Examining the Effects of Trial Order and Conditioning on the Covert Orienting of Visual Attention Task (COVAT)

by

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Table of Contents

List of Tables

List of Figures

Abstract

It has recently been reported by Deller (2006) that the mechanisms of early facilitation followed by late inhibition of return (IOR) attenuated upon ANS activation, manipulated through head-down neck flexion (HDNF). The responses to peripheral targets were measured in a series of trial conditions (i.e. seated, prone, HDNF, prone) all performed in the same trial order. The purpose of the current study was to examine whether the trial order utilized by Deller (2006) led to the attenuated faciliatory and inhibitory mechanisms of attention during ANS activation. There were two major results of the current study: 1) the failure to replicate to the results of Deller (2006) during Trial Block Order A and 2) a trial order effect was observed among the four trial blocks orders. Since a failure to replicate occurred, it cannot be assumed that the specific trial order used by Deller (2006) contributed to the attenuated effects of facilitation and IOR. Possible explanations and secondary factors leading to the inability to replicate the results of Deller (2006) are discussed.

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Introduction

The act of cognition includes many complex processes, such as the ability to learn, remember, and think. Another important component is that of attention, and how we allocate attention to perform the complex processes of cognition. The study of attention is, and has remained one of the oldest and most relevant topics of interest in psychological science. One of the first thinkers to provide insight into the concept of attention was Aristotle (370 B.C), in which he stated that attention acted as "a narrowing of the senses." (Raz, 2004, p.21). Aristotle believed that attention was a component of the sensory system and that to be attentive, one would have to ignore, or narrow all other sensory input occurring at the same moment. Many centuries later, William James (1890) provided one of the more thorough definitions of attention, in which he stated:

> everyone knows what attention is. It is the taking possession of the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others. (pp. 403-404)

James' definition included many elements of attention that helped further the development of attention research. First, James stated that to be attentive, one must direct the "mind" to "objects or trains of thought", which indicated that the mind as a whole acts as the unit of attention. From this element, numerous studies understanding the anatomy of the attention system have been conducted to help determine if in fact attention exists as a whole brain function, or if certain regions act as purveyors of the attentional process (Fan, McCandliss, Sommer, Raz, & Posner, 2002; Fernandez-Duque & Posner, 2001; Posner & Fan, 2004; Posner & Petersen, 1990; Posner,

Sheese, Odludas, & Tang, 2006). Second, James stated that attention can be directed towards "objects" or "trains of thought", which indicated that attention can be guided by internal or external stimuli. The fact that attention can be directed by both types of stimuli helped provide the basis for the study of exogenous and endogenous orienting of attention, which are modes of attentional shifting that utilize separate stimuli and are situated within different cortical and subcortical structures (Berger, Henik, & Rafal, 2005; de Haan, Morgan, & Rorden, 2008 & Funes, Lupianez, & Milliken, 2007). Third, James stated that attention is "of its essence" a conscious process, which indicated that attention only operates during voluntary control. More recent research indicated that attention can be automatically or reflexively operated and as such does not require volitional control (Fu, Greenwood, & Parasuraman, 2005; Prinzmetal, McCool, & Park, 2005; Schneider & Shiffrin, 1977) Finally, James stated that attention is a limited process, since we must "withdrawal from some things, in order to deal effectively with others." James indicated that attention acted as a limited mechanism, and that multiple objects or trains of thought can only be attended to on an individual basis. Numerous models of attention have since been created, which showcased attention as both a single-channel (Broadbent, 1958) and as a limited-capacity (Kahneman, 1973) system.

Posner and Petersen's Model of Attention

By the 1970s, research on attention shifted from a psychological construct to an anatomical construct and this culminated with the establishment of Posner and Petersen's (1990) model of attention. Posner and Petersen's model was based on three working statements: (1) the attention system is anatomically separate from various other cognitive and processing systems of the human brain, (2) attention consists of three networks that is neither the property of a single brain region nor a collective function of the entire brain, and (3) the attentional networks each

carry out specific functions necessary to the whole of attention. From these three working statements, Posner and Petersen suggested that attention consisted of three working networks: (1) vigilance, (2) anterior attention (AAN), and (3) posterior attention (PAN). First, the vigilance network was defined as "the process of achieving and maintaining a state of high-sensitivity to incoming stimuli" (Raz, 2004, p.22). The vigilance network operates by maintaining an alert state necessary for preparing the AAN and PAN for their eventual action. Second, the AAN was defined as "the mechanism for monitoring and resolving conflict among thoughts, feelings, and responses" (Raz, 2004, p.22). The AAN network operates to resolve conflict among competing stimuli by making executive decisions sometimes based upon working memory (short- or long-term). Finally, the PAN, or otherwise known as the orienting network was defined as "the aligning of attention with a source of sensory input or internal semantic structure stored in memory" (Posner, 1980, p.4). The orienting network operates to shift attention to the various regions within the visual field.

Orienting Network

Of the three networks within Posner and Petersen's (1990) model of attention, the orienting network performs an important role within the attentional process. According to Posner (1980), orienting can either be directed by internal (semantic structure stored in memory) or external (sensory input) loci indicating that attention can be oriented in one of two ways: voluntarily or reflexively. First, voluntary orienting requires the intentional shift of attention from one location in the visual field to another, such as when looking both ways before crossing the street. Anatomically, voluntary orienting operates in higher-order cortical centers (e.g. superior temporal gyrus, temporo-parietal junction) to process the qualities of the predictive nature of the stimuli (e.g. direction, size, colour, etc.) necessary for the shift in attention (Jonides,

1981). Voluntary orienting has also been referred to as endogenous orienting. Second, reflexive orienting does not require higher-order cortical centers necessary for processing, and so operate primarily by the qualities of the stimuli itself (e.g. intensity, abruptness, etc.). Therefore, reflexive orienting can be captured by a brief flash that is seen out of the corner of ones' eye, which has also been referred to as exogenous orienting.

Covert Orienting of Visual Attention Task

An important function of the orienting network is the ability to shift attention to stimuli in the visual field for processing, while ignoring other competing stimuli. Since reflexive orienting operates by the qualities of the stimuli presented, attention can either be oriented to regions that have initially been observed or shifted to new novel locations that have yet to be viewed. Once a location has been initially examined, the process of re-examining that same location reduces the effectiveness of the visual search. The ability to shift attention to novel locations improves the efficiency of visual searches and promotes the sampling of the entire visual environment. The mechanism identified to limit reflexive orienting to previously attended locations, and instead bias towards new novel locations has been termed *inhibition of return* (IOR).

IOR is a function associated with the orienting network first identified by Posner and Cohen (1984) and first coined by Posner, Rafal, Choate, and Vaughn (1985). In the study by Posner and Cohen (1984), they used a Covert Orienting of Visual Attention Task (COVAT) to measure reaction times at both cued and uncued locations. The COVAT consisted of the outlines of two peripheral boxes located to the left and right of a central placeholder box all placed along the horizontal meridian. Participants were placed at a viewing distance of 40 cm from the display and instructed to maintain eye fixation upon the central placeholder box during the entire

task. A trial began with a brightening of the outline of one of the two peripheral boxes, which appeared for 150 msec. The brightening of the outline was termed the 'cue' and acted to draw the participants attention to the peripheral box, and away from the central box. Following the appearance of the cue was a target, which consisted of a filled in white square that appeared in either the central or peripheral boxes to which the participants were instructed to respond. The interval between the appearance of the cue and target was termed the stimulus onset asynchrony (SOA). The target would appear at variable SOAs of 0, 50, 100, 200, 300, and 500 msec after the appearance of the cue. The target had a probability of 0.6 or 60% of appearing in the central placeholder box, and a probability of 0.1 or 10% of appearing in either peripheral box, respectively. Catch trials were also included, which consisted of the entire trial sequence except for the appearance of the target. Catch trials had a probability of 0.2 or 20% of appearing. Posner and Cohen observed a biphasic pattern of results of 1) early facilitation followed by 2) late inhibition. They found that responses were faster towards the cued compared to the uncued targets at shorter SOA intervals (e.g. 50, 100 msec), but that the responses were slower towards the cued compared to the uncued targets at longer SOA intervals (e.g. 300, 500 msec). Posner and Cohen suggested that attention is first facilitated towards the previously attended location since there is not enough time to disengage attention from the cued side. But that once the SOA was greater than or equal to 300 msec, attention was inhibited from returning to the previously attended location and instead responded quicker to the novel location.

Origins of IOR

To further examine whether the inhibitory effect seen during the COVAT was due to the original paradigm, Posner and Cohen (1984) performed a series of additional experiments to determine the origins of the inhibitory effect. The additional experiments were based upon three

hypotheses: 1) IOR occurred because the participants had only two alternative locations, 2) IOR could have occurred because attention had shifted away from the cued side and back to the center of the display in order to attend to the target, and 3) IOR could have occurred through the role of sensory factors associated with the cue (Posner & Cohen, 1984). Based upon these three hypotheses, numerous studies have been conducted to examine the components and alterations of the COVAT paradigm, such as the differences between object- and location-based IOR (Tipper, Driver, & Weaver, 1991; Tipper, Weaver, Jerreat, & Burak, 1994), target intensity (Reuter-Lorenz, Jha, & Rosenquist, 1996), simultaneous cueing (Pratt & Hirschhorn, 2003), and endogenous orienting (Rafal, Calabresi, Brennan, & Sciolto, 1989; Ristic & Kingstone, 2006).

Object- and Location-Based IOR

In order to test the first two hypotheses, Posner and Cohen (1984) created a slightly different paradigm in which they included a central box surrounded by four peripheral boxes. They first found an initial faciliatory effect towards the cued side, followed by an inhibitory effect that was not limited to the opposite side of the cue. Posner and Cohen therefore suggested that IOR exists regardless of the position in the visual space. IOR was further observed in the two orthogonal locations from the cued side, which suggested that IOR is not the result of a parallel display consisting of only two alternative locations, but can occur in multiple locations. They also found that IOR to the side opposite the cue was no faster than the two orthogonal locations, indicating that the movement of attention from the cued side to the centre and over to the opposite side does not provide an advantage over the orthogonal locations. Overall, Posner and Cohen showcased that IOR was not associated with the use of a two alternative location paradigm but can be observed in various locations within the visual field. This eventually led to

further research which examined whether IOR was limited only to locations, or to objects within those locations (Tipper et al., 1991; Tipper et al., 1994).

In the study by Tipper et al. (1991), the effects of IOR on both objects and locations within a visual search paradigm were investigated. They found that IOR moved with the cued object within the paradigm rather than the cued location and so suggested that IOR was an object-based attentional effect. Tipper et al. (1991) indicated that IOR can only be associated with one frame of reference – object-based – and that location-based IOR was the result of the paradigm used in the Posner and Cohen (1984) study. Subsequent work by Tipper et al. (1994) found that both object- and location-based IOR were present and can exist simultaneously, yet separately. They suggested that object-based IOR must be associated with a visible object, while location-based IOR must be associated with an objectless environment. It was concluded that both object- and location-based IOR contributed to the efficiency of visual searches, which was necessary by not only helping to find a pen on a desk (location-based), but by helping to locate a friend moving through a crowd of people (object-based). Further research has helped confirm the work of Tipper et al. (1994) in that IOR was found to be modulated by both object- and location-based components, and that the effects of these two components can be inhibited jointly or independently (Jordan & Tipper, 1998; Jordan & Tipper, 1999; Leek, Reppa, & Tipper, 2003; Tipper, Jordan, & Weaver, 1999) while mediated through cortical structures (Tipper et al., 1997). However, more recent research has questioned the existing notion of separate object- and location-based components and suggested that IOR operates as a unitary mechanism that prioritizes objects when present in the search array (McAuliffe, Pratt, & O'Donnell, 2001). Overall, the majority of research supports the notion that IOR can operate on different frames of

reference. Additional research is needed to further delineate the boundary conditions for object- and location-based IOR.

