INTERNATIONAL JOURNAL OF RESEARCH IN EDUCATION AND PSYCHOLOGY (IJREP)
An International Peer Reviewed Journal
http://ijrep.com/

Vol.2 Issue 1
2016

RESEARCH ARTICLE

ISSN:2455-426X

EXOGENOUS AND ENDOGENOUS CUEING DURING VIGILANCE IN YOUNG AND OLD ADULTS

Richa Singh[*1] , Anurag Upadhyay[2]

[1*](*Assistant Professor, Department of Psychology Vasanta Collage for Women (Krishanmurti Foundation of India), Rajght Fort, Varanasi-221001, U.P.*)

[2](*Lecturer, Government Inter College, Uttar Pradesh*)

Article Info:
Article Received 24/01/2015
Revised on: 23/02/2016
Accepted on: 25/03/2016

ABSTRACT

Effect of exogenous and endogenous cueing on vigilance task was examined in young and old adults. Cues were presented central and peripheral location at stimulus onset asynchronies (SOAs) of 300ms. Target and non-target was the square of size 3.3 cm 3.0 cm respectively. The participant's task was to pay attention to the cue and then to make a speeded decision about the presence or absence of the target by pressing the response key. A 2 (Age Group: Young and Old) x 2(Central and peripheral location) x 3 (Cue validity: valid, invalid and neutral) x 3 (Time period: 3 Blocks of 10 min. each) analysis of variance (ANOVA) with repeated measure on last two factor was used. Results revealed that spatial cueing benefits lead to better vigilance performance. The rate of decline in detection rate was small indicating that spatial cueing improved the vigilance performance. Valid cue improves performance more than invalid or neutral cue for both young and old adults. However, young adults were faster in detecting the targets in comparison to their older counterparts.

Keywords: *Orienting, Exogenous Cue, Endogenous Cue, Vigilance, Aging.*

INTRODUCTION

The simplest way to select among several stimulus inputs is to orient our sensory receptors toward one set of stimuli and away from another. Orienting is the aligning of attention with a source of sensory input (Posner 1980). Allocating attention to an area in the periphery without making eye movement is referred to as covert orienting of attention and is different from overt orienting in which shift of attention is accompanied with eye and head movement. Spatial covert attention enhances visual performances in specific area of visual field, without eye movements to that location. Covert attention allows us to monitor the environment and guides our eye movements (overt attention) to locations of the visual field where salient and/or relevant information is. Covert attention is routinely deployed in many everyday situations, such as searching for objects, driving, crossing the street, playing sports and dancing.

Posner (Posner, Nissen, & Ogden, 1978; Posner, 1980) with his location cueing paradigm demonstrated that with eyes kept still at fixation, if the participants were cued to a particular region of space where the target was likely to appear, detection was faster at cued location. Faster and accurate responses to targets appearing at cued location either increases perceptual sensitivity to targets presented at cued location or it influences observer's response criteria (Lappin & Uttal, 1976; Shaw, 1983). Hawkins, et al. (1990) suggested that spatial cueing speeds signal detection by modulating the processing of sensory information during detection or by creating a decision bias favoring inputs at the cued location. Psychophysical and electrophysiological procedure has demonstrated that location cueing increased perceptual sensitivity to targets (Bonnel, Possamai, & Schmidt, 1987; Doallo, et al, 2004; Downing, 1988; Fu, Caggiano, Greenwood, & Parasuraman, 2005; Muller, 1994, Muller & Humphries, 1991; Possamai & Bonnel, 1991).

POSNER'S LOCATION CUEING PARADIGM

Location cueing paradigm developed by Posner and colleagues (Posner, 1980; Posner & Cohen, 1984; Posner & Snyder, 1975; Posner, Snyder, & Davidson, 1980) is the most common method to study covert orienting. The basic paradigm involves fixing eyes at the central fixation then presenting observers with a cue that precedes the presentation of a target stimulus requiring a response (e.g., target detection or discrimination). When the cue correctly indicates the location of the subsequent target, the trial is termed valid. Alternatively, when the target appears at the location other than cue, the trial is termed invalid. Thus, location cueing experiments have three aspects (i) a central fixation point that subject must continuously direct their eyes throughout each experimental trial, (ii) a target item to which subject must respond (e.g. detect or identify) and (iii) a location cue that is presented immediately before the target appears (Wright & Ward, 2008).

EXOGENOUS AND ENDOGENOUS COMPONENT OF COVERT VISUAL ATTENTION

Posner (1980) proposed that there are two modes of control over covert visual orienting: (1) *Exogenous*: Involuntary, automatic and stimulus driven orienting response to a location where sudden stimulation had occurred and (2) *Endogenous*: Voluntary and controlled allocation of attention to information at a given location at will. Experimentally these two types of orienting are manipulated using different types of cues. Exogenous orienting is manipulated using peripheral cues, such as a peripheral flash and requires about 100 ms while endogenous orienting is manipulated using central symbolic cues, such an arrow, which directs attention in a goal driven manner and requires about 300 ms (Cheal & Lyon, 1991; Jonides, 1981; Müller & Findlay, 1988; Nakayama & Mackeben, 1989; Posner, 1980, Yantis, 1996).

