to voluntary attention because the visual system now divides its attention onto multiple objects instead of just one, as with voluntary attention. Also, valid and invalid cues have an effect on target identification, which will be discussed in more detail later.

Prinzmetal et al. (2005a) investigated this very issue of channel enhancement and channel selection. Specifically, they investigated whether channel enhancement occurs with voluntary attention and whether channel selection occurs with involuntary attention when studying covert visual attention. Participants went through the spatial cueing paradigm (see Figure 5) where they had to identify if they saw an “F” or “T” in a spatial cueing paradigm. One condition used informative cues (i.e., non-chance validity) whereas the other used non-informative cues (i.e., chance validity cues). Half of the trials for each cue type had a short stimulus onset asynchrony (SOA; 0 ms), whereas the other half used the long SOA (300 ms); SOA represents the time difference between the onset of the cue and the target. These two SOAs were used to measure whether a particular cue type (i.e., voluntary attention or involuntary attention) was associated with a particular SOA (i.e., long SOA or short SOA), which will be explained in more detail below.

Figure 5. Spatial Cueing Paradigm in Prinzmetal et al. (2005a). Participants were cued with an abrupt-onset cue.

There were two experiments in the study by Prinzmetal et al. (2005a), Reaction Time (RT) Experiment and the Accuracy experiment (see Figure 6). Some participants went through the RT experiment, while another set went through the Accuracy experiment (between-subject design). In general, the RT experiment involved a task where the target display was presented for a set duration (e.g., 250 ms), while participants were encouraged to respond rapidly but accurately. The Accuracy experiment presented the target display for a short duration to achieve a 70% to 80% accuracy rate, while participants were encouraged to take their time for accuracy. Note that Prinzmetal et al. (2005a) reduced accuracy by making the target font size smaller. However, duration adjustments may also reduce accuracy. In the Accuracy experiment, if a participant performed better than an accuracy score of 80%, the program decreased the target display exposure until the participants achieved between 70% to 80% accuracy. If the participant performed worse than 70%, the program increased target display exposure to achieve a

70% to 80% accuracy rate. Thus, it was possible for each participant to have different target display duration in the Accuracy experiment.

Figure 6. Experiment Types. In this study, the RT and accuracy are identical with only one exception. The RT experiment presents the target display for a set time (250 ms), while the Accuracy experiment presents the target display just fast enough to achieve 70% to 80% accuracy. Thus, the duration of the target display in the Accuracy experiment may change among participants.

A final variable that Prinzmetal et al. (2005a) considered when testing their hypothesis was SOA. There is evidence that voluntary and involuntary attention differ when presented with different SOAs. The SOA needed to produce a cueing effect with involuntary attention is shorter than the SOA needed with voluntary attention (Warner,

Joula, & Koshino, 1990). Prinzmetal et al. suggested that voluntary and involuntary affect different processes or mechanisms because their evidence showed that different SOAs had different effects for each cue type. Through these observations, Prinzmetal et al. made two predictions.

First, they felt that channel enhancement occurs with voluntary attention in both the RT experiment and Accuracy experiment because voluntary attention uses informative cues. Note that although these are two different experiments, the fact that they both used informative cues should cause channel enhancement to occur, no matter the experiment type. However, involuntary attention should not affect both the RT experiment and Accuracy experiment similarly because channel selection is affected differently depending on the conditions. Prinzmetal et al. (2005a) predicted that involuntary attention should not cause channel enhancement; however, it was predicted to affect the decision process (e.g., where the target is located) in only RT experiments. Since it does not affect perceptual representation, channel selection should not affect accuracy scores (Prinzmetal et al. 2005a). Prinzmetal et al. predicted this outcome because involuntary attention results from non-informative cues. Thus, channel selection should affect the RT experiment and Accuracy experiment differently. Lastly, SOA effects were expected to differ between voluntary and involuntary attention indicating that these attention types result from different processes.

Prinzmetal et al. (2005a) found that voluntary attention enhanced object perception in the cued location and not in the uncued location. For example, the RT

experiment found that RT was faster when shown a valid cue than an invalid cue when using informative cues. Thus, valid cues and invalid cues result in a *cue-validity effect*; valid cues had faster RTs. When presented with non-informative cues, observers were significantly faster with valid than invalid cues when presented with the short SOA condition (0 ms). In both the informative and non-informative conditions, subjects were faster with long SOA (300 ms) than with short SOA (0 ms). Overall, participants did better with valid cues than with invalid cues.

In the Accuracy experiment, performance was affected by SOA (i.e., short and long) across informative and non-informative cues. In general, accuracy was better with long SOA (300 ms) than with short SOA (0 ms). For informative cues, participants in the short SOA trials were less accurate with valid cues than with invalid cues. Thus, participants did better with invalid trials than valid trials. Long SOAs resulted in greater accuracy scores following only a valid cue. Thus, only informative cues and long SOA matched with the RT experiment results in that participants did better with valid cues than invalid cues. For non-informative cues, participants were significantly less accurate on trials with valid cues than invalid cues during short SOA. There was no difference between valid and invalid cues for long SOA. Thus, the Accuracy experiment demonstrated that valid cues were not more influential than invalid cues when there is a short SOA, suggesting channel selection. Note it was predicted that there would be no significant difference between valid and invalid cues during the non-informative condition in the Accuracy experiment, which was not the result.