Target Intensity and Simultaneous Cueing

In order to test the third hypothesis, Posner and Cohen (1984) performed another variation of the COVAT by using a slightly dimmer cue and two simultaneous cues in both peripheral boxes. The first experiment examined whether a dimmer cue produced similar faciliatory and inhibitory effects compared to the original brighter cue. They found no significant change between both types of cues, which indicated that the enhancement effects of the cue produced no difference on facilitation and IOR. Reuter-Lorenz et al. (1996) expanded upon this experiment by examining whether target intensity affected the amount of IOR present. They performed a similar paradigm to that of Posner and Cohen (1984) but with two levels of target luminance. Reuter-Lorenz et al. found that target intensity did play a role in the magnitude of IOR, with greater IOR being observed on trials with a dimmer target and less IOR observed with bright targets. These results were further supported by Hunt and Kingstone (2003) in which they found greater IOR associated with dimmer targets. Overall, they both concluded that the difference in magnitude between target luminance suggested that IOR is an attentional effect dependent upon the sensory-perceptual loci for detection.

Along with the target intensity experiment, Posner and Cohen (1984) also performed the COVAT with two peripherally simultaneous cues. They found that the faciliatory effect was not significantly different between the double and single cue trials, but that IOR during the double-cue trials was as strong as in the single-cue trials. They believed that attention could not be split to both sides of the visual field once the cues were present. Posner and Cohen further suggested

that IOR was the result of the change in energy emitted at the fovea from the cued position and thereby does not arise from an orienting effect. In a similar study, Pratt and Hirschhorn (2003) examined the effects of simultaneous cues on both the faciliatory and inhibitory effects of attention. They found that both a faciliatory and IOR effect were observed during simultaneous cueing, similar to Posner and Cohen (1984), but that the inhibitory effect occurred earlier than expected. Pratt and Hirschhorn (2003) suggested that both facilitation and IOR are present during divided attention tasks (e.g. simultaneous cues) and that the differing time course observed indicated the separate phenomena of both facilitation and IOR.

Endogenous Orienting

To further expand on the third hypothesis, Posner and Cohen (1984) performed an "arrow experiment" by replacing the peripheral cue (flash) with a central cue (arrow). By altering the nature of the cue, Posner and Cohen manipulated the mode of attentional orienting to determine if the orienting type (exogenous/endogenous) influenced the magnitude of facilitation/IOR. Each trial began with a central arrow (cue) that appeared above the central box pointing either in the left or right direction, towards one of the two peripheral boxes. The cue provided an incentive to shift attention towards the target, in which the target appeared in the same direction as the cue at a probability of 0.8 or 80%. So, the cue would incorrectly predict the direction of the target at a probability of 0.2 or 20%. Posner and Cohen found that the participants showed periods of early facilitation at the shorter SOA interval (450 msec), similar to that of exogenous cues, and facilitation at the longest SOA interval (1250 msec). But contrary to the findings observed with exogenous cues, IOR was not found at long SOAs (950 and 1250 msec). As a result, Posner and Cohen stated that IOR is dependent upon the type of sensory information present. If the central arrow correctly indicated the direction of the target at an accuracy of 80%, then the participant

would always likely follow that correct direction. The effect of facilitation was expected. However, IOR should not be observed with endogenous cues since the incentive to shift attention in the direction of the arrow was almost perfect. The participants should have expected that the direction of the arrow would have led to the target, and should therefore not have inhibited attention from returning in the direction of the cue.

In a later study by Rafal et al. (1989), they performed a similar endogenous paradigm to Posner and Cohen (1984) in which participants were either instructed to perform a pre-programmed saccadic shift in the cued direction, or remain neutral and follow the direction of the central arrow. They found that during the pre-programmed saccadic eye movement, IOR was observed and was as strong as with exogenous cues. Even when the saccade was cancelled just prior to the trial, the act of programming the saccade resulted in a strong occurrence of IOR. This indicated a close link between IOR and the visual oculomotor system. Rafal et al. (1989) also suggested a link between the nature of reflexive and volitional orienting in regards to IOR, which has been further supported by more recent studies (Ristic & Kingstone, 2006; Stevens, West, Al-Aidroos, Weger, & Pratt, 2008; Tipples, 2002; Weger, Abrams, Law, & Pratt, 2008).

Effect of Trial Order and Conditioning on Predictability-Based Tasks

One significant element regarding many attention and IOR based studies has been whether participants can predict the nature of the task using short-term working memory (Stout, Amundson, & Miller, 2005). Stout et al. (2005) examined whether trial order (i.e. recency effect) and memory retention length (i.e. primacy effect) played a significant role in the effects of predictive judgement. Participants observed both reinforced (cue-target trials) and nonreinforced (cue-no target trials) presentations in one of three conditions: 1) latent inhibition

(LI) – nonreinforced followed by reinforced trials, 2) partial reinforcement (PR) – randomized ordering of reinforced and nonreinforced trials, and 3) extinction (EXT) – reinforced followed by nonreinforced trials. Stout et al. found that judgements were biased towards the more recent trial types when the participants were required to present their findings immediately following the sequence of trials (i.e. persistence of recency effect). They also found that the ratings of human predictive judgement were not solely dependent upon the retention interval length (48 hours post-test), and so the participants did not show this shift towards primacy. It has been found that when using predictive based tasks, the recency and trial-order effects tend to be more readily observed than when using causal based tasks (Matute, Vegas, & De Marez, 2002; Rescorla & Wagner, 1972). The flexible use of trial order information and stimuli must be considered when attempting to examine predictive based ratings. Overall, this provides the first shred of evidence to suggest that elements of conditioning and short-term working memory may play a role on a prediction-based task.

Effect of Trial Order and Conditioning on Reaction-Based Tasks

Since both recency-bias and trial order effects have been examined while using predictive based tasks, the next step should be to determine if the effects of trial order and conditioning exist during reaction- based tasks (e.g. COVAT). Both Dodd and Pratt (2007) and Maylor and Hockey (1987) examined whether the effects of the previous trial type influenced the magnitude of IOR on the COVAT. They both found that IOR was greater in trials following an uncued compared to a cued trial. Participants were also quicker to respond to trials when the previous trial was identical (e.g. cued-cued; uncued-uncued), which indicated that IOR may be a trial specific effect and that some form of working memory may influence the magnitude of IOR (i.e. persistence of recency effect). The results of Dodd and Pratt (2007) and Maylor and Hockey

(1985) concur with the work of Logan (1988), who suggested that participants may automatically retrieve information from their short-term working memory in order to aid in the performance of the current task. Studies within the context of negative priming have suggested that the most recently occurring elements tend to be more easily recalled, and that performance becomes enhanced when identical elements are perceived (i.e. cued-cued trials) (Neill & Mathis, 1998; Neill & Valdes, 1992). Based on upon the various research, IOR may be influenced by short-term working memory, and that the effect of trial order may directly influence the results on the COVAT. Pratt and Abrams (1995) further suggested that IOR only affects the most recently attended location (i.e. previous trial) and that future shifts in attention may displace the effects of memory to those same locations. They indicated that the effect of short-term working memory either does not exist, or exists in a limited extent and so may not significantly contribute to mechanism of IOR. Overall, further research is warranted to determine the extent of short-term working memory on the magnitude of IOR.

Effect of Practice on Reaction-Based Tasks

Another important element in attention research has been the role of practice on reaction-based tasks (COVAT) and whether the effect of practice influences the magnitude of IOR (Deller, 2006; Pratt & McAuliffe, 1999; Weaver, Lupianez, & Watson, 1998). Weaver et al. (1998) examined whether practice altered the effects on object-, location- and static based IOR. To examine the effects of practice on object-, and location-based IOR, they used a rotating display consisting of three peripheral boxes that formed a triangle around the central placeholder box. To examine the effects of practice on static-based IOR, they used a stationary display. They found that even after a small number of trials (190), a decrease in IOR was evident during all conditions (object-, location-, and static displays), which indicated that all three conditions

respond to practice in the same manner – less IOR. They also noted that prior to each condition, a series of unrecorded practice trials (20 trials) took place. Weaver et al. suggested that while these trials may not have contributed significantly to the overall effects of practice, they believe that the practice trials may have led to slight habituation just prior to the recording of the test. Overall, they concluded that practice plays a significant role in the reduction of IOR, and that this effect is observed regardless of the frame of reference (object, or location). Next, Pratt and McAuliffe (1999) examined whether they could replicate the reduction in IOR found by Weaver et al. (1998) using only a static display. They found no evidence of a reduction in IOR due to the effects of practice, contrary to that of Weaver et al. and suggested that IOR is a robust phenomenon that occurs regardless of the effects of practice. They further noted that any reduction in IOR due to practice are unlikely to occur in single-session experiments consisting of 300-1000 trials. Similar results were observed by Deller (2006) who also found no evidence of a practice effect on the reduction of the faciliatory and inhibitory responses on the COVAT. Overall, the research equivocally suggests that practice may not significantly contribute to a reduction in facilitation and IOR on the COVAT, especially when participants complete less than 1000 trials in a single-session experiment.

Effect of SOA Predictability on Reaction-Based Tasks

Not only have previous trial types and practice effects been investigated, but the effect of SOA predictability on IOR has also been examined (Gabay & Henik, 2008). Gabay and Henik (2008) manipulated three SOA intervals: 1) aging fore-period – SOAs were equally likely to predict a target, 2) non-aging fore-period – 50% chance that SOAs would predict a target, and 3) accelerated-aging fore-period – which had conditions that were opposite to the non-aging group. The aging fore-period design is common in many cueing experiments since the SOAs are equally

likely to occur during testing. The probability of the target increases once the SOA progressively increases, which makes the cue predictive as to when the target will appear. The non-aging design only allows a 50% chance that the SOA will correctly predict when the target will appear. Finally, the accelerated aging component utilizes the condition opposite the non-aging design, in which the SOA was more likely to predict when the target will appear, since the cue was more predictive compared to the other designs. The use of an aging and non-aging design along with an accelerated-aging component can help determine whether the probability of a target will increase when the SOA increases and if this contributes to IOR, due to the static nature of SOA intervals. They found that IOR was not affected by cue-target temporal predictability and that the interval between the cue and target did not lead to a significant reduction in IOR. As further supported by Tipper and Kingstone (2005), Gabay and Henik (2008) suggested that IOR may be modulated by the participants level of alertness and that the temporal predictability may become elevated during a vigilant state. When under periods of physiological arousal, the ability to predict when the target will appear may be enhanced and lead to a reduction in IOR. However, IOR shows no reductions due to temporal predictability and that the temporal information contained within a trial does not lead to a reduction in IOR.

To summarize the related research, the effects of trial order and conditioning may influence the responses on both predictability and reaction-based tasks, such as the COVAT. Due to the repetitive nature of the COVAT paradigm, the participants may have become conditioned to the basic structure of the task and in fact may have led to a slight conditioning effect. It has been shown that the most recent trial types tend to be referred to when compared to more distant trials, which indicates a persistence of the recency effect (Stout et al., 2005). Research also indicated that the structure of a preceding trial influences the response on the

subsequent trial (Dodd & Pratt, 2007; Maylor & Hockey, 1987). While the element of practice may contribute to the habituation argument (Weaver et al., 1998), in some cases other research suggested that practice does not play a significant role in the reduction in IOR (Pratt & McAuliffe, 1999) or on the effects of early facilitation and late inhibition (Deller, 2006) on the COVAT. Further research is warranted to fully understand the effects of practice and trial order on the results of the COVAT.

