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Voluntary Orienting during Vigilance Task in Young and Old Adults

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Age differences in cued vigilance task performance were examined. Cues were presented central location at stimulus onset asynchronies (SOAs) of 300ms. Target and non-target were the squares of 3.3 cm and 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 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 performance was facilitated under valid cue condition for both young and old adults. It further indicated qualitative difference on vigilance performances in young and old adults. Overall detection was similar for both the groups but young adults were faster in detecting the targets in comparison to their older counterparts.

Keywords: aging, Posner's paradigm, Cue, Voluntary orienting, Vigilance

Shifting attention voluntarily or involuntary to specific location in the environment is essential for everyday life activities. For example, when driving a car attention may be involuntarily drawn to an object that suddenly appears in the visual field or voluntarily attending to the traffic signals, thereby avoiding possible collision. Shift in visual spatial attention in response to advance knowledge regarding the probable location of target results in faster detection of target at that location. As we grow older reaction time tends to increase, in this situation shifting of attention (orienting) becomes increasingly important. The idea behind conducting the present study was based on the observation made by Pratt and Bellomo (1999) who argued that if the mechanism that underlie attentional capture deteriorate with age, older adults experience a double disadvantage in that they would be slower to orient attention to an object and would also be slower to produce the appropriate response to the attended object. Further, the benefit of orienting attention has mostly been investigated for selective attention task while few studies had investigated its benefit in sustained attention task. However, very few studies have tried to examine the effect of orienting attention during vigilance task in older adults. Thus, the present study was conducted to gain some insight into possible age related differences in voluntary orienting of attention during vigilance task.

Orienting of attention

Shift in visual spatial attention in response to advance knowledge regarding the probable location of salient information plays an essential role in many kinds of cognitive tasks (Pratt & Bellomo, 1999). Attention can be shifted by moving one's eyes towards a location or by attending to an area in the periphery without actually directing one's gaze toward it. Shift of attention without eye or head movement is called covert orienting (Posner, 1980). Orienting attention towards particular region of space facilitates perception of stimuli within that region where attention has been shifted (Posner, Nissen, & Ogden, 1978;

Posner, Synder & Davison, 1980; Maylor & Hockey, 1985). Spatial cuing speeds signal detection by modulating the processing of sensory information during detection or by creating a decision bias favoring inputs at the cued location (Hawkins et al., 1990).

Location cueing paradigm has been used to study the dynamics of covert shift of visual attention since Posner published his classic paper in 1980. In this paradigm, a cue is presented prior to the target onset. Previous researches have revealed that it takes less time to detect or identify the target, and response accuracy is facilitated during cued trial compared to an uncued trial. But this is true only when the cue accurately indicates the target's location (valid cue). When the cue indicates a location other than the target's location (invalid cue), response times are longer and accuracy is worse relative to cases in which cues are valid or no cue is presented.

Posner (1980) also proposed that there are two systems of covert orienting, which deal with facilitation and selection of information: (i) *voluntary* i.e., ability to monitor information at a given location at will; and (ii) *involuntary* i.e., automating orienting response to a location where sudden stimulation has occurred. Experimentally, these systems can be differentially engaged by using distinct cues. Central or symbolic cues are used to direct attention voluntarily in a goal- or conceptually-driven fashion, whereas peripheral cues grab attention involuntarily in a stimulus-driven, automatic manner.

Age related differences in orienting of attention

Findings for age-related differences in orienting attention were quite inconsistent some studies indicated that visuo-spatial attention is relatively unaffected by normal adult ageing at least up to about 75 years of age. When demands on perception are low, as in simple detection, clear effects of cue validity are seen, although there is little effect of aging on costs and benefits of location cuing (Greenwood, Parsuraman & Haxby, 1993; Hoyer & Familian, 1987; Nissen & Corkin, 1985; Robinson & Kertzman, 1990). In contrast when demands on perception are increased by the requirement to discriminate, the effect of aging on location cuing emerge under certain conditions of stimulus onset asynchrony (SOA) and cue type (Folk & Hoyer, 1992; Greenwood & Parsuraman, 1994; Greenwood et al., 1993; Hartley, Slabach & Kieley, 1990). Greenwood et al. (1993) and Hartley et al. (1990) showed that ageing affects voluntary orienting elicited by central cues but not the involuntary orienting associated with peripheral cues.