EXOGENOUS ORIENTING

Abrupt onset of intense stimuli can cause covert orienting by capturing attention. For example, abruptly appearing letters on a computer monitor capture attention and are responded faster than gradually appearing letters (Jonides & Yantis, 1988; Yantis & Jonides, 1984). If such an abrupt onset stimulus (a direct cue) appears about 100 ms before another stimulus (a target) in the same spatial location, the latter is processed faster and more accurately than if it appears in another location (Muller & Humphreys, 1991. Thus, exogenous orienting is an automatic, reflexive, stimulus-driven response that is resistant to interruption and has a relatively short time course.

ENDOGENOUS ORIENTING

Attention oriented in space or to an object voluntarily (endogenously) in a goal driven manner often based on cue that tells us where to look or listen. Information about where or what to look at or listen to for an environmental event, we often prepare for the event by orienting attention to that location (LaBerge, 1995). This advance goal driven alignment of attention enhances processing of the target when it appears there (Posner, 1980). Endogenous orienting is a controlled, top-down response that can be suppressed voluntarily, elicits its maximal effects at longer intervals between cue and target.

EXOGENOUS - ENDOGENOUS ORIENTING IN YOUNG AND OLD ADULTS

Differential effect of age on exogenous and endogenous orienting has been reported. Studies revealed that attention shifts due to exogenous cues was not significantly affected in the aging process while results with endogenously cued shift of attention were less clear. Hartely et al ((1990) found that peripheral cueing effect was similar in young and old adults while Greenwood et al (1993) showed that endogenous cueing effect was more with older adults. However, Folk and Hoyer (1992) reported no age differences in orienting, for both central and peripheral cues.

Exogenous orienting in response to peripheral cues has been found to be relatively well preserved in healthy older adults (Hartley & Kieley, 1995; Hartley, 1993; Greenwood et al., 1993; Folk & Hoyer, 1992; Hartley, et al, 1990; Madden, 1990, 1986; Robinson & Kertzman, 1990; Muller & Rabbitt, 1989) i.e. no difference cueing effect was found between young and old adults. The probable reason behind such outcomes was provided by the results of studies assessing automatic visuospatial orienting in healthy older adults. They suggested that the posterior attention system responsible for reflexive covert orienting of visuospatial attention remained relatively well preserved in healthy aging (Dempster, 1992; Hartley, 1993: Spieler, Balota & Faust, 1996).

Studies have shown age related differences in the ability to localize targets under endogenous orienting using central symbolic cue (Greenwood, et al., 1993; Hartley, et al., 1990; Hoyer & Familiant, 1987; Madden, 1983; Nissen & Corkin, 1985). However, the effect of age on endogenous orienting has shown a mixed trend. Some studies have shown large orienting effect for older than younger adults (Hartley, et al, 1990, Experiment 2; Madden, 1983; Nissen & Corkin, 1985) whereas others have found smaller effects for older adults (Hoyer & Familant, 1987, Experiment 1 and 2). Greenwood et al. (1993) and Hartley et al. (1990) both suggested that an endogenous cue could produce greater cueing effect for older participants, but only for quite long cue-target intervals.

EXOGENOUS ENDOGENOUS ORIENTING AND SUSTAINED ATTENTION

Since, orienting has been found to enhance performance at the attended location, attempts have been made to combine the covert orienting and sustained attention paradigms to see whether orienting improves performance during vigilance task. Bahri (1990) combined the paradigms of sustained attention and covert orienting. In his study with young adults, result showed cue validity benefits while attention was directed to the target location (allocation) with valid cues in 30-min vigilance task in low event rate condition. Bahri (1994) suggested that there is a close relationship between orienting of attention and vigilance which is dependent on the event rate during the vigilance task. Bhari (1997) further suggested that under certain conditions, attentional orienting may enhance vigilance performance.

Exogenous and endogenous orienting has been well studied in relation to visuospatial selective attention over short time periods (Folk, Leber, & Egeth, 2002; Folk, Remington, & Johnston, 1992). However, less is known about how exogenous and endogenous attention systems interact over longer periods of time. The ability to maintain high levels of focused attention or vigilance over long periods of time underlies success on a range of tasks, from reading, driving to airport security monitoring; but concentration often fails in such situations (Mackworth, 1948). Assuming that vigilance requires attentional effort, it is important to determine whether endogenous and/or exogenous attention manipulations might improve vigilance performance. Robertson, Mattingley, Rorden, & Driver (1998) examined the relationship between vigilance and spatial attention, and demonstrated that improvements in sustained attention can lead to better spatial attention (e.g., less severe symptoms in patients with hemispatial neglect after sustained attention training). But the reverse i.e. spatial attention benefits may lead to better vigilance performance, has received less consideration.

Exogenous and endogenous cues may improve vigilance in different ways. For example, the deleterious effects of insufficient resources over time during a vigilance task may be offset by manipulating exogenous attention, such as by inserting attention-grabbing, salient stimuli to transiently prime resources. Previous research on the effects of exogenous stimulation during vigilance has shown promising effects for procedures that capitalize on the effects of strong alerting cues (O'Connell et al., 2008; Robertson, Tegner, Tham, Lo, & Nimmo-Smith, 1995). Fernandez-Duque and Posner (1997) proposed that improvement in performance with exogenous cue results from the alerting effect due to its sudden onset. Sebstiani, Casagrande, Martella and Raffone (2009) reported that with exogenous cue performance improved in vigilance task while decrease in sustained attention emerges with endogenous orienting using continuous attentional orienting task (CAOT). . However, in both the condition RT were faster with valid cue than invalid and neutral cue.