Vestibular Apparatus

Research on the COVAT has been extensively examined using many different experimental designs, such as the use of static/dynamic displays (Tipper et al., 1994), practice (Weaver et al., 1998), and previous trial types (Dodd & Pratt, 2007). One similarity among all these studies has been that the participants performed the COVAT while in a relaxed seated position in a controlled laboratory setting. However, attending to objects in the visual field is usually accompanied by performing a number of different actions on a simultaneous basis (e.g. driving). Performing visual attention tasks while in a controlled laboratory environment is therefore not indicative of common everyday activities that occupy our daily life. During these varying activities, it is common for the Autonomic Nervous System (ANS) to modulate activity, which provides another measure to consider when examining attention. A common method used to modulate the ANS involves the stimulation of the vestibular apparatus located in the inner ear (Carter, Ray, & Cooke, 2002; Kerman & Yates, 1998; Kitano, Shoemaker, Ichinose, Wada, & Nishiyasu, 2005; Normand, Etard, & Denise, 1997; Ray, Hume, & Shortt, 1997; Wilson, Serrador, & Shoemaker, 2002).

The vestibular apparatus is the system responsible for answering two very basic questions: 1) "where am I going?" (pg. 801), which provides information detecting the rate of change in linear and angular motion and 2) "what way is up?" (pg. 801), which details the position of the head relative to gravity (Kandel, Schwartz, & Jessell, 2000). The vestibular apparatus, as shown in Figure 1 (Mann, 1997), consists of two sets of structures: the semicircular canals and otolith organs. The first structure is that of the semicircular canals, which helps answer the first question by detecting the rate of linear, rotational and angular acceleration/deceleration of the head. Each ear contains a set of semicircular canals and each semicircular canal contains a set of three loops that are situated at right angles from each other, located in horizontal, vertical, and lateral positions. Each canal detects motion within its associated direction and sends its information via the vestibular nerve to the cardiovascular control centre for autonomic adjustments. The second structure is that of the otolith organs, which helps answer the second question by providing information of the position of the head relative to gravity.

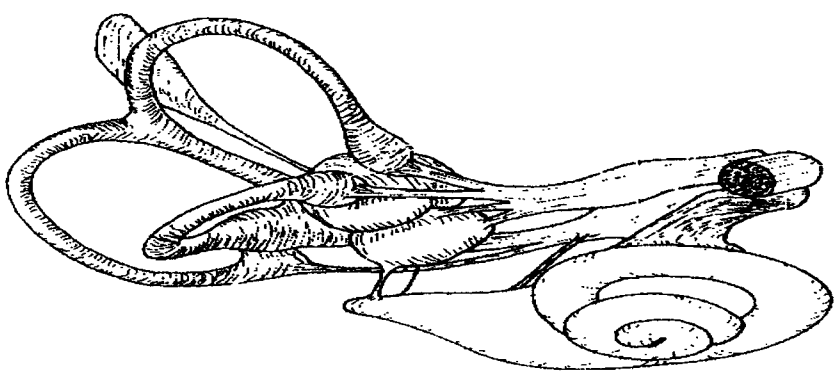

Figure 1. Schematic of the vestibular apparatus

The otolith organs consist of two sac-like structures, the utricle and saccule, which are located medially to the semicircular canals. Both the utricle and saccule detect changes of the

affecting the way the gravity vector (9.8 m/s^2) is experienced. Once in HDNF, the vestibular apparatus detects a change in head position, which results in the activation of autonomic activity.

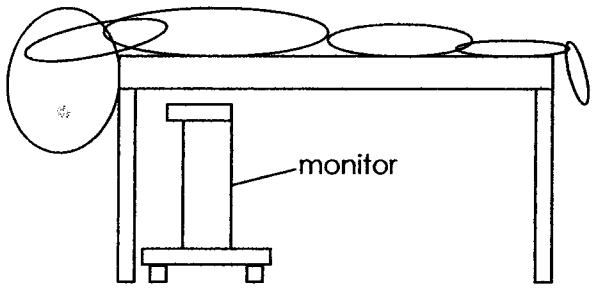

Figure 2. Head-down neck flexion

To determine the physiological effects produced by HDNF, numerous studies have been conducted to examine how HDNF contributes to vascular resistance, muscle sympathetic nerve activity (MSNA), and overall autonomic tone. Hume and Ray (1999) examined the effects of various HDNF positions and durations on sympathetic activation and vascular resistance. They found three main results: 1) MSNA increased as the degree of HDNF increased, 2) MSNA remained elevated during prolonged HDNF, and 3) sympathetic responses to HDNF were not associated with nonspecific receptors activated by increases in cerebral pressure. The first result indicated that the magnitude of MSNA depended upon the degree of HDNF implemented, in which they observed a 37% increase in MSNA during intermediate-HDNF and a 50% increase during maximal HDNF. The increase in MSNA indicated the elevation of sympathetic arousal caused by otolithic stimulation. Activation of the otolith organs that produced an increase in MSNA further supported the second result, in which MSNA remained elevated during prolonged HDNF. Since the otolith organs contain hairs that shift with the change in head position, any prolonged exposure in that position resulted in the maintenance of the elevated levels of sympathetic arousal. The final result found that certain receptors located in the head were not

associated with increases in sympathetic activation. They addressed this issue by comparing MSNA levels during HDNF to head-down neck extension (HDNE) and found that MSNA did not increase during HDNE. Hume and Ray (1999) proposed that otolithic activation during HDNE occurs in the opposite direction to that of HDNF and as such does not result in any increase in sympathetic arousal.

Similar to the previous study, Ray and Hume (1998) examined if neck muscle afferents produced any significant effects on sympathetic activation, or if sympathetic activation was caused simply through vestibular stimulation. To remove the effect of vestibular stimulation, MSNA measurements were collected before and after head rotation, which activated the neck receptors and not the otolith organs. They found that MSNA did not increase during horizontal head rotation indicating that the activation of neck muscle afferents does not lead to an increase in sympathetic arousal. Also, this study further supported the concept that HDNF, elicited through vestibular stimulation leads to an increase in sympathetic activity. To further determine whether HDNF activates the vestibulosympathetic reflex, Shortt and Ray (1997) conducted an experiment examining MSNA and arterial pressure during HDNF. They observed a large increase in MSNA with a slight increase in arterial pressure during 10 minutes of HDNF suggesting that HDNF activated the vestibulosympathetic reflex. It can be determined that the arterial and cardiopulmonary baroreflexes were not activated and that the vestibulosympathetic reflex solely caused this increase in sympathetic arousal.

Basis for Current Study

Deller (2006) examined the effects of autonomic arousal on the magnitude of faciliatory and inhibitory responses on the COVAT. Participants were healthy males and females between

the ages of 18-25 with normal or corrected to normal vision. The COVAT performed included both a 100 msec SOA interval in order to observe early facilitation and an 800 msec SOA interval in order to observe late IOR as originally reported by Posner and Cohen (1984). Responses were made to the appearance of the target at both cued and uncued locations with a hand-held microswitch. Participants performed the COVAT in a series of trial conditions: (1) seated, (2) prone, (3) HDNF, and (4) prone of which all participants (N=15) performed in the same trial order. The application of HDNF was used in order to evoke the stimulation of the vestibular apparatus, which was immediately preceded and followed by the prone trial condition. Deller (2006) required the participants to perform the prone condition twice in order to first provide a control prior to entering HDNF (as is common in many HDNF studies – see Shortt & Ray, 1997) and secondly to determine whether the effects of the ANS persisted following HDNF. Similar to the findings of Posner and Cohen (1984), Deller (2006) found a biphasic pattern of results including both facilitation at short SOAs and IOR at long SOAs. However, during the application of HDNF, the cueing effects (difference between cued and uncued RT) for both facilitation and IOR were found to be attenuated. Less facilitation and less IOR were observed during HDNF, which indicated that under autonomic arousal attention acted to narrow at a central element and thereby refused to shift unnecessarily to peripheral stimuli. Deller (2006) found that during the 100 msec SOA trials, the mean faciliatory cueing effect decreased from 25 msec in the seated trial condition to 6 msec during HDNF, an overall reduction of 19 msec. During the 800 msec SOA trials, the mean inhibitory cueing effect decreased from 43 msec during seated to 31 msec during HDNF, an overall reduction of 12 msec. In Deller (2006) the trial conditions tested were not counterbalanced and so all participants performed the same trial conditions in the same trial order (i.e. seated, prone, HDNF, prone). The participants may

have been conditioned to the order of the trial conditions when performing the COVAT and that when the participants entered HDNF, the attenuated faciliatory and inhibitory cueing effects have been due to the repetitive nature of testing.

Purpose

The purpose of the current study was to determine if trial order affects the attenuation of the faciliatory and inhibitory responses during autonomic arousal. The first element of the current study was to replicate the findings of Deller (2006) and then secondly, expand by re-ordering the trial conditions to determine whether the influence of trial order led to the attenuated faciliatory and inhibitory responses. If a trial order effect was to occur, then the faciliatory and inhibitory responses should follow a similar pattern of reduction from the first to final trial condition performed, regardless of the order of trial conditions (Dodd & Pratt, 2007; Maylor & Hockey, 1985; Stout et al., 2005). But if no trial order effect was to occur, then the reduction in the responses should only be observed during HDNF within each specific order of trial conditions performed (Deller, 2006).

Method

Participants

A convenience sample of sixty (32 males and 28 females) undergraduate and graduate students from Lakehead University were recruited for this study. Participants were asymptomatic young adults between the ages of 18 and 25 with normal or corrected to normal vision, and were clear of any existing cardiovascular, neurovascular, or respiratory medical conditions. All participants volunteered their time and were asked to complete one testing session lasting between 30 to 45 minutes, of which they were free to withdraw from at any time.

Recruitment was done through classroom, office and laboratory announcements with additional recruitment conducted through the use of a mass email sent to all undergraduate students within the Kinesiology Department at Lakehead University. Ethics was approved from the Lakehead University Research Ethics Board.

Apparatus and Procedure

Covert orienting of visual attention task.

The basic trial procedure (100 and 800 msec SOA) for the COVAT was similar to the procedure used by Posner and Cohen (1984), as illustrated in Figure 3. Each trial began with a blank screen for 1000 msec. Next, participants were presented with an initial display consisting of the outlines of two squares (1° wide and 1° high) located on the horizontal meridian, 5° to the left and right of a central fixation dot (filled in circle 0.2° in diameter) for an additional 1000 msec. All stimuli was presented as white (49.2 cd/m^2) on a black (0 cd/m^2) background. A cue consisting of the enlargement of one of the two peripheral boxes (1.1^0 square) appeared for 50 msec and then was immediately removed, which provided to the participant with the appearance that the box brightened. During the 100 msec SOA trials, there was a delay of 50 msec after the initial appearance of the cue, called the interstimulus interval (ISI), which was then immediately followed by the appearance of the target. Similarly during the 800 msec SOA trials, an ISI of 750 msec followed the appearance of the cue, which was then immediately followed by the appearance of the target. The target consisted of a filled in square (0.70° square) centered 5.5° to the right or left of the central fixation dot, located inside one of the two peripheral boxes. The target then remained on the screen until the participant responded or 1500 msec had elapsed.