Vigilance and orienting

Vigilance (sustained attention) is the maintenance of alertness for longer period of time. The fundamental problem with sustained attention is the decrement in performance when it is performed for longer period of time. 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) was the pioneer researcher, who combined the paradigms of sustained attention and covert orienting. In his study with young adults he finds that cue validity benefits while attention was directed to the target location (allocation) with valid cues in 30-min vigilance task. He suggested that there is a close relationship between orienting of attention and vigilance which is dependent on the event rate during the vigilance task. The results further suggested that under certain conditions shifts of attention (orienting) may enhance vigil performance.

Parsuraman, Nestor and Greenwood (1989) had suggested that the elderly experienced greater vigilance decrement than that of young on hit rate performance. They have also reported that old adults showed high

RT in the processing of information at invalidly cued location than young adults (Greenwood & Parsuraman, 1994). Singh, Greenwood and Parsuraman, (2006; 2008) examined the effect of ageing on covert orienting using sustained attention task paradigm. They found that detection of target is facilitated when attention is oriented to the target location and inhibitory effect was seen when the target appeared on the opposite side of the cue (invalid condition). The benefit of cue validity was more with young than with old.

Thus, the goal of the current study was to examine the effect of voluntary orienting during vigilance task among young and old adults. Our first aim was to determine how cue validity affects performance. And the second aim was to examine the age differences in cued vigilance task performance. It was hypothesized that with valid cues performance would be more accurate and faster than invalid and neutral cue condition. Further, it was also hypothesized that there would be age-related differences in cued vigilance task performance

Method

Design

A 2 (Age Group: Young and Old) x 3 (Cue validity: valid, invalid and neutral) x 3 (Time period: 3 Blocks of 10 min. each) mixed factorial design was employed with repeated measure on last two factors. A low event rate i.e. 15 events/min. was used. Cues were manipulated as valid, invalid and neutral. Two age groups, young and old were manipulated as between subject factor and cues (valid, invalid and neutral) and time (three 10-min. blocks) were treated as within subject factors.

Participants

Ten young adults (M=21.0 years, age range: 18-22 years), and ten old adults (M=64.0 years, age range: 60-68 years), participated in the experiment. All the participants had normal or corrected to normal visual acuity of 6/6.

Cued visual vigilance Task:

The experiment was planned on SuperLab Software for Windows v. 4.0 and was displayed on a 15" colour monitor of a Pentium IV computer. The display of the task consisted of fixation presented centrally on the screen. Then a central arrow cue was used to orient the attention voluntarily. 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 of the target or non-target about where it would appear; invalid cue indicated the incorrect location whereas neutral cue didn't show any location. Cues were valid on 80% of the trial, invalid on 10% and neutral on 10%. Target and the non-target were the squares of 3.3 cm and 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. The target was always preceded by a location cue that varied in validity. Following the fixation the cue was presented then the target or non-target appeared, then the screen remained blank during which participants had to make the response.

Tools:

Hindi Mental State Examination (HMSE) a Hindi version of the MMSE (Mini Mental State Examination) adopted for illiterate Hindi speaking population (Ganguli, Ratcliff, Chandra, Sharma, Gilby, Pandav et.al, 1996) was administered to screen individuals with cognitive impairment. This test consists of 22 items, which test different components of cognitive functioning such as orientation to time and place, memory, attention and concentration, recognition of objects, language function, both comprehension and expressive speech, motor functioning and praxis.

Procedure:

After taking the written consent to participate in the experiment biographical and

other personal information was recorded. For older adults Hindi Mental State Examination (HMSE) was administered to screen individuals with cognitive impairment. Then the instruction with brief introduction about the task was imparted lucidly to all the participants.