The aim of the present study was to investigate whether exogenous and endogenous orienting may improve vigilance performance and to see how ageing may influence it. For this we used the continuous attentional orienting task (CAOT) (Sebastiani et al, 2009) by combing the two experimental paradigms i.e. CPT for vigilance and the spatial cueing paradigm. This task allowed the examination of how manipulation of exogenous and endogenous orienting modulates vigilance performance in both young and old adults. Our first aim was to demonstrate how exogenous and endogenous orienting affects performance on a vigilance task. We hypothesized that valid cue would improve detection performance as compared to invalid and neutral cues. Our second aim was to test the competing claims of various researchers that young adults use pre-cue information more efficiently than old adults. We hypothesized that young subjects would receive more benefit of cued target location than would old subjects on sustained attention performance and endogenous cue would produce more benefits for older participants than exogenous cue.

MATERIALS AND METHOD

PARTICIPANTS

40 participants (20 young and 20 old adults) participated in this study. 20 young undergraduate and postgraduate students of Department of Psychology, Banaras Hindu University were randomly selected, signed an informed consent before participating as volunteers in the study. They were then randomly assigned to two groups (10 in each group) who participated either in central or peripheral cue conditions. Participants ranged from 20 to 24 years of age. Their mean age was 22 years for Group 1 (central cue condition) and 21.8 years for Group 2 (peripheral cue condition). All had normal or corrected-to-normal vision.

Similarly, two groups were formed from 20 older adults randomly selected, signed an informed consent before participating as volunteers in the study. They were randomly assigned to central and peripheral cue conditions. All older adults self-reported their health as being good to excellent. Participants ranged from 61 to 70 years of age. Their mean age was 63.5 years for Group 1 and 65.4 years for Group 2. All the participants reported normal or corrected to normal visual acuity of 6/6.

APPARATUS

The stimuli was planned and presented via SuperLab Software for Windows v. 4.0 and was displayed on a 15" colour monitor of a Pentium IV computer. The responses were collected through the computer keyboard.

EXPERIMENTAL TASK

The display of the task consisted of fixation (plus sign) presented centrally on the screen for 500 ms. Then an arrow was used as cue to orient the attention. Cues were presented at central or peripheral locations for 300 ms. Cues indicated the location of the target or non target. This arrow cue was manipulated as valid, invalid and neutral. Valid cue indicated the correct location where the target or non target would appear; invalid cue indicated the incorrect location whereas neutral cue didn't show any location. Cues were valid on 80%, invalid on 10% and neutral on 10% of the trials. Target was the bigger square of size 3.3 cm and the non-target was the square of 3.0 cm which were presented for 100 ms. Low event rate was used.

TASK

The participant's task was to pay attention to the cue and then to make a speeded decision about the presence or absence of the target by pressing the response key (space bar of the keyboard).

PROCEDURE

After taking the written consent to participate in the experiment biographical and other personal information was recorded. Then the instruction with brief introduction about the task was imparted lucidly to all the participants. Each trial began with a fixation presented at the center of the screen then a location cue (either valid, invalid or neutral) appeared before the target or non-target. In endogenous condition arrow cues were presented at the centre of the screen while in exogenous condition arrow cues were used at the peripheral location where the target or non target appeared. A response time was provided during which the screen remained blank and the participants were instructed to response quickly once they make the decision regarding the presence of the target. Targets and non-targets were randomly presented. Each participant received a 3-min demonstration of the task then they received 5-min of practice. Participant's who scored 75 % or above on hit rate performance measure was selected for the study. After practice session, selected participants were assigned to the final experimental task of 30 min.

EXPERIMENTAL DESIGN

A 2 (young and old) x 2(central and peripheral) x 3 (valid, invalid and neutral) x 3 (blocks: 10-min) mixed factorial design was employed with repeated measure on last two factors. A low event rate i.e. 15 events per minute in each condition was used. Age group (young and old) and two types of cue locations i.e. central and peripheral were used as between subject factors. Three types of visual cues valid, invalid and neutral were manipulated as within subject factor. The time period consist of three 10-min blocks with total of 450 trials. Each block will consist of 80% (i.e.120) valid cues and 10% (i.e. 15) invalid cues and 10% neutral cues (i.e. 15).

DATA ANALYSIS

Correct detection (hit rates), incorrect detection (false alarm), and reaction times (RT) of the participants were recorded as a performance measure. On the basis of correct detection and incorrect detection of target, the sensitivity index (d') was calculated. Mean and standard deviation for correct detection, RT and sensitivity were calculated. Then the data was submitted to mixed factorial analysis of variance (ANOVA).

RESULT

CORRECT DETECTION (HIT RATES)

The mean performance of participants on correct detection measure indicated that both young and old adults detected more targets under central cue location (Young=78.1%; Old=79.4%) than under peripheral cue location (Young=76.4%; Old=74.1%). ANOVA revealed a significant effect of cue validity ($F_{2, 72} = 61.19$, $p < 0.001$) which indicated that both young and old adults detected maximum number of targets in the valid cue condition than invalid and neutral cue condition for both central and peripheral cue location. Detection accuracy was found more for both young and old adults under both central and peripheral cue locations when cue was valid than when the cue was invalid and neutral. These findings are shown in Figure 1.