Prinzmetal et al. (2005a) felt that the effect of voluntary attention on accuracy is a genuine effect of channel enhancement. In general, voluntary attention may be responsible for channel enhancement, and involuntary attention may be responsible for channel selection to some extent. Thus, the authors concluded that the mechanism responsible for object perception with voluntary attention is distinct from the mechanism responsible for object perception with involuntary attention.

Note that the claim that involuntary attention does not affect accuracy is still controversial. For example, Handy, Jha, and Mangun (1999) oppose channel selection and claim that accuracy *is* affected with non-informative cues. Specifically, Handy et al., (1999) study investigated whether non-informative cues affect accuracy in a spatial cueing paradigm task (i.e., participants had to identify the orientation of the target) while prompted with abrupt-onset cues. Results showed that scores were significantly higher at the cued location than in the uncued location when using non-informative cues. Thus, Handy et al., (1999) argues that non-informative cues do in fact affect accuracy. In support of Handy et al., (1999) claim, Dufour (1999) also reports that non-informative cues may affect accuracy. The Dufour (1999) study also used a spatial cueing paradigm and paired it with auditory cues. Results in this study found that accuracy was affected by involuntary attention. If the auditory cue was on the same side as the target, then participants had faster RTs and higher accuracy scores.

Although Handy et al. (1999) and Dufour (1999) do not support the claim that channel selection occurs with accuracy scores when using non-informative cues, the

current study choose to investigate this issue in greater depth. The purpose of the present study was to replicate the findings in Prinzmetal et al. (2005a) study with a slightly different paradigm while investigating whether non-informative cues do in fact cause channel selection. Also, the current study investigated if voluntary attention and involuntary attention reflect different mechanisms.

The Present Study

The present study investigated the effects of informative and non-informative cues on voluntary and involuntary attention using arrow cues. Many previous studies on covert visual attention have used abrupt-onset cues (e.g., Prinzmetal et al. 2005a; Prinzmetal et al. 2009). However, the vast majority of spatial cueing studies have focused on both arrow cues and abrupt-onset cues (Gibson & Kingstone, 2006). It has been found that abrupt-onset cues and arrow cues have the same cueing effects when comparing younger and older participants (Juola et al., 2000), and abrupt-onset cues were not more effective at orienting attention than arrow cues (Warner, Juola, & Koshino, 1990). Therefore, presenting arrow cues may be an effective cueing method. More importantly, arrow cues allow all target locations to be accessed equally and efficiently (Gibson & Kingstone, 2006), also known as the *equal-accessibility hypothesis*. For example, it would take the same amount of time to attend to a target above or to the left of the fixation. The present study used arrow cues because all target locations will be equally accessible and directional in nature, and they have a great deal of social significance (e.g., driving, looking at a map).

It is important to note that studies have found cueing effects with informative arrow cues (Gibson & Kingstone, 2006; Kingstone, Smilek, Ristic, Friesen, & Eastwood, 2003) and non-informative arrow cues (Tipples, 2002; Ristic, Friesen, & Kingstone 2002; Hsu et al., 2011). Performance tends to be better (i.e., higher accuracy scores, faster RT) with informative arrow cues than with non-informative arrow cues (Kingstone et al., 2003). Recent research has suggested that central non-informative cues may shorten RT with involuntary attention (Hsu et al., 2011), and voluntary attention may improve accuracy (Hsu et al., 2011; Prinzmetal et al. 2009; Prinzmetal, Park, & Garrett 2005b; and Prinzmetal et al. 2005a). These findings are consistent with the proposal that voluntary attention acts on perceptual representation (i.e., channel enhancement), making targets easy to access and more accurately distinguishable, while involuntary attention affects the decision process but does not affect object perception (i.e., channel selection).

The present study did not use the target display used by Prinzmetal et al. (2005a) but instead used a slightly different unambiguous target display. Recently, there have been two types of target displays used within a spatial cueing paradigm. According to Davis and Gibson (2012), a target display could be either an ambiguous target display (ATD) or an unambiguous target display (UATD). An ATD has ambiguous targets while a UATD has unambiguous targets (see Figure 7). A typical ATD consists of four letters or objects in which two letters are identical (e.g., two “H” and two “T”). Thus, correct target discrimination requires 100% cue validity; it is only through the cue that the target is identified. Note that ATD is used to measure only voluntary attention because participants are presented with an informative cue (Davis & Gibson, 2012).

Figure 7. Target Display Types. The ambiguous target display depends on the cue to identify the target letter, while the unambiguous target display has a predetermined target letter that may be identified with or without the cue.