The task required a speeded decision and response about the presence or absence of the target. 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. 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 common 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.

Data analyses

Correct detection (hit rates), incorrect detection (false alarm), and reaction times (RT) of the participants were recorded as a performance measure. Mean and standard deviation for all the performance measures were calculated. These data were then submitted to mixed factorial analyses of variance (ANOVA). Analyses were carried out to assess the cue validity effect on age differences (young-old) on performance measures (i.e., correct detection, incorrect detection and reaction time).

Results

Correct detection (Hit rates):

Correct detection (hit rates) was analyzed in a 2 (Age Group: Young & Old) 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 factors. The effect of cue validity was significant, $F_{(2, 36)} = 36.46$, $p<0.01$. Both young and old adults had highest correct detection rates in valid cue condition (Young: M=91.1%, SD=0.08; Old: M=87.8%, SD=0.11) in comparison to invalid (Young: M=71.1%, SD=0.16; Old: M=75.0%, SD=0.11) and neutral cue condition (Young: M=71.6%, SD=0.10; Old: M=75.3%, SD=0.09). However, the interaction of age group and time period (block) was not significant ($F_{(2, 36)} =2.34$, p=0.11). Figure 1 indicates difference in hit rates between young and old adults across time periods. Young adults showed more decrement in vigil performance across blocks than their counterparts i.e. older adults.

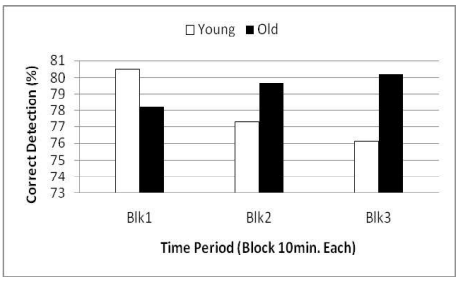

Figure 1. Correct detection as function of age group and time period

Incorrect detection (false alarm)

Incorrect detection data were submitted to the same 2x3x3 ANOVA as correct detection. Figure 2 indicates the difference in false alarm rates between young and old adults in valid, invalid and neutral cue conditions. The main effect of cue validity ($F_{(2, 36)} = 12.42$, $p<0.01$) was significant. Both young and old adults committed more false alarms in invalid (Young: M=24.3%, SD=0.14; Old: M=12.5%, SD=0.08) and neutral (Young: M=13.8%, SD=0.10; Old: M=14.9%, SD=0.11) cue condition as compared to valid (Young: M=7.3%, SD=0.04; Old: M=12.0%, SD=0.08) cue condition. Though the effect of age was not significant ($F_{(1, 18)} =0.45$, p=0.51), young adults committed more false alarm (M=15.1%)

than old adults (M=13.1%). However, the interaction between age group and cue validity ($F_{(2, 36)}$ = 12.12, p<0.01) was significant.

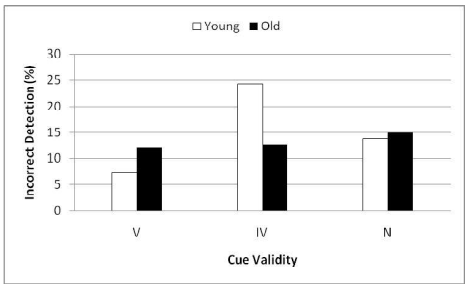

Figure 2: Incorrect detection (false alarm) as a function of age group and cue validity

Reaction time

Figure 3 displays the RT of young and old adults across time period in valid, invalid and neutral cue conditions. RTs were generally faster in valid trials for both the groups (Y=312.5 ms, O=547.0 ms) as compared to invalid (Y=334.5 ms, O= 587.0 ms) and neutral (Y= 330.2 ms, O= 539.0 ms) trials, indicating RT benefits for both young and old adults in valid condition. Analysis of variance revealed that the main effect of age group was significant, $F_{(1, 18)}$ =21.80, p<0.01, indicating that reaction time (RT) increased with age group, older adults being slower (M=557.7 ms) than young adults (M=325.7 ms) in detecting the targets. However, both the groups showed increase in RT across block (Young: Blk1=308.5 ms, Blk2= 313.5 ms, Blk3= 355.2 ms; Old: Blk1=547.9 ms, Blk2= 557.5 ms, Blk3= 567.7 ms) i.e. as time passed both the groups become slower to respond to the targets.