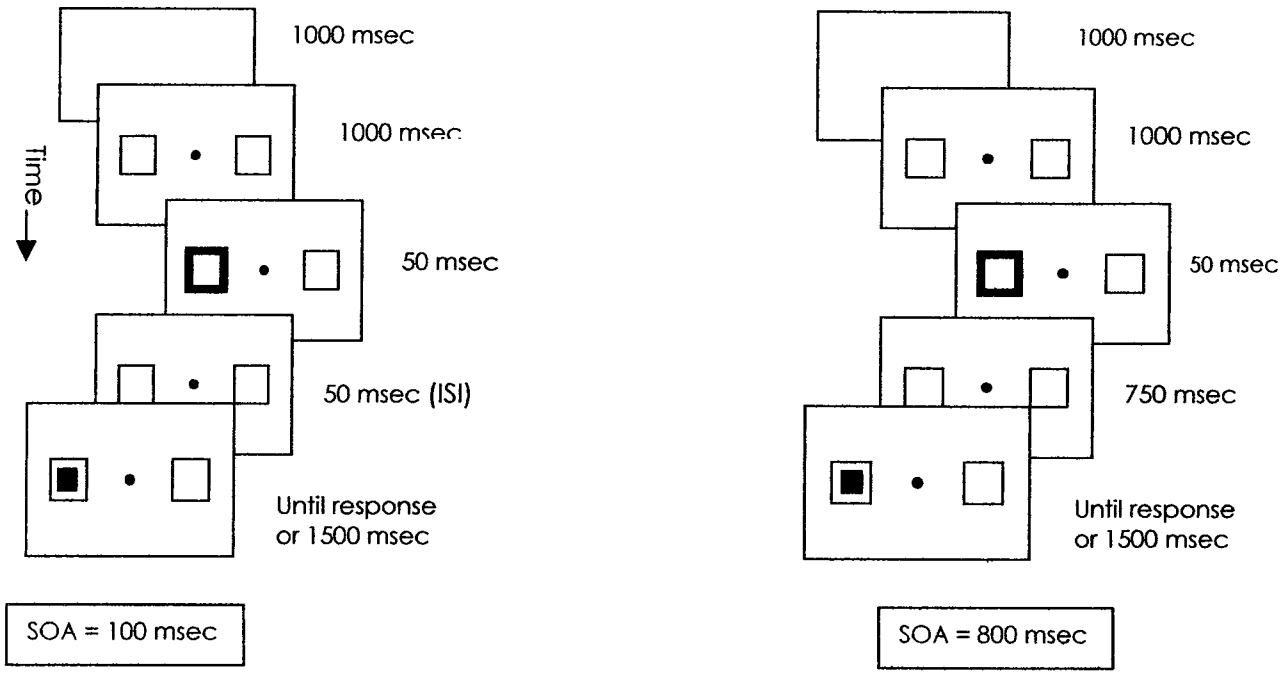

Figure 3. Sequence of 100 and 800 msec SOA COVAT trial

For the duration of each trial, participants were instructed to maintain fixation upon the central dot, and not to follow the appearance of the cue or target on the display. Once the participants recognized the target, they were instructed to respond by pressing the spacebar on the designated keyboard as quickly as possible. Half of the peripheral cues appeared on the right peripheral box and half on the left box. Half of the targets appeared on the same side as the cue (cued trials) and half on the opposite side (uncued trials). The cue location provided no useful information about the location of the target since it was based on a 50/50 cue-to-target relationship. Participants were instructed to ignore the cue and respond only to the appearance of the target. Catch trials were also included on 20% of the total trials. Catch trials consisted of all the events in the trial sequence except for the appearance of the target. Participants were instructed to refrain from responding if a target did not appear during the catch trials.

For each block of trials, participants completed 100 trials, forty with an SOA of 100 msec, and forty with an SOA of 800 msec, with an additional 20 catch trials. Each set of 100 trials took approximately 7-10 minutes to complete. By the end of testing, participants performed four COVATs thereby completing a total of 400 trials lasting approximately 30-45 minutes.

All testing took place in the Motor Development Laboratory (SB 1028) at Lakehead University. The COVAT was performed on three identical cathode ray tube (CRT) monitors, one for the seated condition, a second for both prone conditions performed, and a final CRT monitor for the HDNF condition. Each CRT monitor was centred at a distance of 40 cm from the participant and angled at 15° from the horizontal. Participants responded to the appearance of the target by striking the spacebar on the designated keyboard with their right hand. Also, either directly above (e.g. seated, prone) or beside (e.g. HDNF) the CRT monitor depending upon the space requirement of each trial condition was a small webcam that recorded the eye movements of the participants while performing the COVAT. This was required because voluntary shifting of the eyes would not produce the same results (facilitation at short SOAs, and IOR at long SOAs) that were observed by Posner and Cohen (1984).

Trial conditions and trial block orders.

Participants performed the COVAT in three different trial conditions: 1) seated, 2) prone, and 3) HDNF. Both the seated and HDNF trial conditions were each completed once by the participants. The prone trial condition was completed twice in order to fully reproduce the study by Deller (2006), which required both a control and recovery period before and after HDNF. To eliminate the effect of trial order, the trial conditions were counterbalanced into trial block orders based upon a '4x4' Latin Square, as shown in Table 1. The Latin Square was designed to ensure

that every trial condition appeared both before and after each condition an equal number of times. On the day of testing, participants randomly selected a trial block order (A, B, C, D), which indicated what order of trial conditions (e.g. seated, prone, HDNF, prone) they were to perform. Trial condition '1' was designated the seated condition, trial condition '2' was the prone condition, trial condition '3' was HDNF, and trial condition '4' was the prone condition. This method produced a total of 4 trial block orders, in which each block was completed by a total of 15 participants.

Table 1. Trial Block Order Using a '4 x 4' Latin Square

A =	1 2 3 4
B =	2 4 1 3
C =	3 1 4 2
D =	4 3 2 1

Trial condition '1', or the seated condition required the participants to perform the COVAT in a comfortably seated position centered at a distance of 40 cm from the CRT monitor, as shown in Figure 4 (Deller, 2006). The participants right hand was placed on the designated keyboard slightly to the right of the monitor.

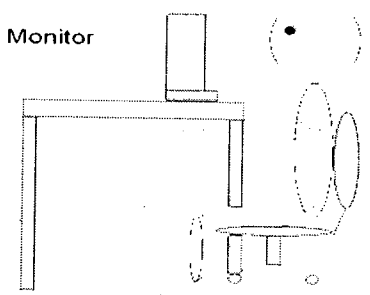

Figure 4. Trial condition '1' - seated

Trial conditions '2' and '4', or the prone conditions both assumed the same set-up and procedure. These trial conditions required the participants to assume a prone position on the HDNF table and have their neck extended with their chin supported by a chinrest, as shown in Figure 5 (Deller, 2006). The participants performed the COVAT on the CRT monitor centered at a distance of 40 cm with their right hand placed on the designated keyboard to the right of the monitor.

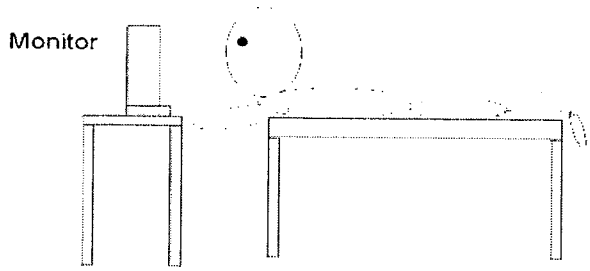

Figure 5. Trial conditions '2' and '4' - prone

Trial condition '3', or the HDNF condition, as shown in Figure 6 (Deller, 2006) first required the participants to assume the prone position. Once the participants assumed the prone position, the researcher passively lowered the head of the participants over the edge of the table until their neck was in full flexion. This transition to full flexion took about 1-2 seconds in length. A CRT monitor was placed directly underneath the HDNF table at a distance of 40 cm within the participants field of view. The participants were asked to place their right hand on the spacebar of the designated keyboard that was attached to the legs of the HDNF table within comfortable reach of the participants.

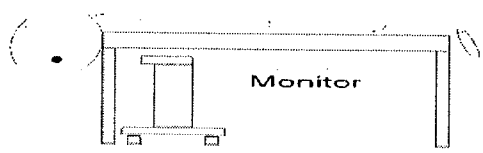

Figure 6. Trial condition '3' - HDNF

Statistical Analyses

Mean, median, and standard deviation for the errorless trials were calculated based on the reaction times (RT) (msec) during all trial conditions. Errors were also collected, which consisted of false positives (responding to catch trials), responding too fast (RT less than 100 msec), or responding too slow (RT greater than 800 msec) (Deller, 2006; Pratt & McAuliffe, 1999). Responses less than 100 msec indicated that the participants did not react to the appearance of the target but in fact anticipated the target, while responses greater than 800 msec indicated that the participants did not react as quick as possible to the target. To analyze the effects of an attenuated faciliatory and inhibitory mechanism of attention within each individual trial block order, a 2 (SOA: 100, 800) x 2 (Trial Type: cued, uncued) x 4 (Trial Condition: seated, prone, HDNF, prone) repeated measures analysis of variance (ANOVA) was used. To analyze the effect of trial order among the trial block orders, a 2 (SOA: 100, 800) x 2 (Trial Type: cued, uncued) x 4 (Trial Condition: seated, prone, HDNF, prone) x 4 (Trial Block Order: A, B, C, D) mixed factorial ANOVA was conducted. Significance was set at $p<0.05$ for all analyses.

Results

Trial Block Order A

Trial Block Order A consisted of seated, prone, HDNF, and prone (n=15), which was the trial order used by Deller (2006). The mean cued and uncued RTs from the errorless trials for

Trial Block Order A are listed in Table 2, with the cueing effects illustrated in Figure 7. The main effects for SOA [$F(1,14) = 2.045$, $MS_e = 3858$, $p>.05$], trial type [$F(1,14) = 4.163$, $MS_e = 1500$, $p>.05$], and trial condition [$F(3,42) = 2.880$, $MS_e = 3745$, $p>.05$] were not significant. The two-way interactions of SOA by trial condition [$F(3,42) = 1.298$, $MS_e = 648$, $p>.05$], and trial type and trial condition [$F(3,42) = 1.157$, $MS_e = 266$, $p>.05$] were not significant. The two-way interaction of SOA by trial type [$F(1,14) = 209.840$, $MS_e = 312$, $p<.05$] was significant. The interaction of SOA by trial type indicates significant facilitation at short SOA and IOR at long SOA. For the 100 msec SOA trials, the mean RT for the cued trials was 365 msec compared to 387 msec for the uncued trials. This is the typical facilitation effect. For the 800 msec SOA trials, the mean RT for the cued trials was 386 msec and the mean RT for the uncued trials was 343 msec. This is the typical IOR effect. Finally, the three-way interaction of SOA by trial type by trial condition [$F(3,42) = 2.071$, $MS_e = 396$, $p>.05$] was not significant. The lack of a three-way interaction indicates that there was no reduction in the cueing effect during HDNF. The results of Trial Block Order A do not replicate the results of Deller (2006).