However, UATD may be used to study voluntary and involuntary attention because it uses informative and non-informative cues. A UATD consists of four *unique* letters or objects (e.g., “H,” “E,” “N,” “T”) with a predetermined target (e.g., “T” or “F”); very few cases involve three identical letters (e.g., “O”) and one predetermined target letter (e.g., “F” or “T”). Thus, the target may be identified with or without the cue by simply searching the display. Manipulating only attention types (i.e., voluntary and involuntary attention) would suggest that any differences between RT and accuracy were due to voluntary or involuntary attention. Note that this was not possible in the ATD because cues need to be perceived and processed. The UATD differentiates the two cue types nicely. Thus, the present study chose to use the UATD.

There is little readily available information on the effects of target perception when using arrow cues and UATD. Arrow cues and UATD may help to further understand object perceptual representation between voluntary and involuntary attention. The primary goal of the present study was to investigate voluntary and involuntary attention in the RT and Accuracy experiments while using a UATD. Participants in this study completed both an RT experiment and an Accuracy experiment (i.e., within-subject design), and each experiment put participants into an informative and non-informative condition.

According to Prinzmetal et al. (2005a), voluntary attention should affect perceptual representation when using unambiguous targets, but involuntary attention should not affect perception. This study predicted that those in the RT experiment would have faster RTs and be more accurate within the informative condition than in the non-informative condition. Also, valid cues showed results in faster RTs and higher accuracy than invalid cues, since previous results have suggested that perception is affected. Those in the Accuracy experiment were predicted to have a difference between the informative condition and the non-informative condition but no difference between valid and invalid cues in the non-informative condition because the perception of a target is not affected. These differences will further support that voluntary and involuntary attention result from different mechanisms. Note a UATD that had central arrow cues was used in the current study. Central arrow cues were used because they are equally accessible, directional in nature, and socially significant. The fact that this study also used arrow cues has the potential to increase the generalizability of the conclusion by Prinzmetal et al.

(2005a), which suggests channel enhancement occurs with voluntary attention and channel selection may occur with involuntary attention.

This study intended to answer the following research questions:

1. Is target perceptual representation affected in the RT experiment? If so, are there main effects between cue type and validity? Do informative cues result in faster RTs than non-informative cues? Do valid cues result in faster RTs than invalid cues? Is there an interaction between cue type and validity? Do informative valid cues result faster RTs than non-informative invalid cues?
2. Is target perceptual representation lacking in the Accuracy experiment ? If so, are there no accuracy score differences between informative and non-informative cues? Do valid cues result in higher accuracy scores than invalid cues? Is there a difference between informative valid cues and non-informative invalid cues?

Method

Participants

Thirty-seven students enrolled in a general psychology course were recruited to participate in the experiment to fulfill a course requirement. The sample size of thirty-seven was determined by the power analysis with a medium statistical power.

Participants were required to have normal or correct-to-normal vision. The sample was gathered from the SONA online system at San José State University.

Apparatus/ Stimuli

A trial consisted of a fixation (500 ms), cue (250 ms), target display (250 ms or achieve 70%-80% accuracy rate), response instructions (3 s or 5 s), and feedback information (1500 ms: see Figure 8 and 9). Note that the cue in the informative cue conditions had above chance validity (i.e., 75% validity for cued target location), and the cue in the non-informative cueing conditions had chance validity (i.e., 25% validity per target location). Stimulus presentations were controlled by E-Prime software on a standard PC laptop with a 17-inch screen. Stimuli (i.e., fixation, letters, cues) were presented in black on a white background, which had a visual angle of about 2 degrees. The viewing distance was about 50 cm. Sessions were conducted individually in a small experimental room with normal indoor lighting. Target RTs, target response, and accuracy were documented for each trial.

Figure 8. RT experiment. The fixation, cue, response instructions, and feedback information was all be placed in the center of the display. The letters in the target display (slide “C”) appeared in the top center, bottom center, left center, and right center.

The target display stimuli presented a total of four letters, one of which was the predetermined target letter (i.e., “F,” “T”). The predetermined target letters were randomly alternated among one another and appeared in one of the four-target locations randomly (i.e., top center, bottom center, left center, right center), while the other distracter letters (i.e., “H,” “E,” “N”) filled in the three remaining target locations. Note that each predetermined target letter had an informative and non-informative condition. There was a total of 16 target display variations: eight for the target letter “F” (four for informative, four for non-informative) and eight for the target letter “T” (four for informative, four for non-informative). However, for the informative cue condition, there were 24 valid cue trials and eight invalid cue trials (i.e., 75% were valid cue trials). As

for the non-informative cue condition, there were eight valid cue trials and 24 invalid cue trials (25% are valid cue trials). Trials were randomly presented within each condition (informative, non-informative) and moved rapidly without breaks within a condition. Participants independently controlled their eyes movement because the fact that stimuli were moving rapidly suggested they did not have time to move their eyes in any particular direction to locate the correct target letter. Thus, moving the eyes from the fixation point did not provide any advantage.