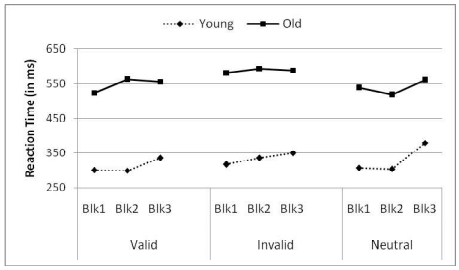

Figure 3: Reaction time of young and old adults in cued vigilance task

Response Criteria (â):

Response Criteria (â) was calculated on the basis of hit and false alarm rates. Figure 5 shows that during first 10 min. of the task old adults adopted stringent response criteria as compared to young adults (Blk1: O=1.7, Y=1.5) thereby detecting fewer targets than young adults. But as time elapse the response criteria for both the groups changed, old adopted liberal criteria while young became more stringent (Blk3: O=1.5, Y=2.1) resulting in more correct detection for older adults in comparison to young adults. ANOVA revealed that none of the main effect was significant, however the interaction between age group and block ($F_{(2, 36)}$ =3.38, p<0.05) was significant.

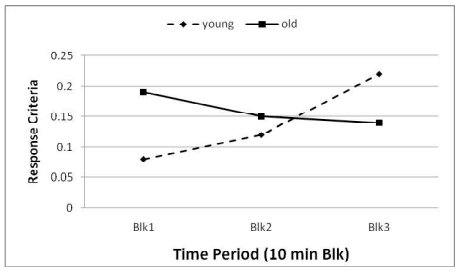

Figure 4: Response criteria (â) as a function of time period and age group

Discussion

The finding of the present experiment revealed that performance was facilitated under valid cue condition for both young and old adults. The benefit of valid cue obtained in the present study is consistent with the previous findings (e.g. Posner, 1980; Maylor & Hockey, 1985). The 'benefit' of valid cues occurs because the focus of attention is shifting to cued location, thereby facilitating sensory processing of the target at that location (Downing, 1998; Hawkins et al., 1990). Results also indicates that with valid cues participants not only detected more

targets, but also committed fewer false alarm and took less time to respond for targets in comparison to invalid and neutral cue condition. Thus, the obtained results confirm our hypothesis that with valid cues performance would be more accurate and faster than invalid and neutral cue condition. Results also corroborate findings of Bahari (1990) and Singh, Greenwood & Parsuraman (2006, 2008) who also used cued vigilance task.

Our second aim was to examine the age differences in cued vigilance task performance. Reaction time is usually found slower in older adults than younger adults (Birren & Schaie. 1985). The results of the current study showed that the older adults were slower than the young adults i.e. older adults took more time to respond which may be due to the age related general slowing in cognitive processing (Cerella, 1990). However, the overall performance was similar for both the groups. Young adults in the beginning detected more targets than the old adults but as time elapse performance of young adults declined while older adults showed improvement in performance. This difference in performance as time passed could be due the difference in response criteria adopted by both the groups. Previous studies have suggested that age differences in vigilance performance emerge under conditions of spatial uncertainty (Plude & Hoyer, 1985). However, no age differences in vigilance performance is seen when uncertainty is low or the targets are cued (Greenwood, et al., 1993; Hartely, et al, 1990). Since cued vigilance task was used, location cues reduced spatial uncertainty bringing, older participant's performance up to the level of young adults.

The results indicate qualitative difference on vigilance performances in young and old adults. Performance of both young and old adults is similar when detection accuracy is considered in a cued vigilance task but young adults are faster in making the responses. Thus, the current result showed that cues provide advance knowledge about where the target or non-target would appear thereby reducing spatial uncertainty and improving target detection during vigilance task.

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