Table 2. Mean Cued and Uncued RT (msec) for Trial Block Order A

	CUED RT (msec)	UNCUED RT (msec)	CUEING EFFECT Cued-Uncued RT (msec)
100 SOA			
SEATED	375	397	-22
PRONE	363	398	-35
HDNF	357	382	-25
PRONE	363	371	-8
800 SOA			
SEATED	400	352	48
PRONE	392	350	42
HDNF	372	326	46
PRONE	379	343	36

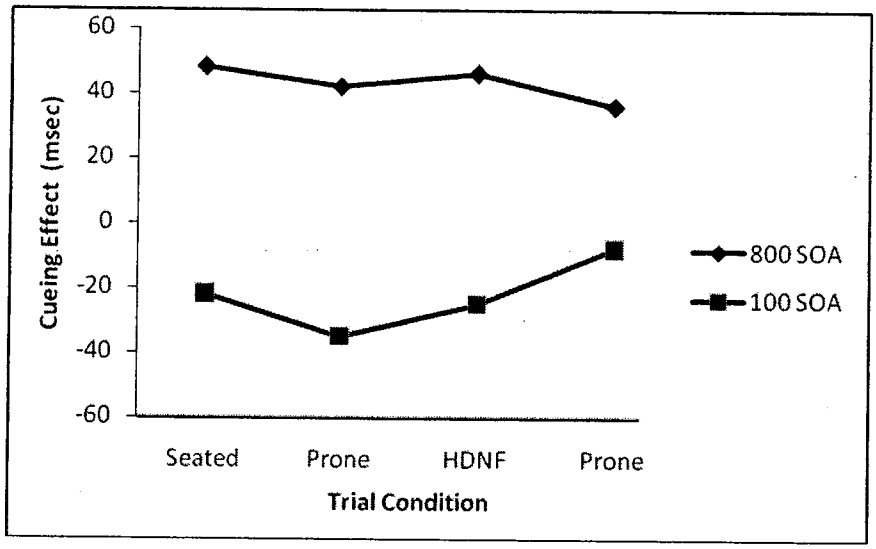

Figure 7. Cueing effect (cued-uncued RT) for trial block order A

Trial Block Order B

Trial Block Order B consisted of prone, prone, seated, and HDNF (n=15). The mean cued and uncued RTs from the errorless trials for Trial Block Order B are listed in Table 3 with the cueing effects illustrated in Figure 8. The main effects of SOA [$F(1,14) = 16.852$, $MS_e = 997$, $p<.05$], trial type [$F(1,14) = 7.437$, $MS_e = 929$, $p<.05$], and trial condition [$F(3,42) = 6.285$, $MS_e = 1236$, $p<.05$] were significant. The two-way interactions of SOA by trial condition [$F(3,42) = 1.192$, $MS_e = 253$, $p>.05$] and trial type by trial condition [$F(3,42) = .681$, $MS_e = 350$, $p>.05$] were not significant, however, the interaction of SOA by trial type [$F(1,14) = 57.694$, $MS_e = 822$, $p<.05$] was found to be significant indicating that the typical pattern of facilitation and IOR were present during Trial Block Order B. For the 100 msec SOA trials, the mean RT for the cued trials was 374 msec compared to 392 msec for the uncued trials, indicating the presence of facilitation at short SOA. For the 800 msec SOA trials, mean RT for the cued trials was 385 msec compared to 347 msec for the uncued trials, indicating the typical IOR effect. Finally, the

three-way interaction of SOA by trial type by trial condition [$F(3,42) = 2.457$, $MS_e = 432$, $p>.05$] was not significant indicating no reduction in the cueing effects during HDNF.

Table 3. Mean Cued and Uncued RT (msec) for Trial Block Order B

	CUED RT (msec)	UNCUED RT (msec)	CUEING EFFECT Cued-Uncued RT (msec)
100 SOA			
PRONE	380	407	-27
PRONE	377	391	-14
SEATED	372	398	-26
HDNF	367	370	-3
800 SOA			
PRONE	401	361	40
PRONE	382	339	43
SEATED	392	350	42
HDNF	366	337	29

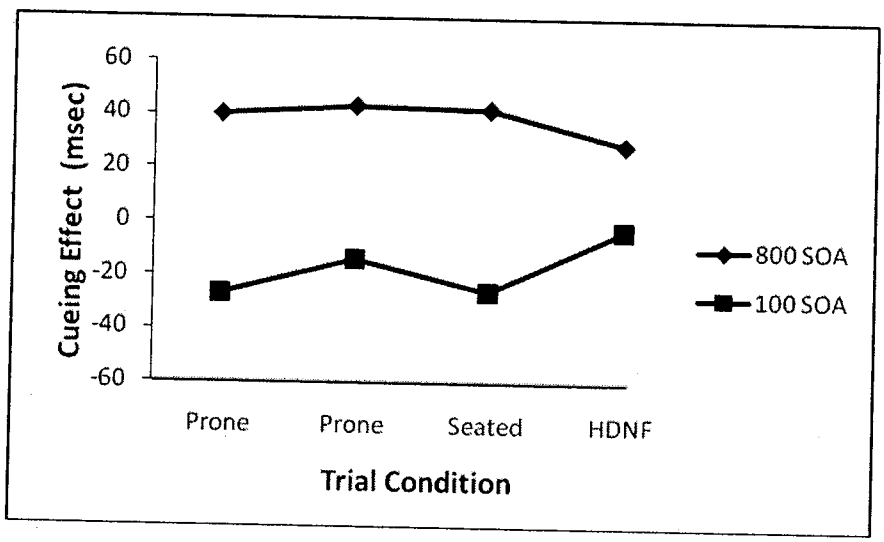

Figure 8. Cueing effect (cued-uncued RT) for trial block order B

Trial Block Order C

Trial Block Order C consisted of HDNF, seated, prone, and prone (n=15). The mean cued and uncued RTs from the errorless trials for Trial Block Order C are listed in Table 4 with the cueing effects illustrated in Figure 9. The main effects of SOA [$F(1,14) = 7.471$, $MS_e = 1671$, $p<.05$], trial type [$F(1,14) = 15.146$, $MS_e = 766$, $p<.05$], and trial condition [$F(3,42) = 3.755$, $MS_e = 941$, $p<.05$] were significant. The two-way interactions of SOA by trial condition [$F(3,42) = 1.682$, $MS_e = 319$, $p>.05$] and trial type by trial condition [$F(3,42) = 1.511$, $MS_e = 310$, $p>.05$] were not significant. Similar to Trial Block Orders A and B, the two-way interaction of SOA by trial type [$F(1,14) = 73.943$, $MS_e = 422$, $p<.05$] was significant indicating the typical pattern of facilitation and IOR. Mean RT for the cued trials was 339 msec compared to 347 msec for the uncued trials. For the 800 msec SOA trials, mean RT to the cued trials was 347 msec compared to 310 msec for the uncued trials. Finally, the three-way interaction of SOA by trial type by trial condition [$F(3,42) = .696$, $MS_e = 431$, $p>.05$] was not significant indicating no reduction in the cueing effects during HDNF.

Table 4. Mean Cued and Uncued RT (msec) for Trial Block Order C

	CUED RT (msec)	UNCUED RT (msec)	CUEING EFFECT Cued-Uncued RT (msec)
100 SOA			
HDNF	340	350	-10
SEATED	355	357	-2
PRONE	329	343	-14
PRONE	331	339	-8
800 SOA			
HDNF	346	304	42
SEATED	358	317	41
PRONE	346	311	35
PRONE	338	309	29

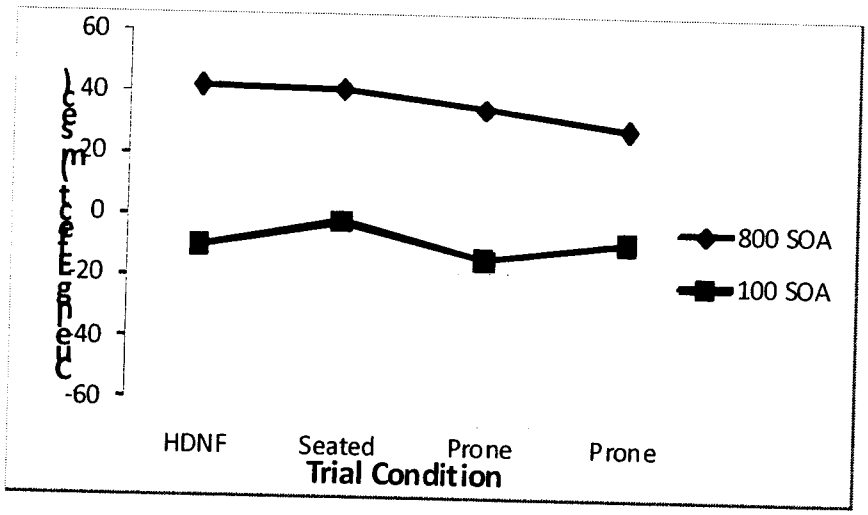

Figure 9. Cueing effect (cued-uncued RT) for trial block order C

Trial Block Order D

Trial Block Order D consisted of prone, HDNF, prone, and seated (n=15). The mean cued and uncued RTs from the errorless trials for Trial Block D are listed in Table 5 with the cueing effects illustrated in Figure 10. Significant main effects were found for both SOA [$F(1,14) = 5.031$, $MS_e = 1523$, $p<.05$], and trial condition [$F(3,42) = 3.774$, $MS_e = 3378$, $p<.05$]. The main effect of trial type [$F(1,14) = 4.412$, $MS_e = 1288$, $p>.05$] was not significant. The two-way interactions of SOA by trial type [$F(1,14) = 196.653$, $MS_e = 286$, $p<.05$], and SOA by trial condition [$F(3,42) = 5.374$, $MS_e = 402$, $p<.05$] were significant. The significant SOA by trial type interaction indicates that both facilitation and IOR were present during Trial Block Order D. For the 100 msec SOA trials, the mean RT for the cued trials was 350 msec compared to 371 msec for the uncued trials. This indicates the typical facilitation effect. For the 800 msec SOA trials, the mean RT for the cued trials was 370 msec compared to 329 msec for the uncued trials. This indicates the typical IOR effect. The two-way interaction of trial type by trial condition [$F(3,42) = .189$, $MS_e = 221$, $p>.05$] was not significant. Finally, the three-way interaction of

SOA by trial type by trial condition [$F(3,42) = .762$, $MS_e = 262$, $p>.05$] was not significant. There was no significant reduction in the cueing effects during HDNF.

Table 5. Mean Cued and Uncued RT (msec) for Trial Block Order D

	CUED RT (msec)	UNCUED RT (msec)	CUEING EFFECT Cued-Uncued RT (msec)
100 SOA			
PRONE	373	396	-23
HDNF	350	371	-21
PRONE	343	359	-16
SEATED	335	359	-24
800 SOA			
PRONE	378	332	46
HDNF	373	336	37
PRONE	366	330	36
SEATED	361	319	42

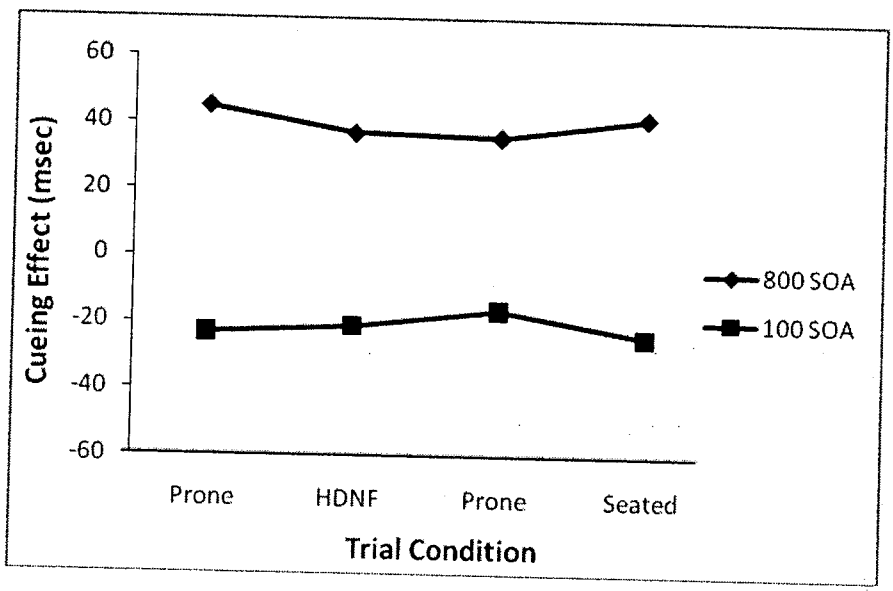

Figure 10. Cueing effect (cued-uncued RT) for trial block order D

Analysis of Trial Block Order Effect

In order to determine whether the effect of trial order led to the pattern of results found on the COVAT, the mean RTs from the errorless trials were analyzed with a 2 (SOA: 100 msec, 800 msec) x 2 (Trial Type: cued, uncued) x 4 (Trial Condition: seated, prone, HDNF, prone) x 4 (Trial Block Order: A, B, C, D) mixed factorial ANOVA. The mean cued and uncued RTs from the errorless trials for all four trial block orders are listed in Table 6, with the cueing effects illustrated in Figure 11. The main effects of SOA [$F(1,56) = 21.676$, $MS_e = 2012$, $p<.05$], and trial type [$F(1,56) = 26.589$, $MS_e = 1121$, $p<.05$] were significant, while the main effect of trial condition [$F(3,168) = 2.481$, $MS_e = 1779$, $p>.05$] was not significant. The two-way interactions of SOA by trial condition [$F(3,168) = 2.006$, $MS_e = 353$, $p>.05$], and trial type by trial condition [$F(3,168) = .321$, $MS_e = 248$, $p>.05$] were not significant. The SOA by trial type [$F(1,56) = 427.435$, $MS_e = 460$, $p<.05$] interaction was significant suggesting that facilitation and IOR were observed. The three-way interaction of SOA by trial type by trial condition [$F(3,168) = .646$, $MS_e = 339$, $p>.05$] was not significant further supporting the previously analyzed trial block orders, which did not find an overall reduction in the cueing effects upon HDNF.