Figure 9. Accuracy experiment . The fixation, cue, response instructions, and feedback information will all be placed in the center of the display. The letters in the target display (slide “C”) will appear in the top center, bottom center, left center, and right center.

The RT experiment (see Figure 7) was similar to the Accuracy experiment (see Figure 8) with two exceptions. First, the experiments differed in response instructions. The RT experiment asked participants to respond as quickly as possible without making an error, while the Accuracy experiment asked participants to take their time to make an accurate response. Participants had 3s to respond in the RT experiment and 5s to respond in the Accuracy experiment. The second difference between these two experiments was the duration of the target display (see slide “C” for Figure 7 and 8). The RT experiment always presented the target display for 250 ms, while the Accuracy experiment modified the target display duration to achieve a 70% to 80% accuracy rate per participant. Every participant in the Accuracy experiment began at 250 ms during the practice trials. If the participant achieved an accuracy score higher than 80%, the target display duration decreased by 25 ms, and the participant went through the practice trial again with the new target display duration. If the participant achieved lower than a 70% accuracy rate, the target display duration increased by 25 ms. Participants went through the practice trials until they got to a target display duration that achieved 70% to 80% accuracy. Thus, target display duration in the Accuracy experiment was different across participants. All four conditions (i.e., RT experiment with informative cues, RT experiment with non-informative cues, Accuracy experiment with informative cues, and Accuracy experiment with non-informative cues) took about an 1hr 30 min to complete.

Procedure

Participants were asked to make target identification decisions (“Did you see the letter ‘F’ or ‘T’?”) in a spatial cueing paradigm without moving their eyes away from the

center of the screen, which was occupied by the fixation point or the cue. They responded “F” by pressing a labeled key on the keyboard (i.e., pressing “2”) with their right index finger and responded “T” by pressing a labeled key (i.e., pressing “3”) with their right middle finger. If the participant gave the correct answer, no feedback information was given, and the screen was blank white. If the participant gave the incorrect answer, then the word “incorrect” was presented in red in the center of the screen. If the participant did not make a response, the words “no response detected” were presented in red in the center of the screen. After the feedback information, a new trial automatically began.

Participants first completed the practice trials per condition. Following the practice trials, participants were told to press the spacebar to proceed to the experimental trials. After finishing one of the four conditions, participants continued on to the next condition by first completing the practice trials followed by the actual experiment. This continued on until the last condition was completed. The RT experiment had a total of 96 practice trials for the voluntary attention condition (72 valid trials, 24 invalid trials) and 96 practice trials for the involuntary attention condition (24 valid trials, 72 invalid trials). This was followed by 192 experimental trials for the voluntary attention condition (144 valid trials, 48 invalid trials) and 192 experimental trials for the involuntary attention condition (48 valid trials, 144 invalid trials). The Accuracy experiment had a total of 32 practice trials for the voluntary attention condition (24 valid trials, 8 invalid trials) and 32 practice trials for the involuntary attention condition (8 valid trials, 24 invalid trials). There were fewer practice trials in the Accuracy experiment because participants may

have had to go through multiple practice trials, and the researcher wanted to avoid fatigue due to repeating long practice trials. This was followed by 192 experimental trials for the voluntary attention condition (144 valid trials, 48 invalid trials) and 192 experimental trials for the involuntary attention condition (48 valid trials, 144 invalid trials). The order of the conditions was counterbalanced across subjects in a partial Latin square design.

Design/Analysis

There were four conditions (i.e., informative valid condition cue, informative invalid cue condition, non-informative valid cue condition, and non-informative invalid cue condition) each arranged in within-subjects designs. The RTs and total correct responses (i.e., accuracy) were measured in the four conditions. This study analyzed the target identification responses in a 2 x 2 repeated measures (attention types: informative vs. non-informative; validity: valid vs. invalid) of analysis of variance (ANOVA). One-tailed post hoc tests were used to examine the simple effects of all interactions. Each participant had a mean RTs and accuracy score per cue type and validity type in each condition.

Results

This study analyzed covert visual attention response times and accuracy using a repeated-measure design in the RT experiment and the Accuracy experiment. One participant was eliminated because accuracy score was below chance, leaving a total of 37 participants. In general, it was found that cue type (i.e., informative, non-informative) affects RT and accuracy, but that main effect might differ depending on whether the cue is valid or invalid.

Reaction Time Experiment

The present experiment emphasized speeded responses. Participants were asked to respond as quickly as possible while still being accurate. This study hypothesized that there would be a main effect of cue type (i.e., informative, non-informative cues) and validity (i.e., valid, invalid cues) on RT and an interaction between these two variables. Specifically, the informative condition should produce faster RTs, demonstrating voluntary attention, than the non-informative condition. Also, valid cues were predicted to produce faster RTs and better accuracy scores than invalid cues. These hypotheses were tested in a 2 x 2 repeated measure ANOVA with cue type and validity as the independent variables and RT as the dependent variable.