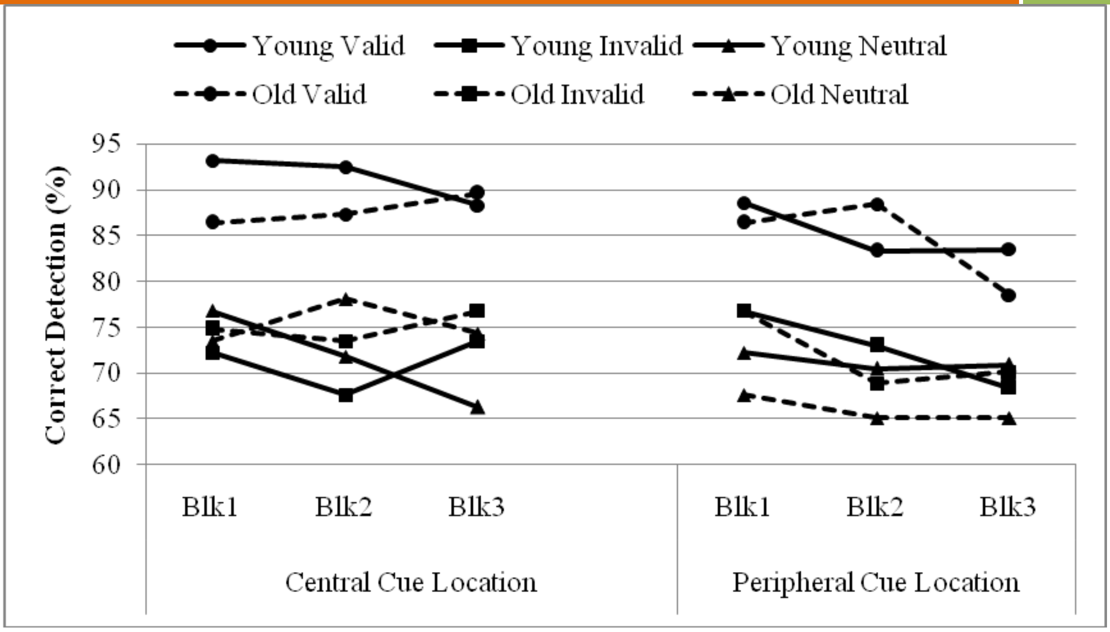

Figure 1. Mean correct detection (hits) as function of age group, cue location, cue validity and time period.

The main effect of time period (block) was significant ($F_{2, 72} = 4.18$, $p = 0.019$) indicating that the accuracy performance of the participants changed as the time elapsed. The rates of decline in detection for young adults were similar in both central and peripheral location. Young adults exhibited 4.7% decline in detection rate from block 1 to block 3 in central cue location and 4.9% in peripheral location. Similarly, older adults also exhibited 5.7% decline in detection with peripheral cue condition. However, older adults showed improvement of 2% in target detection under central cue condition. These findings are shown in Figure 2.

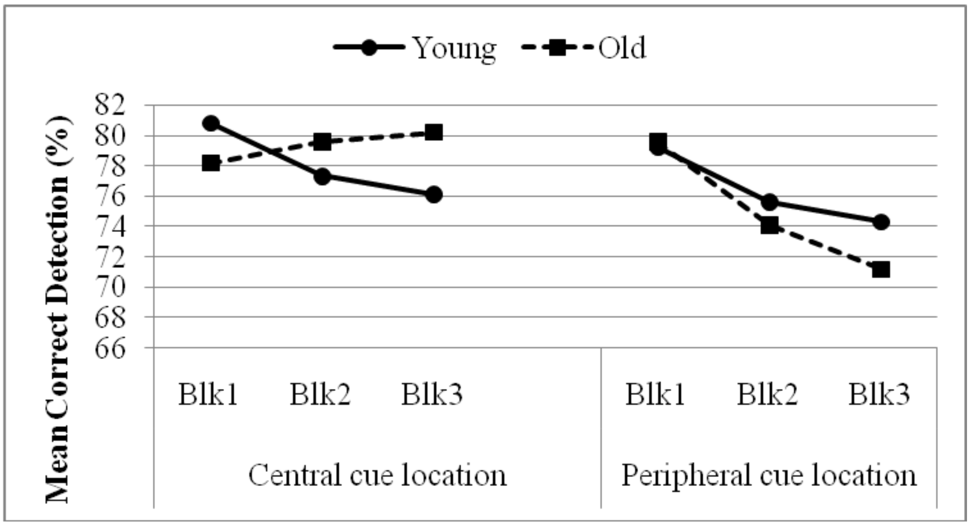

Figure 2. Mean correct detection (hits) as function of age group, cue location and time period.

REACTION TIME (RT)

The overall RT performance indicated that young adults were faster (407.74 ms) than older adults (516.30 ms). The mean RT performance across time periods indicated that both young and old adults were faster during the first 10 min (block 1) of the task, young being faster in the central cue location (308.46ms) than in peripheral cue location (493.37ms) while the older adults were faster in the peripheral cue location (436.39ms) than in central cue location (547.93ms). As the time progressed, both young and old adults showed increase in RT after 20-minutes i.e. block 2 in central cue location (Young: 313.55ms; Old:557.54ms) and in peripheral cue (Young: 516.20ms; Old: 438.54ms) locations. Similarly, both the groups were slow in responding to the targets during block 3 in central cue (Young: 355.22ms; Old: 567.72ms) and peripheral cue (Young: 459.68ms; Old=549.37ms) locations.