Table 6. Mean Cued and Uncued RT (msec) Across Trial Block Orders

	CUED RT (msec)	UNCUED RT (msec)	CUEING EFFECT Cued-Uncued RT (msec)
100 SOA			
BLOCK A	365	387	-22
BLOCK B	374	392	-18
BLOCK C	339	347	-8
BLOCK D	350	371	-21

800 SOA			
BLOCK A	386	343	43
BLOCK B	385	347	38
BLOCK C	347	310	37
BLOCK D	370	329	41

There was a significant main effect for trial block order [$F(3,56) = 2.965$, $MS_e = 24262$, $p<.05$]. The significant main effect of trial block order suggests that the order of the trial conditions plays a factor in the responses to the COVAT. The two-way interactions of SOA by trial block order [$F(3,56) = .202$, $MS_e = 406$, $p>.05$] and trial type by trial block order [$F(3,56) = .191$, $MS_e = 214$, $p>.05$] were not significant. The two-way interaction of trial condition by trial block order [$F(9,168) = 4.459$, $MS_e = 7037$, $p<.05$] was significant indicating that RT differed from trial condition to trial condition within each trial block order. The three-way interactions of SOA by trial type by trial block order [$F(3,56) = 2.488$, $MS_e = 1146$, $p>.05$] and trial type by trial condition by trial block order [$F(9,168) = .720$, $MS_e = 178$, $p>.05$] were not significant. The non significant SOA by trial type by trial block order interaction indicated that early facilitation and late IOR were present throughout all four trial block orders. The three-way

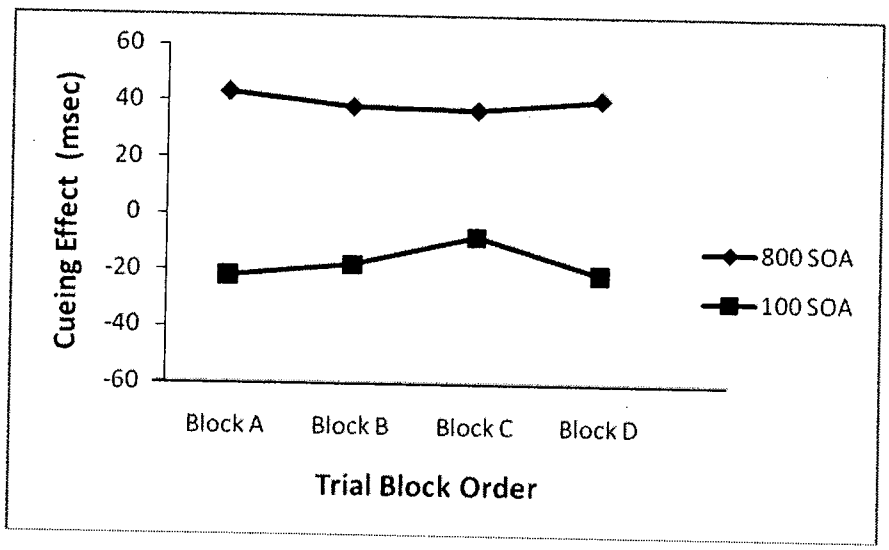

Figure 11. Cueing effect (cued-uncued RT) across trial block orders

interaction of SOA by trial condition by trial block order [$F(9,168) = 2.721$, $MS_e = 949$, $p<.05$] was significant. Finally, the four-way interaction of SOA by trial type by trial condition by trial block order [$F(9,168) = 2.013$, $MS_e = 682$, $p<.05$] was significant. A Tukey's HSD was conducted among the trial block orders, which found that the mean scores only significantly differed between Trial Block Orders B and C ($p = 0.044$). Trial Block Orders B and C are important because of when HDNF was performed. In Trial Block Order B, HDNF was performed last, while in Trial Block Order C, HDNF was the first trial condition performed. Depending upon whether HDNF was performed first or last, RT significantly differed compared to when HDNF was performed in the middle of a set of trial conditions. However, due to the inconsistent results in the cueing effects of Trial Block Orders B and C, and the lack of the replication in Trial Block Order A, the specific order of trial conditions cannot be assumed to play a significant role in the pattern of results found on the COVAT. The present results do suggest that the order to perform the trial conditions should be carefully considered, especially when conducting research using HDNF as an experimental component.

Discussion

There were two major results of the current study. First, there were no effects of autonomic arousal on the faciliatory and inhibitory cueing effects observed during all four trial block orders. Specifically during Trial Block Order A, which was identical to Deller (2006) there was no reduction in the cueing effects observed upon HDNF. Both the faciliatory and inhibitory cueing effects remained relatively stable between the seated and HDNF trial conditions indicating that there were no differences in the magnitude of responses on the

mechanisms of facilitation and IOR. The stabilization of the cueing effects suggests that attention was able to shift to the periphery and respond quickly to peripheral stimuli when physiologically aroused. Due to the lack of reduction in the faciliatory and inhibitory cueing effects during HDNF, it can be concluded that the current study failed to replicate the results of Deller (2006) in Trial Block Order A. Second, a significant trial order effect was observed among the trial block orders tested. However, since there was a failure to replicate the results of Deller (2006) in Trial Block Order A, and due to the inconsistent results observed between Trial Block Orders B and C, a trial order effect cannot be assumed to have led to the reduction in the faciliatory and inhibitory cueing effects observed in Deller (2006).

The present experiment used the same test and trial conditions as Deller (2006). Participants performed the typical COVAT paradigm within a specific order of trial conditions (e.g. seated, prone, HDNF, prone). Similar to the original findings of Posner and Cohen (1984), participants in the current study showed a biphasic pattern of results independent of the trial condition performed. The significance of the interaction of SOA by trial type in all four trial block orders further provided evidence of the biphasic pattern of early facilitation followed by late inhibition. When the SOA was less than 300 msec, RT to the cued targets were faster than to the uncued targets (cued<uncued). Facilitation was evident in the current study indicating that the participants were able to disassociate the cue from the target on the 100 msec SOA trials. Research has shown that at short SOAs, the magnitude of facilitation has either been reduced or not been observed due to the temporal difference between the cue and target (Collie, Maruff, Yucel, Danckert & Currie, 2000; Maruff, Yucel, Danckert, Stuart & Currie, 1999; McAuliffe & Pratt, 2005). So participants may confuse the cue and target stimuli on the display. The overall effects of facilitation in the current study were strong suggesting that the participants were able

to clearly identify the cue stimuli from the target. Similarly, when the SOA was greater than 300 msec, RT to the uncued targets were faster than to the cued targets (uncued<cued). The pattern of faster RT to uncued compared to cued targets indicated the robust effect of IOR evident during the 800 msec SOA trials.

The results from Trial Block Order A found no significant reduction in both the faciliatory and inhibitory cueing effects during HDNF. In Trial Block Order A, the mean faciliatory cueing effect increased from seated (22 msec) to HDNF (25 msec) among the 100 msec SOA trials, while the mean inhibitory cueing effect decreased from seated (48 msec) to HDNF (46 msec) among the 800 msec SOA trials. However, a lack of significance was found for the interaction of SOA by trial type by trial condition in Trial Block Order A, which suggests that the effects of facilitation and IOR cannot be attributed to the application of ANS modulation. The results from Trial Block Order A suggest that both the faciliatory and inhibitory cueing effects remained relatively stable between the seated and HDNF trial conditions. Stabilization of the cueing effects indicated that attention was able to respond as quickly to peripheral stimuli during autonomic arousal compared to when seated. Basically, attention was able to respond in the same manner and to the same extent when physiologically aroused compared to when relaxed, which is contrary to the findings of Deller (2006). Deller (2006) found that participants showed an attenuation of the mean faciliatory cueing effect from seated (25 msec) to HDNF (6 msec), an overall reduction of 19 msec. An attenuation of the mean inhibitory cueing effect was also found from seated (43 msec) to HDNF (31 msec), an overall reduction of 12 msec. It was suggested that the attenuation of the cueing effects were due to the modulation of the ANS indicating that when physiologically aroused, attention acts to narrow at a central element. Unfortunately, the

current study observed a stabilization of the cueing effects in Trial Block Order A, which confirms the failure to replicate the results of Deller (2006).

The failure to observe a reduction in the faciliatory and inhibitory cueing effects due to the modulation of the ANS was quite unexpected. Whereas Deller (2006) found a robust reduction in the cueing effects upon HDNF, there was no such evidence of those effects in the current study. Many of the same instruments were used for both studies including the same COVAT, CRT monitors, and even the same testing room. Many of the same techniques were also used such as the distance the participants were situated from the monitors (40 cm), the angle of the monitors (15°), and the method for calculating the mean RT scores per participant. Finally, the same types of participants (undergraduate and graduate Kinesiology students) were also included between both studies. The exact reproduction of the study by Deller (2006) was taken very seriously in order to reduce the amount of variability between the studies and to observe a similar attenuated response in the cueing effects. One major difference between the current study and that of Deller (2006) was the method by which the participants responded to the appearance of the target. Deller (2006) had participants respond to the appearance of the target with a hand-held microswitch that was held in the participants preferred hand. In the current study, the hand-held microswitch was replaced with a keyboard to which the participants responded by striking the spacebar. It seems unlikely that a small component of the experimental design could lead directly to the failure to replicate, considering that all other aspects were carefully controlled. Also, no research currently exists which suggests that the response mode (i.e. keyboard vs. microswitch) significantly influences the results on manual reaction-based tasks, such as the COVAT.