Reaction time condition results and discussion. The RTs from only the correct responses were analyzed. There was no main effect of RT between the informative condition and the non-informative condition ($F(1,36) = 3.35, p = .08$; see Table 1). However, there was a significant difference between valid cue RTs and invalid cue RTs,

indicating that individuals performed better when presented with valid cues ($F(1,36) = 60.38, p > .001$; see Table 2), known as the *cue-validity effect* (Prinzmetal et al. 2005a).

Table 1. *Means Reaction Times for Cue Types in the RT experiment*

Attention Type	Mean	Standard Error
Informative	821.34	28.66
Non-Informative	790.77	25.27

Note. No significant effect of Cue Types, $p = .08$

Table 2. *Mean Reaction Times for Validity in the RT experiment*

Validity	Mean	Standard Error
Valid	761.03	23.00
Invalid	851.07	29.29

Note. Significant effect of Validity, $p < .001$

More importantly, the interaction of cue type and validity was also significant ($F(1,36) = 37.37, p < .001$). As Figure 10 shows, cue type may contribute to RTs, but the effect differs across validity groups. Specifically, those presented with valid cues in the informative condition had faster RTs than those presented with invalid cues (see Table 7). Those in the non-informative condition presented with valid cues also had faster RTs than those who experienced invalid cues (see Table 3), but effect of cue validity was most pronounced in the informative condition. In general, the informative valid cues resulted in faster RTs than in the non-informative valid condition. When

participants were presented with invalid cues during the informative condition, they had longer RTs than when in the non-informative condition. Two post hoc tests were used to determine whether there was a significant difference between RTs in the two validity conditions for the informative condition and the two validity conditions for the non-informative condition (two-tailed). The first post hoc test indicated that there was a significant difference in RTs for valid cues and invalid cues in the informative condition ($t(36) = -8.09, p < .001, d = 1.33$). The second post hoc test indicated that there was a marginally significant difference between valid cues and invalid cues in the non-informative condition ($t(36) = -2.02, p = .051, d = .33$). Overall, these results indicate that voluntary attention may be causing channel enhancement, and involuntary attention may be causing channel selection.

As shown in Figure 10, in the informative condition where the cue was valid on 75% of the trials, participants were much faster on the valid trials than on the invalid trials. It seems that highly valid cues encouraged the participants to voluntarily direct their attention to the cued location, resulting in faster RTs. When the target was not in the cued location, there was a significant increase in RTs. Following Prinzmetal et al. (2005a), this result indicates channel enhancement. In the non-informative condition, where the cue was only valid 25% of the time, there was no difference in RTs for valid and invalid trials. Since the cue provided no information, there was no reason to voluntarily direct attention to the cued location. Rather, participants simply selected the channel to process once the target display was presented.

Figure 10. Mean Reaction Time for Cue Types and Validity in the RT Experiment. Interaction in the RT experiment between Validity and Cue Types. Significant interaction between cue type and validity. Error bars (i.e., standard error) indicate that informative cues have greater variability in error among RTs than non-informative cues.

Table 3. *Mean Reaction Times for Cue Types and Validity in the RT experiment*

Attention Type	Validity	Mean	Standard Error
Informative	Valid	742.86	26.20
	Invalid	899.82	33.84
Non-Informative	Valid	779.20	25.20
	Invalid	802.33	26.60

Note. Significant interaction for Cue type and Validity, $p < .001$

The mean accuracy scores per participant were calculated and converted into percentages, correct responses. These percentages were analyzed in a 2 (i.e., attention type) x 2 (i.e., validity) repeated measures ANOVA. Results indicated that there was no speed-accuracy trade off. For the accuracy data, the effect of cue type was significant ($F(1,36) = 13.36, p = .001$), as was the effect of validity ($F(1,36) = 45.02, p < .001$). Participants were more accurate following a valid cue (i.e., 79%) than an invalid cue (i.e., 70%). As Table 3 shows, responses were also faster.

Accuracy experiment

In the Accuracy experiment, participants were not encouraged to respond as quickly as possible. In fact, they were encouraged to take their time to determine the correct target, unlike the RT experiment. It was hypothesized that there would be a difference in accuracy scores when presented with informative cues but not when presented with non-informative cues. Specifically, there should be no difference between valid cues and invalid cues within the non-informative cue condition. Informative cues

should demonstrate channel enhancement, while non-informative cues should demonstrate channel selection.

Accuracy results condition and discussion. Accuracy scores (i.e., correct responses) were analyzed in a 2 (i.e., attention type) x 2 (i.e., validity) repeated measures ANOVA. Note that accuracy scores were calculated in the same manner as in the accuracy scores in the RT experiment. When participants performed the task under the informative condition, there was no significant difference in accuracy ($F(1,36) = 1.33, p = .26$) then when they performed the task in the non-informative condition (see Table 4), not supporting the hypothesis. However, there was a significant difference in accuracy between valid cues ($F(1,36) = 51.00, p < .001$) and invalid cues, indicating that individuals performed better when presented with valid cues than with invalid cues (see Table 5), known as the *cue-validity effect*.