The main effect of age group was significant ($F_{1, 36}$ =12.77, p=0.001), suggesting that age has significant effect on the RT performance in detecting the targets, young being significantly faster than older adults. The interaction effect between age group and cue location was also significant, ($F_{1, 36}$ =16.51, $p < 0.001$) indicating that young received more benefit in RT in central cue location while older adults in peripheral cue location. The three way interaction between time period, age group and cue location was also significant, ($F_{2, 72}$ =5.21, p=0.008) indicating that time period affected the age group and cue location differently. These findings are graphically presented in Figure 3.

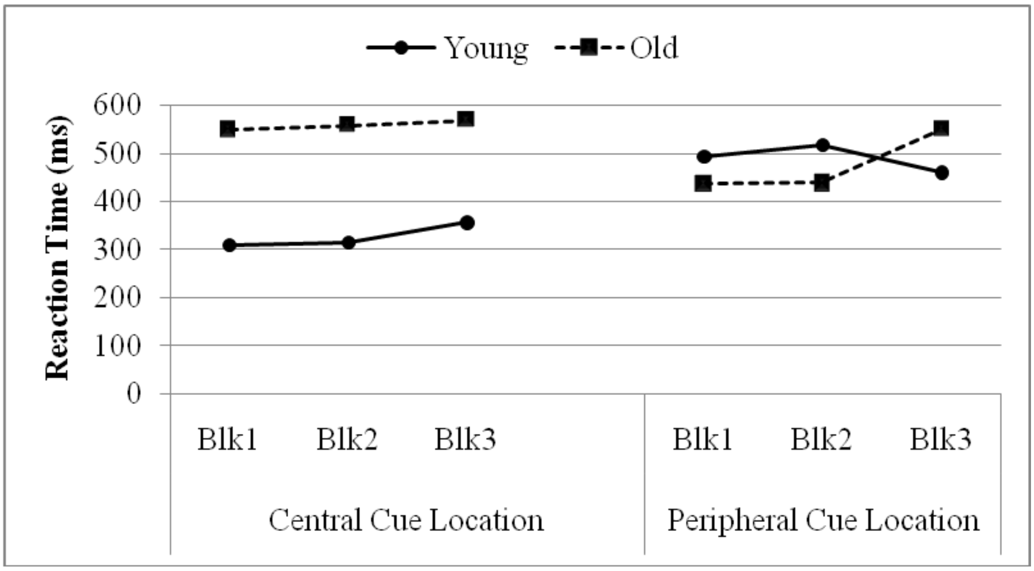

Figure 3: Mean Reaction Time as function of age group, cue location and time period.

SENSITIVITY PERFORMANCE (D')

The mean sensitivity index of participants indicated that perceptual sensitivity index was greater in the central cue location for both the age groups (Young=2.08; Old=2.13) than peripheral cue location (Young=1.79; Old=1.74). Sensitivity was better reported under valid cue condition by both young and old adults in both central (Young=3.07, Old=2.62) and peripheral cue locations (Young=2.42, Old=2.30,) in comparison to invalid cue (Central – Young=1.37, Old=1.93, Peripheral - Young=1.44, Old=1.58) and neutral cue conditions (Central – Young=1.78, Old=1.83, Peripheral - Young=1.50, Old=1.33).

Main effect of the cue location was significant, ($F_{1, 36}$ = 6.09, p=0.018) which indicated that the two locations of the cue i.e. central and peripheral differently affected the perceptual sensitivity of the participants. Central cue improved sensitivity more than the peripheral cue. Main effect of the cue validity was highly significant, ($F_{2, 72}$ = 108.03, $p < 0.001$) indicating that cue validity played a major role in affecting the sensitivity index, greater sensitivity with valid cue in comparison to invalid and neutral cue. The two way interaction between age group and cue validity was also significant, ($F_{2, 72}$ = 8.18, p=0.001). Furthermore, four way interaction between cue validity, time period, age group and cue location was also significant, ($F_{4, 144}$ = 2.49, p=0.046), which demonstrated that valid cue improved perceptual sensitivity of young and old adults in both the cue locations across time period on a cued vigilance task. These findings are graphically presented in Figure 4.