One possible explanation for the failure to replicate was the fact that ANS activity was not monitored during the current study and the study by Deller (2006). Since the ANS was not monitored, the levels of physiological arousal may have not been balanced between the studies and possibly leading to the differing results. Studies have shown that attention responds in different strategies depending upon the level of physical exertion or arousal levels experienced (Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008). Both Hutchinson and Tenenbaum (2007) and Tenenbaum and Connolly (2008) found that attention employs a dissociative perspective when under low levels of workload, but then shifts to an associative perspective when workload increases. This suggests that when under a low level of physiological arousal, attention is focused outward and away from bodily sensations (e.g. heart rate, blood flow, sweat) and as such can react more quickly to peripheral stimuli. On the other hand, when under an increased level of arousal, attention shifts inward or narrows and as such is more focused on internal bodily sensations. Finally, they further observed that when under a low to moderate levels of arousal, attention can act to voluntarily shift between both the dissociative and associative modes. The results of Trial Block Order A suggest that upon an increase in ANS activity, the mechanisms of facilitation and IOR may have more closely employed a dissociative strategy. The fact that the participants were not constantly under higher levels of physiological arousal may indicate why there were no differences observed between the seated and HDNF trial conditions on the mechanisms of facilitation and IOR. As such, the participants were able to employ a wider search array during HDNF. Contrary to the results of Trial Block Order A, Deller (2006) found that an associative strategy was possibly employed suggesting that the participants were constantly under higher levels of physiological arousal. The application of an associative strategy makes sense since the participants showed an attenuated effect of facilitation

and IOR during HDNF, which means that a more narrow focus of attention was employed. Overall, more research must be conducted to determine the true nature of reflexive orienting during physiological arousal.

A second possible explanation for the failure to replicate was that the degree of HDNF achieved between both studies may have not been identical. Research has shown that intermediate to maximal degrees of HDNF increase ANS activity by 37-50%, and that to reach maximal HDNF the degree of neck flexion must reach approximately 128° (Hume & Ray, 1999). The results of Trial Block Order A may suggest that the participants may have not reached or maintained maximal levels of HDNF when performing the COVAT. The inability to reach maximal HDNF may have led to the dissociative strategy of attention and therefore may have contributed to the lack of significance in the faciliatory and inhibitory cueing effects. More than likely the participants only reached a sub-maximal to intermediate degree of HDNF during Trial Block Order A. On the other hand, the results of Deller (2006) possibly indicated that the participants reached an intermediate to maximal degree of HDNF resulting in an associative strategy of attention. The difference in the degree of HDNF may have led directly to the opposing strategies of attention achieved between both studies. The inconsistent results emphasize the importance of monitoring ANS activity and HDNF degrees during testing and not to assume that certain previously tested conditions (e.g. HDNF) always lead to the same results on a per participant basis.

A third possible explanation for the failure to replicate was that the effects of autonomic arousal may enhance reaction times and attentional mechanisms, rather than reduce the responses as observed by Deller (2006) (Davranche & Audiffren, 2004; Yagi, Coburn, Estes, & Arruda, 1999). Davranche and Audiffren (2004) found that at 20 % maximal aerobic power (MAP), RT

was 10 msec faster while at 50% MAP, RT was 20 msec faster compared to at rest. They suggested that when physiological arousal increases an enhancement in RT was observed. The results of Trial Block Order A somewhat agree with Davranche and Audiffren (2004) in which the cueing effects to peripheral stimuli were either stabilized or in some cases faster during periods of physiological arousal compared to rest. While the results of the current study do not completely concur with Davranche and Audiffren (2004), they do provide some evidence that the mechanisms of attention respond in a similar manner. However, more research should be conducted to fully understand the effects of exercise on the mechanisms of facilitation and IOR. Davranche and Audiffren (2004) also found that submaximal exercise performed at 20% MAP actually helped alleviate the boring nature of the task being performed contributing to the decrease in RT. They suggested that during lower levels of physiological arousal, the boring nature of the task may have become a secondary issue to the participants allowing them to focus on the important components of the task. The results of Trial Block Order A may also partially agree with this finding since the participants relative boredom levels may have been alleviated due to the lower level of physiological arousal experienced. With the participants boredom levels alleviated, they may have been able to respond as quickly to peripheral stimuli during HDNF compared to when seated. But since the ANS and relative boredom levels were not monitored during the current study, this can only be speculated until further studies examine whether the relative boredom levels are alleviated during ANS activity when performing the COVAT. In a similar study to Davranche and Audiffren (2004), Yagi et al. (1999) found that reaction times were enhanced (i.e. decreased) during periods of exercise compared to rest. They found that RT decreased during periods of exercise in which the participants heart rates increased to an average of 134 beats per minute (bpm) for men and 145 bpm for women. A similar pattern

in heart rate was found by Tenenbaum and Connolly (2008) suggesting that this level of physiological arousal led to the dissociative strategy of attention. Even though it is unknown to what level of heart rate participants experienced in Trial Block Order A, the lack of reduction in the faciliatory and inhibitory cueing effects suggests that the participants may have maintained similar heart rates. Yagi et al. (1999) also found that as arousal levels increased, errors rates increased at a similar rate. This is problematic because an increase in errors may suggest that the participants either became fatigued or bored with the test, which could possibly account for the inability to replicate the results of Deller (2006) in Trial Block Order A. However, errors were only found on less than 1% of all target present trials and that errors during HDNF (0.06%) were found to be less compared to the seated trial condition (0.3%). An increase in errors was not observed in Trial Block Order A when the participants entered a state of elevated arousal. While this is not in agreement with Yagi et al. (1999), it is in agreement with Davranche, Audiffren and Denjean (2006) who found that as exercise increased, participants RT became faster without becoming less accurate or more variable.

Error Analysis

The error rates and percentages of errors per trial block order are listed in Table 7. The total number of errors committed was 196, which equates to less than 1% of the total number of trials performed (24000 trials). Errors consisted of either responding too fast (RT≤100 msec), or too slow (RT≥800 msec) on all target present trials, or responding to the appearance of catch trials (false positives). Of the total number of errors committed, 10 errors (0.05%) were committed by responding too fast, 99 errors (0.5%) were committed by responding too slow, and 87 errors (1.8%) were committed by responding to catch trials.

Further analysis of the errors revealed that during each trial block order, a disproportionate number of errors occurred on the first trial performed (Table 8). During Trial Block Orders A, B, C, & D, over half of the errors were committed on the very first trial suggesting that the participants may have not been prepared for the start of the first trial. The high error rate could be due to the fact that no practice trials were included prior to testing. The participants were only verbally instructed on how to perform the COVAT and then when the researcher left the room, the participants began the test trials. As such, some participants may have not been fully prepared for the start of the first trial. The high number of errors highlights the need for a set of practice trials to be included prior to testing (i.e. 5-10 trials) so that the participants can experience the specific timing and stimuli components of the COVAT before the actual test begins.

Table 7. Error Rates and Percentage of Errors Across Trial Block Orders

	Errors (Target-Present Trials)	Errors (Catch Trials)	Total	Percentage (%)
Block A	25	23	48	0.8%
Block B	27	25	52	0.9%
Block C	36	21	57	0.95%
Block D	21	18	39	0.65%
Total	109	87	196	0.8%

Participants' eyes were also monitored for voluntary shifting that exceeded more than 5% of the trials. The recording of the eyes was conducted to ensure that eye fixation upon the

central fixation dot was maintained while performing the COVAT. No participants made voluntary eye movements on more than 5% of trials.

Table 8. Percentage Comparison of Errors on First Trial

	Block A	Block B	Block C	Block D
% Error on First Trial	52	52	53	67
% Error on Remaining Trials	48	48	47	33

Secondary Factors Contributing to Failure to Replicate

Analysis of practice influence.

In order to examine all possibilities of why there was a failure to replicate the results of Deller (2006), further analysis was conducted to determine if the participants experienced a practice effect from the first to last COVAT performed. The analysis of practice was conducted because the participants may have become conditioned to the repetitive nature of the COVAT by the time they completed the last test. Because the participants had completed 400 trials by the end of testing, RT may have significantly decreased from the first to last COVAT performed due to the effect of practice. The overall mean RT scores (cued + uncued trials) per trial block order are listed in Table 9. The main effect of trial condition was analyzed within each individual trial block order through a 2 (SOA: 100, 800) x 2 (Trial Type: cued, uncued) x 4 (Trial Block Order: A, B, C, D) mixed factorial ANOVA. The main effect of trial condition was not significant for Trial Block Order A [$F(3,56) = 1.241$, $MS_e = 4880$, $p>.05$], Trial Block Order B [$F(3,56) = .951$, $MS_e = 8168$, $p>.05$], Trial Block Order C [$F(3,56) = .837$, $MS_e = 4222$, $p>.05$], and Trial Block

Order D [$F(3,56) = .654$, $MS_e = 11725$, $p>.05$]. The lack of significance suggests that RT did not decrease from the first to last COVAT performed within all four trial block orders tested. Since the main effect of trial condition was not found to be significant in Trial Block Order A, the failure to replicate the results of Deller (2006) cannot be attributed to the influence of practice. Participants did not show a significant pattern of decreasing RTs as a result of the increasing number of trials being performed, regardless of the trial block order. It should be noted that a proper method to analyze the effects of practice was restricted due to the current research design. To examine the effects of practice, two criteria must be met. The first criterion requires the same participants to perform the same tests so that the individual differences are identical across the block of tests performed. The second criterion requires the same tests to be performed in the same conditions across the trial block orders so that no variations in the design of the tasks influence the results. The 2 (SOA) x 2 (Trial Type) x 4 (Trial Block Order) ANOVA used to analyze the effect of practice was based upon the first criteria, which examined the same participants performing the same tests. Examining the same participants eliminated the individual differences observed on the responses to the COVAT, which made the current method more appropriate. It was also chosen because it was a stronger method compared to the alternative, which examined the same trial conditions (e.g. seated) from each individual trial block order (e.g. A, B, C, D). Unfortunately the lack of significance observed for the main effect of trial condition violated the second criteria in that the participants performed the COVAT in a slightly different trial condition (e.g. seated, prone, HDNF, prone). So the change in design between trial conditions may have led to the lack of significance in Trial Block Orders A, B, C, and D rather than due to the lack of a practice effect. Overall, the research design of the current study would not allow for a proper analysis for the effect of practice. Further research should be

conducted to determine if the effect of practice was evident during each individual trial condition across the four trial blocks.

Table 9. Overall RT (msec) Across Trial Block Orders

	COVAT 1 (msec)	COVAT 2 (msec)	COVAT 3 (msec)	COVAT 4 (msec)
100 SOA				
BLOCK A	386	380	369	367
BLOCK B	394	384	385	369
BLOCK C	345	356	336	335
BLOCK D	384	361	351	347
800 SOA				
BLOCK A	376	371	349	361
BLOCK B	381	361	371	351
BLOCK C	325	338	329	324
BLOCK D	355	354	348	340

Analysis of reaction time variance.

An analysis of RT variance was also conducted in order to determine if the amount of variance in the responses to peripheral stimuli increased during HDNF. If a significant increase in RT variance was observed upon HDNF compared to seated, then the influence of response variability could have led to the failure to replicate the results in Trial Block Order A. The variance was analyzed by examining a set of two trial conditions (e.g. seated by HDNF) through the use of a Pitman's T-test. The Pitman's T-test examined the hypothesis that the correlated samples used were drawn from populations with identical variances. All possible trial condition combinations were examined to determine if significant differences existed in the variability between the trial conditions for the series of cued 100, uncued 100, cued 800, and uncued 800 trial types. For the sake of this analysis, the set of seated by HDNF trial condition combinations

were examined in order to determine whether the influence of autonomic arousal led to an increase in RT variance. Since a failure to replicate was observed, the possible increase in RT variance was thoroughly examined in Trial Block Order A. If the variance was not found to increase during HDNF in Trial Block Order A, then further examination and discussion of Trial Block Orders B, C, and D are not necessary. The analysis of greater variance for the series of cued 100 trials [$t(13) = 0.917$, $p>.05$], uncued 100 trials [$t(13) = 0.869$, $p>.05$], cued 800 trials [$t(13) = 0.173$, $p>.05$] and uncued 800 trials [$t(13) = 0.130$, $p>.05$] for the seated by HDNF trial conditions were not significant in Trial Block Order A. There was no difference in the RT variance between the seated and HDNF trial conditions during any combination of trial types. The lack of significance suggests that the amount of variance in RT did not increase during levels of physiological arousal, and so the failure to replicate the findings of Deller (2006) were not due to the differences in RT variance seen during Trial Block Order A. Once participants entered into HDNF, the variance in the responses to the COVAT did not increase but remained constant. Significance was found during the series of cued 100 trials between the trial conditions of prone by HDNF [$t(13) = 2.647$, $p<.05$] and HDNF by second prone [$t(13) = 2.294$, $p<.05$]. Significance was also found during the series of uncued 800 trials between HDNF by second prone [$t(13) = 2.288$, $p<.05$] and prone by second prone trial conditions [$t(13) = 3.058$, $p<.05$] in Trial Block Order A. Significance suggests that the amount of variance in RT during HDNF differed from the conditions that either preceded or followed HDNF during the selected set of trials. The level of variance observed during HDNF was only greater during the series of cued 100 trials and not during the series of uncued 800 trials. So even if an increase in variance did occur, it did not occur on a consistent basis to imply that the variance increased as a function of arousal levels (pre- or post-HDNF). Overall, these results suggested that the level of variance

did not increase during autonomic arousal and so did not further contribute to the failure to replicate in Trial Block Order A. Slightly different results were found within the other three Trial Block Orders (B, C, and D) however, these differences were not consistent from sample to sample analyzed. So similar to Trial Block Order A, it cannot be stated that the level of variance increased upon HDNF during Trial Block Orders B, C, and D.