Table 4. *Mean Accuracy for Cue type in the Accuracy experiment*

Attention Type	Mean	Standard Error
Informative	.77	.01
Non-Informative	.78	.01

Note. No significant effect of Cue Types, $p = .26$

Table 5. *Mean Accuracy for Validity in the Accuracy experiment*

Validity	Mean	Standard Error
Valid	.83	.01
Invalid	.72	.02

Note. Significant effect of Validity, $p < .001$

The interaction of cue type and validity was also significant ($F(1,36) = 32.04, p < .001$). As Figure 11 shows, cue type may contribute to accuracy, but the effect differs across validity groups. Specifically, those presented with valid cues in the informative condition were more accurate than those presented with invalid cues (see Table 6). Also, those with valid cues in the non-informative condition were more accurate than those who experienced invalid cues (see Table 11), which does not support the hypothesis. Note that the difference between valid and invalid cues in the informative condition was large and more defined than the difference between valid and invalid cues in the non-informative condition. Two post hoc tests were used to examine the interaction (two-tailed). The first post hoc test indicated that there was a significant difference in accuracy scores for valid cues and invalid cues in the informative condition ($t(36) = 7.33, p < .001, d = 1.2$). The second post hoc test indicated that there was also a significant difference between valid cues and invalid cues in the non-informative condition, ($t(36) = 3.28, p = .002, d = .50$), which does not support the hypothesis. As in the RT experiment, these results may demonstrate that channel enhancement occurs with informative cues. However, the finding that accuracy was higher for valid than invalid trials in the non-

informative condition is not consistent with the channel selection hypothesis. Overall, it was concluded that optimization for accuracy is accomplished by using informative cues to direct attention to the target location. Note that in the non-informative condition in the study by Prinzmetal et al. (2005a); participants were more accurate with invalid cues than with valid cues. The reverse was found in this experiment.

Figure 11. Mean Accuracy for Cue Types and Validity in the Accuracy Experiment. Interaction in the Accuracy experiment between Validity and Cue Types. There was a significant interaction effect between cue type and validity. Error bars (i.e., standard error) indicate that informative cues and non-informative cues had almost similar variability in error in accuracy scores.

Table 6. *Mean Accuracy for Cue Types and Validity in the Accuracy experiment*

Attention Type	Validity	Mean	Standard Error
Informative	Valid	.86	.01
	Invalid	.67	.02
Non-Informative	Valid	.80	.01
	Invalid	.76	.01

Note. Significant interaction for Cue Types and Validity, $p < .001$

The RTs were calculated in the same manner as in the RT experiment. These RTs were analyzed in a 2 (i.e., attention type) x 2 (i.e., validity) repeated measures ANOVA. The RT results were not consistent with a speed-accuracy trade off. For the RT data, the effect of cue type was not significant ($F(1,36) = .32, p = .57$), while the effect of validity was significant ($F(1,36) = 56.88, p < .001$). Participants were faster following a valid cue (i.e., 830 ms) than an invalid cue (i.e., 916 ms). As Table 6 shows, participants were also more accurate in both conditions.

General Discussion

Reaction Time Experiment General Discussion

The present study was an extension of the Prinzmetal et al. (2005a) study and investigated voluntary and involuntary attention using arrow cues in an unambiguous target display (UATD). There were two important findings in the RT experiment. First, those presented with valid cues had faster RTs than those presented with invalid cues. Interestingly, those in the informative condition did not have significantly faster RTs than those in the non-informative condition. Second, an interaction was found between validity and attention type. Thus, cue type may affect RTs, but the effects depend on validity. As previously mentioned, those presented with valid cues had faster RTs than those presented with invalid cues in both the informative and non-informative conditions. However, the effect of cue validity differed between conditions. In general, those presented with valid cues in the informative condition had much faster RTs than those presented with invalid cues. Also, those in the non-informative condition presented with valid cues had similar RTs to those who experienced invalid cues. Overall, the interaction effect was consistent with the hypotheses in that there is a significant difference between cue type and validity. The findings indicate that informative cues might lead to channel enhancement. However, the process that results from non-informative cues is unknown. Something unknown is occurring here because there was a marginal significant difference between valid and invalid cue RTs in the non-informative condition.

Prinzmetal et al. (2005a) found similar results. First, they found a significant cueing effect in the informative and non-informative conditions. Specifically, participants in the informative condition had faster RTs when presented with valid cues than with invalid cues. Also, the participants in the non-informative condition had significantly faster RTs when presented with valid cues than with invalid cues although the effects were not as pronounced as in the informative condition. Their results were similar to the present study results in that a cueing effect was found in the informative condition, and a marginal cueing effect was found in the non-informative condition.