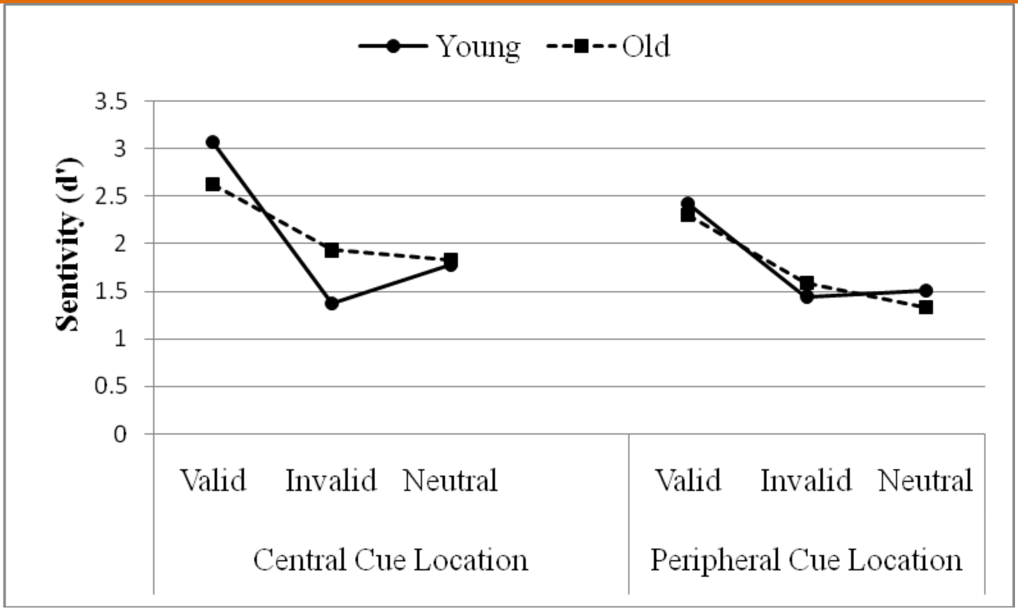

Figure 4. Mean sensitivity index performance as function of cue location, cue validity and block.

DISCUSSION

The present study explored how exogenous (peripheral cue) and endogenous (central cue) orienting affects performance in a vigilance task. The first hypothesis is an attempt to know whether cue validity would affect performance on valance/sustained attention task. For this we hypothesized that valid cue would improve detection performance as compared to invalid and neutral cues. Results revealed that valid cue facilitated the detection of targets in both young and old adults in both central and peripheral location than invalid and neutral cues. Both the groups detected more targets in valid than in invalid and neutral cue condition. Also, results on RT measure demonstrated that valid cue lead to faster detection of targets than invalid and neutral cues in both young and old adults and is consistent with the previous findings (Posner, et al, 1978; Posner, et al, 1980; Bashinski & Bacharach, 1980; Henderson, 1992) who reported that when cue directed the attention to the correct location the stimuli presented at that location are detected with greater speed and accuracy.

The second hypothesis is an attempt to elucidate which age group received more benefit of cued target location on sustained attention task. The results revealed that young detected more targets than the older adults and they were faster in making the response than older adults. Thus, the results support our second hypothesis and goes in accordance with the previous researches (Greenwood & Parasuraman, 1994; Greenwood, et al, 1993) that showed differences in the ability to orient attention in different age groups and ability to shift attention declined as age advances (Rabbitt, 1979; Rabbitt & Vyas, 1980). We further hypothesized that endogenous cue would produce more benefits for older participants than exogenous cue. The results revealed that young adults showed decline in their detection of targets from block 1 to block 3 in both central and peripheral cue locations. However, older adults showed decline in their detection rate only in the peripheral cue (exogenous orienting) location while in central cue (endogenous orienting) location they showed improvement in their detection performance. Since, Robertson, et al, (1998) demonstrated that improvements in sustained attention can lead to better spatial attention the present result indicated that spatial attention benefits may lead to better vigilance performance. Also the rate of decline in detection rate was small indicating that spatial cueing improved the vigilance performance.

Thus, results supports our hypothesis that old adults received more benefit of endogenous cue than exogenous cue and are consistent with previous researches (Greenwood et al, 1993; Hartley et al., 1990; Hoyer & Familiant, 1987; Madden, 1983; Nissen & Corkin, 1985) which have shown age related differences in the ability to localize targets under endogenous orienting using central symbolic cue. However, results are in contradiction to some of the previous studies which reported that exogenous orienting is relatively well preserved in healthy older adults (Hartley & Kieley, 1995; Hartley, 1993; Greenwood et al., 1993; Folk & Hoyer, 1992; Hartley, et al, 1990; Madden, 1990, 1986; Robinson & Kertzman, 1990). The reason may be the longer SOA (300ms) and symbolic cue taken in the present study.

Exogenous and endogenous orienting also affects the perceptual sensitivity (d'). The results revealed that sensitivity index was greater for endogenous orienting for both the age groups in comparison to exogenous condition. This result supported the findings of Prinzmetal, McCool & Parks (2005) that endogenous attention produce signal enhancement. The significant effect of age on RT indicated that young adults were faster in making the response than the older adults. The slower response made by older adults could be due to the age related general slowing in cognitive processing (Cerella, 1990). Young adults were faster in detecting the targets than older adults, both the groups showed slight increase in their RT as they moved from block 1 to block 3. However in peripheral cue condition both the groups were similar in making the response. Thus, the results are consistent with previous researches (Hartley & Kieley, 1995; Hartley, 1993; Greenwood et al., 1993; Folk & Hoyer, 1992; Hartley, et al, 1990; Madden, 1990) which indicated no age differences with peripheral cue.

CONCLUSION

Thus, we can conclude that exogenous and endogenous cueing affects vigilance performance by modulating the sensitivity of the observer at the cued location. Results indicated that spatial cueing benefits may lead to better vigilance performance. Also the rate of decline in detection rate was small indicating that spatial cueing improved the vigilance performance. Valid cue improves performance more than invalid or neutral cue for both young and old adults. Young received more benefit of cueing than older adults by being faster and detecting more targets, however older adults received more benefit of endogenous cue than exogenous cue.

REFERENCES

[1] Bahri, T. (1990). *Orienting of attention and vigilance*. Doctoral Dissertation, Department of Psychology, Catholic University of America, Washington, DC, USA.