Conclusion

In this study, participants performed the COVAT within a specific order of trial conditions (e.g. seated, prone, HDNF, prone) to determine if the trial order performed led to the attenuation of the faciliatory and inhibitory responses during autonomic arousal. The first major result of the current study was the stabilization of the faciliatory and inhibitory cueing effects observed during all four trial block orders. It was found that the magnitude of faciliatory and inhibitory responses to peripheral stimuli showed no differences between the seated and HDNF trial conditions. The stabilization suggests that the mechanisms of facilitation and IOR respond in the same manner during levels of physiological arousal compared to when relaxed. Since the effects of ANS activity were not found to attenuate the faciliatory and inhibitory cueing effects, it can be concluded that the current study failed to replicate the results of Deller (2006) in Trial Block Order A. The second major finding of the current study was that a trial order effect was observed between the trial block orders. But since there was a failure to replicate the results of Deller (2006) in Trial Block Order A, and due to the inconsistent results between Trial Block Orders B and C, the effect of trial order on the responses to the COVAT cannot be definitively reported to have led to the attenuated cueing effects in Deller (2006). The inability to replicate in Trial Block Order A may be due to the fact that the levels of ANS activity were not monitored, and so may have not been similar between both studies. Various research suggests that certain

levels of autonomic arousal (e.g. low, moderate, high) produce varying strategies of attention (e.g. dissociative, associative), which may be responsible for the differing results (Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008). Further research has also found that the degree of HDNF achieved can result in different levels of ANS activity (Hume & Ray, 1999). The fact that the degree of HDNF may have not been identical could also account for the inability to replicate. Finally, the failure to replicate could also be due to the fact that ANS activation may lead to an enhancement of RT and attentional mechanisms rather than lead to a reduction (Davranche & Audiffren, 2004; Yagi et al., 1999). It was further noted that the failure to replicate was not due to the effects of practice or due to any increase in RT variance during HDNF.

Limitations

A few limitations must be considered when interpreting the findings. First, the level of physiological arousal was not monitored in the current study so it was unknown to what extent the participants experienced an increase in autonomic arousal. The ANS was not monitored in the current study because the ANS was not monitored in the study by Deller (2006). The fact that the ANS was also not monitored by Deller (2006) suggests that it was unknown to what extent of ANS activity was achieved by the participants. Previous research has found that different strategies of attention are employed depending upon the level of arousal experienced (e.g. lower vs. higher). Since the arousal levels achieved may have differed between both studies, the fact that a failure to replicate occurred in Trial Block Order A may have been due to the lack of ANS monitoring. Second, the degree of HDNF was not monitored in the current study, so it was unknown to what extent of HDNF was achieved by the participants. During testing participants were asked to reach maximal HDNF, however once the participants began the test,

the specific degree of HDNF may have lessened. This meant that the participants may have not maintained maximal HDNF throughout the test. Previous research has found that intermediate to maximal HDNF can lead to greater amounts of autonomic arousal and so if participants only achieved a sub-maximal HDNF degree, then that would have led to lower levels of arousal (Hume & Ray, 1999). The failure to replicate in Trial Block Order A could also be attributed to the lack of monitoring of the degree of HDNF. Third, the individual differences between both studies and to the application of HDNF also acted as a limiting factor. The same types of participants were collected between both studies. All were healthy males and females between the ages of 18-25 with no medical conditions. Also, all participants had normal or corrected to normal vision. The same inclusion and exclusion criteria were used between both studies and so there was no variability based upon the criteria for participation. However, since different participants actually participated between both studies, the aspect of individual differences still existed especially on how the participants responded to the COVAT. Historically, the effects of both early facilitation and late IOR have been consistently observed in many studies (Jordan & Tipper, 1998; McAuliffe & Pratt, 2005; Posner & Cohen, 1984; Tipper et al., 1991) along with the attenuated effects of facilitation and IOR during physiological arousal observed by Deller (2006). But the fact that HDNF used in the current study can be subjective to the participants, the individual differences that existed during HDNF may have led to the inability to find the attenuated responses of facilitation and IOR. Participants may have reacted differently to HDNF which would have led to the differing responses between both studies rather than due to the possible explanations such as the specific degree of HDNF or arousal levels achieved. Unfortunately this was a factor that could not be controlled. Fourth, the participants performed no practice trials prior to testing. The COVAT used in the current study was identical to that

used in Deller (2006) and that no practice trials were included prior to the first trial of each test in order to familiarize the participants with the COVAT. The inclusion of practice trials would have been beneficial since the participants committed the majority errors during the first trial within each trial condition. While this is not to suggest that a set of practice trials would alter the results of the current study, it does suggest that a few practice trials would have helped eliminate some errors, thereby strengthening the current data. Finally, the participants may have felt some eye fatigue during testing and possibly led to some errors. All participants completed 400 trials by the end of testing with the only breaks coming in-between the trial conditions. The participants may have felt some fatigue or drowsiness within each individual trial condition performed. Therefore, proper breaks should be included for each participant in future studies in order to eliminate as much fatigue as possible during testing.

Recommendations

Further research is warranted to further examine the effects of physiological arousal on reflexive orienting. Since there was a failure to replicate the findings of Deller (2006) in Trial Block Order A, future studies should be conducted examining this same element with a major emphasis on the importance of monitoring ANS activity. Another aspect to consider for future research is to look at the importance of including four trial conditions (i.e. seated, prone, HDNF, prone) during testing. Deller (2006) used two identical prone trial conditions necessary to monitor any initial baseline changes, pre-HDNF and any continuation in the reduction of the cueing effect, post-HDNF. So the trial conditions can be viewed as a pre-, pre-, experimental, and post- test design. A common convention for HDNF experiments is to include a baseline (e.g. first prone) followed by experimental (e.g. HDNF), and then a recovery period (e.g. second prone) (e.g. Shortt & Ray, 1997). However, motor control studies usually implement the design

of a baseline (e.g. seated) followed by an experimental condition (e.g. test group) (e.g. Pratt & McAuliffe, 1999). The current study and that of Deller (2006) utilized a combination of the two methodologies, but other studies examining similar elements only required three test conditions, pre-, experimental, and post-test (e.g. Yagi et al., 1999). It is unknown if the addition of two prone conditions contributed to the findings of Deller (2006), or to the failure to replicate in Trial Block Order A but that the inclusion of the extra trial condition could have provided an extra element of repetition. Future studies should consider the relevance and importance of the implementation of two baseline conditions, similar to methodologies used in HDNF studies.

The current study examined the role of physiological arousal on reflexive orienting through the use of exogenous cues, but attention can also be oriented in a voluntary manner through endogenous cues. Future studies should examine the role that voluntary orienting plays during autonomic arousal and if it responds in a similar manner to that of reflexive orienting. A similar design to the current study can be implemented to examine the role of endogenous orienting during physiological arousal. But it must be emphasized that the monitoring of the ANS should be included in order to ensure that specific levels of arousal have been reached. Furthermore, varying levels of physiological arousal should be experimented with to determine if voluntary orienting can switch from a dissociative to an associative strategy, similar to other attention and ANS studies (Tenenbaum & Connolly, 2008).

One of the major discussion points in the study by Deller (2006) was that the reduction in the cueing effect observed may have been partly due to the activation of the linear vestibulo-ocular reflex (LVOR). The LVOR acts to stabilize gaze by minimizing retinal image slip during periods of linear movements (e.g. HDNF) and as such possibly led to the attenuated cueing effects in Deller (2006). Further research should be conducted to examine whether the LVOR

influenced the results on the COVAT or whether the ANS is solely responsible for the attenuation in the faciliatory and inhibitory responses. Examining whether the LVOR influences the responses on the COVAT can be conducted by isolating the LVOR through the technique of lower body negative pressure (LBNP). LBNP produces the same physiological effects (e.g. increase HR and peripheral vasoconstriction) as HDNF but does not initiate activation of the LVOR since the participants heads remain stationary (Esch, Scott, & Warburton, 2007). Both the exogenous and endogenous modes of orienting should be further examined with the technique of LBNP.

In conclusion, the current study observed no significant effects of autonomic arousal on the faciliatory and inhibitory cueing effects during HDNF in all four trial block orders. The cueing effects remained relatively stable between the seated and HDNF trial conditions suggesting that an increase in autonomic arousal does not lead to a reduction in the magnitude of faciliatory and inhibitory responses to peripheral stimuli. The overall stabilization of the cueing effects provides evidence that attention can freely shift to the periphery within the visual field in the same manner and to the same extent when physiologically aroused compared to when relaxed. Due to the lack of reduction in the cueing effects observed in Trial Block Order A, it can be concluded that the current study failed to replicate the results of Deller (2006). A trial order effect was also observed in the current study, but since there was a failure to replicate the results of Deller (2006) in Trial Block Order A, and due to the inconsistent results between Trial Block Orders B and C, it cannot be assumed that a trial order effect led to the attenuated cueing effect in Deller (2006). One possible explanation for the failure to replicate was the lack of monitoring of the ANS during HDNF, which may have led to the differing results between both studies. Even though the construct of HDNF has been thoroughly tested to show its effects on

physiological arousal, it should not be assumed that the initial application of HDNF will yield the same results and to the same level as those initial studies (Ray & Hume, 1998; Shortt & Ray, 1997). It should be emphasized that when using HDNF as a measure of activating the ANS, the monitoring of arousal levels should always be conducted to ensure that the proper levels of ANS modulation have been reached. The degree of HDNF achieved should also be controlled since the level of HDNF can lead to varying responses in ANS activation (Hume & Ray, 1999). Since HDNF is subjective to the participant in terms of comfort level and flexibility, more controlled techniques of ANS activation may be more appropriate (e.g. LBNP). The technique of LBNP would also be more beneficial when examining attention since it has been found that varying levels of physiological arousal can lead to significantly different strategies of attention (Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008). If these levels of ANS activation vary due to the degree of HDNF, then certain participants may show one strategy of attention while others may show an opposite strategy, leading to inconsistent results. The findings of the current study do not imply that the results of Deller (2006) are incorrect, but that the lack of monitoring of the ANS and HDNF between both studies possibly led to the failure to replicate. Therefore, more research must to be conducted to find out which strategy of attention occurs during varying degrees of physiological arousal, but while continually monitoring ANS and HDNF levels.

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