Accuracy experiment General Discussion

The Accuracy experiment had two main findings. First, it was found that valid cues resulted in higher accuracy scores than invalid cues. Second, there was an interaction effect meaning the effect that cue type had on accuracy scores depended on whether the cue in a given trial was valid or invalid. Note that there was also a significant difference between valid and invalid cues for the non-informative condition, which does not support the hypothesis.

Prinzmetal et al. (2005a) found slightly different outcomes in their Accuracy experiment. First, they found a significant cueing effect in the informative condition and a non-significant cueing effect in the non-informative condition. These results were similar in that the informative valid cues trials resulted in higher accuracy than invalid cues. However, the present study was different in that there was a significant difference between valid and invalid cues during the non-informative condition. The findings in the

informative condition supported the hypothesis that highly valid cues can produce channel enhancement.

Comparing Reaction Time and Accuracy Results

The findings in the present study were somewhat consistent with past research and have significant implications for models of covert visual attention. Based on the preceding discussion of the results, several conclusions were drawn from these two experiments. Taken as a whole, the results of this study indicated that voluntary attention in the RT experiment may lead to channel enhancement, and involuntary attention may lead to marginal significant channel selection. There is a possibility that there are different processes occurring with voluntary and involuntary attention based on the evidence. Voluntary attention resulting from highly informative cues in the Accuracy experiment may reflect channel enhancement. However, the same may be true about non-informative cues in the Accuracy experiment. This study did identify a significant difference between valid and invalid cues within the non-informative condition. This may imply that channel enhancement may still be occurring within the Accuracy experiment. However, there is something occurring in the non-informative condition that needs to be further investigated to understand the processes more clearly.

A central finding of Prinzemtal et al. (2005a) was that the pattern of results for the RT experiment and Accuracy experiment differed depending on whether cues were informative or non-informative. Thus, there was a strong effect of cue validity in the informative condition for both the RT experiment and Accuracy experiment. However,

while there was an effect of cue validity for the non-informative condition of their RT experiment, that effect was not present in the non-informative condition of the Accuracy experiment. The difference in the pattern of results across the RT experiment and Accuracy experiment lead Prinzemtal et al. (2005a) to conclude that voluntary and involuntary attention are distinct processes. Voluntary attention in the strategic deployment of attention to a potential target location results from a highly valid cue. They proposed that this process results in channel enhancement. Involuntary attention may reflect a more basic response whereby observers arrive at the target location without reliable cueing.

In the present study, the results for the informative condition in both the RT experiment and Accuracy experiment replicated Prinzemtal et al. (2005a). Thus, the results indicated a voluntary deployment of attention that results in channel enhancement. The present study also found that the effect of cue validity differed for the non-informative condition of the RT and Accuracy experiment s. Nonetheless, the finding that the pattern of results differs for the RT experiment and Accuracy experiment is consistent with the assertion that voluntary attention and involuntary attention are different processes. Voluntary attention is fairly well understood, while the process affecting involuntary attention needs further investigation.

Future Direction and Limitations

Covert visual attention is the ability to fixate on one object while attending to another. It is a skill performed by both humans and animals frequently in much of their

everyday lives. This skill is used habitually when performing daily tasks, some of which may be life threatening. Covert visual attention is a key factor for survival during such life threatening tasks, such as driving and the ability to locate and avoid predators, environmental obstacles, or danger. The lack of covert visual attention during life threatening tasks may lead to collisions, serious injuries, or even fatalities. Thus, it is no surprise that covert visual attention is constantly investigated and a topic worth studying.

The present study used a new method to investigate covert visual attention, by investigating covert visual attention using the unambiguous target display (i.e., UATD) paired with arrow cues. The UATD was used to study voluntary and involuntary attention because it allows for informative and non-informative cues. Also, only an SOA of 250 ms was used for the RT experiment and a manipulated SOA (i.e., SOA that achieve 70%-80% accuracy score) was used for the Accuracy experiment. Lastly, the present study used arrow cues instead of abrupt-onset cues. This new method was slightly different from Prinzemtal et al. (2005a) but resulted in similar conclusions, which allowed for generalization of the distinction of voluntary and involuntary attention.

Another variable to consider when interpreting the data is that participants were asked to followed specific instructions. In the RT experiment, they were asked to respond as quickly as possible while being accurate, and in the Accuracy experiment, they were asked to take their time to respond. Results indicated that participants had faster RTs in the RT experiment than in the Accuracy experiment. This is evidence that participants were following basic instructions. Also, participants were asked to keep their

eyes on the fixation point or on the center of the screen during trials. Prinzmetal et al. (2005a) used an eye-tracker to account for eye movement errors, but the present study gave clear instructions to participants not to move their eyes; also, the target display flashed so quickly before them that it would have been difficult to see all four target display letters. Thus, it was concluded that even if participants moved their eyes, it would not have created an advantage. Note that lacking an eye-tracker was a limitation of the present study. While the results were consistent with Prinzmetal et al. (2005a), future studies should consider controlling eye movements using an eye-tracker.