[2] Bahri, T. (1994). Covert orienting of attention controls vigilance decrement at low event rate. *Perceptual and Motor Skills, 79*(1), 83-92.

[3] Bahri, T. (1997). Variability of facilitation and inhibition as a function of cue validity and cue-stimulus intervals in the orienting of sustained attention. *Perceptual and Motor Skills, 84*(3), 1027-1039.

[4] Bashinski, H. S., & Bacharach, V. R. (1980). Enhancement of perceptual sensitivity as a result of selectively attending to spatial locations. *Perception and Psychophysics, 3*, 241-248.

[5] Bonnel, A.M., Possamai, C., & Schmitt, M. (1987). Early modulation of visual in put: A study of attentional strategies. *Quarterly Journal of Experimental Psychology, 39*, 757-776.

[6] Cerella, J. (1990). Aging and information processing rate. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (3rd ed., pp. 201-221). New York: Academic Press.

[7] Cheal, M., & Lyon, D. R. (1991). Central and peripheral precueing of forced - choice discrimination. *Quarterly Journal of Experimental Psychology, 43*, 859 - 880.

[8] Dempster, F. N. (1992). The rise and fall of inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review, 12*, 45-75.

[9] Doallo S., Lorenzo-López L., Vizoso C., Rodríguez Holguín S., Amenedo E., & Bará S. (2004). The time course of the effects of central and peripheral cues on visual processing: An event-related potentials study. *Clinical Neurophysiology, 115,* 199–210.

[10] Downing, C. J. (1988). Expectancy and visual spatial attention: Effects on perceptual quality. *Journal of Experimental Psychology: Human Perception and Performance, 14*, 188-202.

[11] Fernandez-Duque, D., & Posner, M. I. (1997). Relating the mechanisms of orienting and alerting. *Neuropsychologia, 35,* 477–486.

[12] Folk, C. L., & Hoyer, W. J. (1992). Aging and shift of visual spatial attention. *Psychology and Aging, 7*, 453-465.

[13] Folk, C. L., Leber, A. B., & Egeth, H. E. (2002). Made you blink! Contingent attentional capture produces a spatial blink. *Perception & Psychophysics, 64*(5), 741-753.

[14] Folk, C. L., Remington, R. W., & Johnston, J. C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance, 18*(4), 1030-1044.

[15] Fu, S., Caggiano, D. M., Greenwood, P. M., & Parasuraman, R. (2005). Event related potentials reveals dissociable mechanism for orienting and focusing visuospatial attention. *Cognitive Brain Research, 23*, 341-353.

[16] Greenwood, P. M., Parsuraman, R., & Haxby, J. (1993). Changes in visuospatial attention over the adult lifespan. *Neuropsychologia, 31*, 471-485.

[17] Greenwood, P. M., & Parsuraman, R. (1994). Attentional disengagement deficit in nondemented elderly over 75 years of age. *Aging and cognition, 1*, 188-202.

[18] Hartley, A. A., & Kieley, J. M. (1995). Adult age differences in the inhibition of return of visual attention. *Psychology and Aging, 10*, 670-683.

[19] Hartley, A. A., Slabach, E. H., & Kieley, J. M. (1990). Age differences and similarities in the effects of cues and prompts. *Journal of Experimental Psychology: Human Perception and Performance, 16*(3), 523-537.

[20] Hartley, A. A. (1993). Evidence for the selective preservation of spatial selective attention in old age. *Psychology and Aging, 10,* 670-683.

[21] Hawkins, H. L., Hillyard, S. A., Luck, S. J., Mouloua, M., Downing, C.J., & Woodward, D. P. (1990). Visual attention modulates signal probability. *Journal of Experimental Psychology: Human Perception and Performance, 16,* 802-811.

[22] Henderson, J. M. (1992). Visual attention and eye movement control during reading and picture viewing. In K. Rayner (Eds.), *Eye movements and visual cognition: Scene perception and reading*. New York: Springer-Verlag.

[23] Hoyer, W. J., & Familant, M. E. (1987). Age differences in the rate of processing expectancy information. *Cognitive Development, 2,* 59-70.

[24] Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. *Perception & Psychophysics, 43*(4), 346-354.

[25] Jonides, J. (1981). Voluntary versus automatic control over the mind's eye movement. In J. B. Long & A. D. Baddeley (Eds.), *Attention and performance* (Vol. XI, pp. 187-203). Hillsdale, NJ: Erlabum.

[26] LaBerge, D. (1995). *Attentional processing: The brain's art of mindfulness.* Cambridge, MA: Harvard University Press.

[27] Lappin, J. S., & Uttal, W.R. (1976). Does prior knowledge facilitate the detecti on of visual targets in random noise? *Perception & Psychophysics, 20*, 367 - 374.

[28] Mackworth, N. H. (1948). The breakdown of vigilance during prolonged visual search. *Quarterly Journal of Experimental Psychology, 1*, 6-21.

[29] Madden, D. J. (1983). Aging and distraction by highly familiar stimuli during visual search. *Developmental Psychology, 19*, 499-507.

[30] Madden, D. J. (1986). Adult age differences in the attentional capacity demands of visual search. *Cognitive Development*, *1*, 335- 363.

[31] Madden, D. J. (1990) Adult age differences in attentional selectivity and capacity. *European Journal of Cognitive Psychology. 2*, 229-252

[32] Muller, H. J., & Rabbitt, P. M. A. (1989). Reflexive and voluntary orienting of visual attention: Time course of activation and resistance to interruption. *Journal of Experimental Psychology: Human Perception and Performance, 15,* 315-330.

[33] Muller, H. J. & Humphreys, G. W.(1991). Luminance-increment detection: Capacity-limited or not? *Journal of Experimental Psychology: Human Perception and Performance, 17,* 107-124.

[34] Müller, H. J., & Findlay, J. M. (1988). The effect of visual attention on peripheral discrimination thresholds in single and multiple element displays. *Acta Psychologica, 69*, 129-155.

[35] Muller, H. J. (1994). Qualitative differences in response bias from spatial cueing. *Canadian Journal of Experimental Psychology, 48*, 218-241.

[36] Nakayama, K., & Mackeben, M. (1989). Sustained and transient components of focal visual attention. *Vision Research, 29*(11), 1631-1647.

[37] Nissen, M. J., & Corkin, S. (1985). Effectiveness of attentional cueing in older and younger adults. *Journal of Gerontology, 40,* 185-191.

[38] O'Connell, R. G., Bellgrove, M. A., Dockree, P. M., Lau, A., Fitzgerald, M., & Robertson, I. H. (2008). Self-Alert Training: volitional modulation of autonomic arousal improves sustained attention. *Neuropsychologia, 46*(5), 1379-1390.

[39] Posner, M. I., Nissen, M. J., & Ogden, W. C. (1978). Attended and unattended processing modes: The role of set for spatial location. In H.L. Pick Jr., & E. Saltzman (Eds.), *Modes of perceiving and processing information*. Hillsdale: Lawrence Erlbaum Associates.

[40] Posner, M. I., Snyder, C. R. R., & Davison, B. J. (1980). Attention and the detection of signals. *Journal of Experimental Psychology: General, 109,* 160-174.

[41] Posner, M. I. (1980). Orienting of Attention. *Quarterly Journal of Experimental Psychology*, 32, 3-25

[42] Posner, M. I., & Cohen, Y. (1984). Components of attention. In H. Bouman & D. Bowhuis (Eds.), *Attention and performance* (pp. 531-556). Hillsdale, NJ: Erlbaum.

[43] Posner, M. I., & Snyder, C. R. R. (1975). Facilitation and inhibition in the processing of signals. In P.M.A. Rabbitt & S.Dornic (Eds.), *Attention & Perception, Vol. 5*. Hillsdale, N. J.: Erlbaum.

[44] Possamai, C., & Bonnel, A. M. (1991). Early modulation of visual input: Constant versus varied cueing. *Bulletin of the Psychonomic Society, 29*, 323-326.

[45] Prinzmetal, W., McCool, C. & Parks, S. (2005). Attention: Reaction time and accuracy reveal different mechanism. *Journal of Experimental Psychology: General, 134*(1), 73-92.

[46] Rabbitt, P. M. A. (1979). Some experiments and a model for changes in atten- tional selectivity with old age. In F. Hoffmeister & C. Muller (Eds.), *Brain function in old age: Evaluation ofchanges and disorders* (pp. 82-94). New York: Springer-Verlag.

[47] Rabbitt, P. M. A., & Vyas, S. M. (1980). Selective anticipation for events in old age. *Journal of Gerontology,* 35, 913-919.

[48] Robertson, I. H., Mattingley, J. B., Rorden, C., & Driver, J. (1998). Phasic alerting of neglect patients overcomes their spatial deficit in visual awareness. *Nature, 395*(6698), 169-172.

[49] Robertson, I. H., Tegner, R., Tham, K., Lo, A., & Nimmo-Smith, I. (1995). Sustained attention training for unilateral neglect: theoretical and rehabilitation implications. *Journal of Clinical and Experimental Neuropsychology, 17*(3), 416-430.

[50] Robinson, D. L., & Kertzman, C. (1990). Visuospatial attention: Effect of age gender and spatial reference. *Neuropsychologia, 28,* 291-301.

[51] Sebstiani, M., Casagrande, M., Martella, D., & Raffone, A. (2009). The effect of endogenous and exogenous spatial cueing in a sustained attention task. *Cognitive Process, 10*(2), S302-S304

[52] Shaw, M. L. (1983). Division of attention among spatial locations: A fundamenta l difference between detection of letters and detection of luminance increments. In H. Bouma & D.G. Bouwhuis (Eds.), *Attention & Performance, Vol. 10*. Hillsdale, N.J.: Erlbaum.

[53] S Spieler, D. H., Balota, D. A. & Faust, M. E. (1996). Stroop performance in younger adults, healthy older adults, and individuals with Senile Dementia of the Alzheimer's Type. *Journal of Experimental Psychology: Human Perception & Performance, 22*, 461-479.

[54] Wright, R. D., & Ward, L. M. (2008). *Orienting of Attention*. Oxford University Press, New York.

[55] Yantis, S., & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual search. *Journal of Experimental Psychology: Human Perception & Performance, 10*, 601-621.

[56] Yantis, S. (1996). Attentional capture in vision. In A. F. Kramer, M. G. H. Coles, & G. D. Logan (Eds.) *Converging operations in the study of visual selective attention* (pp. 45-76). Washington, DC: American Psychological Association.