Future research could also investigate the discrepancies in the non-informative condition in the Accuracy experiment and their implications for involuntary attention. It is possible that the non-informative condition may be working similarly to that of the informative condition. Note that Prinzmetal et al. (2005a) found a significant difference between valid and invalid cues within the non-informative condition in their Accuracy experiment. Thus, it is necessary for further research to be done to more fully understand these discrepancies. Future studies should investigate if it is possible to manipulate the non-informative condition to result in a non-significant difference between valid and invalid cues. Overall, the findings in this study imply that channel enhancement is clearly occurring with voluntary attention as predicted in the informative condition of both experiments. However, the results for the non-informative condition differ across experiments and do not provide strong evidence for suggesting that involuntary attention is leading to channel selection. The claim that voluntary and involuntary attention reflects different processes was supported by this study but should be further investigated.

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Appendix A: San Jose State University IRB Approval

To: Rocio Luna

From: Pamela Stacks, Ph.D.
Associate Vice President
Graduate Studies and Research

A handwritten signature in black ink, appearing to read "Pamela Stacks".

Date: September 26, 2013

Division of Academic Affairs
Associate Vice President
Graduate Studies & Research
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One Washington Square
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The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

“Visual Spatial Attention: Voluntary and Involuntary Attention using Unambiguous Targets”

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the confidentiality of the subjects' identity when they participate in your research project, and with regard to all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Dr. Pamela Stacks, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subject's portion of your project is in effect for one year, and data collection beyond September 26, 2014 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2427.

Protocol # S1304024

cc. Kevin Jordan 0120

The California State University:
Chancellor's Office
Bakersfield, Channel Islands, Chico, Dominguez Hills,
East Bay, Fresno, Fullerton, Humboldt, Long Beach,
Los Angeles, Maritime Academy, Monterey Bay,
Northridge, Pomona, Sacramento, San Bernardino,
San Diego, San Francisco, San José, San Luis Obispo,
San Marcos, Sonoma, Stanislaus

Appendix B: Informed Consent

SAN JOSÉ STATE
UNIVERSITY

Covert Visual Spatial Attention Study Consent Form

You have been asked to participate in a research study investigating covert visual spatial attention. The primary goal of the present study is to investigate the voluntary and involuntary attention in response time and accuracy experiments while using a spatial cueing paradigm with an unambiguous target display. Participants in this study will go through a response time experiment and an accuracy experiment. The experiment intends to put participants into conditions that measure both voluntary (i.e., informative cues) and involuntary (i.e., non-informative cues) visual attention that may influence channel enhancement and object perception. The responsible investigators are Dr. Kevin Jordan and Rocio Luna. The stimulus display (i.e., spatial cueing paradigm) consists of a fixation, cue, target and feedback on a white background. The goal of the task is to have participants identify if they seen the letter "F" (by pressing 2) or "T" (by pressing 3) among four target locations.

Although the results of this study may be published, no information that could identify you will be included. Only Rocio Luna will view all participants' scores on the spatial cueing paradigm task. Information will be locked in the experimental lab. There is no compensation for participation other than course credit. Questions about this research may be addressed to Rocio Luna at Rocio.luna@sjsu.edu. Complaints about the research may be presented to Dr. Rogers, at (408) 924-5652. Questions about a research subjects' rights, or research-related injury may be presented to Pamela Stacks, Ph.D., Associate Vice President, Graduate Studies and Research, at (408) 924-2427.

No service of any kind, to which you are otherwise entitled, will be lost or jeopardized if you choose not to participate in the study. Your consent is being given voluntarily. You may refuse to participate in the entire study or in any part of the study. If you decide to participate in the study, you are free to withdraw at any time without any negative effect on your relations with San Jose State University.

The signature of a subject on this document indicates agreement to participate in the study. The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject has been fully informed of his or her rights.

_____
Participant's Signature

_____
Date

_____
Investigator's Signature

_____
Date

Appendix C: Debriefing Statement

SAN JOSÉ STATE
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Covert Visual Spatial Attention

In general, covert visual attention is the ability to fixate on one object while attending to another. The present study investigated voluntary and involuntary changes in covert visual attention using arrow cues. Previous studies have found that informative cues produce voluntary changes in covert visual attention while non-informative cues produce involuntary changes in covert visual attention. In this experiment, on the trials where the cue was valid most of the time, it is informative and we expect voluntary deployment of attention. When the cue is not valid most of the time, it is non-informative and we expect involuntary deployment of attention.

The larger question that we are addressing is whether voluntary and involuntary attention are controlled by the same or different mechanisms. That is why you participated in both a speeded reaction time condition and a condition that emphasized accuracy. If the results in the voluntary and involuntary attention conditions are comparable for the reaction time and accuracy conditions, then the two types of attention may be controlled by the same mechanism. If the results differ across the reaction time and accuracy conditions, different mechanisms may control the voluntary and involuntary deployment of attention. We need to look at the pattern of data across over 30 students like yourself in order to determine whether the same or different mechanisms control the voluntary and involuntary deployment of attention.

Thank you very much for your participation!

Rocio Luna