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Cue Validity Effects on Word and Non-word Processing during Reading

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Visual-spatial attention allows individual to select specific regions of the visual field for preferential processing which facilitates the speed and quality of visual processing. Yet, reading literature reports the dichotomous view in regards of its utility in word recognition. Certain studies indicate it to be necessary preliminary to word reading whereas others indicate of it being not a prerequisite for word reading. Therefore, the current study aimed to study the effect of attention allocation through spatial cue manipulations using Posner's Cuing Paradigm. It was hypothesized that participants would perform better for words as compared to non-words in terms of shorter processing time and better accuracy. Also, valid cue conditions would take lower reaction time with higher accuracy as compared to invalid and no cue conditions. Twenty participants within the age range from 18 to 29 years (M= 22.27, SD= 03.34) of Banaras Hindu University took part in the study. A 2 (Letter string: word, non-word) × 3 (Cue type: valid, neutral, no cue) with repeated measure on all the factors was used. Results revealed the importance of cue and attention allocation on visual string recognition as it affected the processing time and accuracy of the stimuli. Therefore, the hypotheses were accepted. Further, the findings have been discussed in the light of feature analytic model of word reading.

Keywords: Reading, Word Recognition, Cue Validity.

Reading, involves coordination of brain areas that process visual and phonological information (Schlaggar & McCandliss, 2007). Beginning with recognition of visual orthography it then moves to phonological processing therefore, either learning to read or natural reading, both tend to be instigated from the basic visual processing of written languages. This process involves visual-spatial attention that allows individuals to select specific regions of the visual field for preferential processing (Carrasco & McElree, 2006; Posner & Peterson, 1990). It is said to be the basis and precondition for reading, and studies of both developmental and acquired reading disorders provide growing evidence that spatial attention is critically involved in word reading, specifically for the phonological decoding of unfamiliar letter strings. Still, its role remains under debate in visual word recognition. Also, questions regarding how attention influences visual word processing have received much less consideration. Therefore, addressing the 'how' part of the visual word recognition and keeping the aforesaid research needs and gaps into account the proposed research attempts to determine the effects of cue manipulation causing differential attention allocation while processing lexical variants in terms of words and non-words.

Visual-spatial attention and visual word recognition

A skilled reader is typically familiar with about 30,000 words and can recognize a visually presented word in less than half a second (Rayner,& Pollatsek,1989) facilitated by several other processes. Role of attention is very basic to visual reading as many studies suggest that orienting of attention might play a causal role in the generation of saccades (Sheperd, Findlay, & Hockey, 1986; Johnson, 1994; Inhoff, Pollatsek, Posner, & Rayner, 1989) thus acting basic to eye movement and visual reading processes.

Interestingly, it is well established that spatial attention is one crucial factor that affects the efficiency of multi-sensory perceptual processing (Carrasco, Ling, & Read, 2004; Mondor, & Bryden, 1991). The major effect on perceptual functions of spatial attention is that it apparently enhances the neural representation of stimuli at the attended location (Reynolds, & Chelazzi, 2004). This signal enhancement affects the processing in a variety of ways like faster reaction times (Posner, 1980), improved sensitivity (lowered thresholds; e.g., Carrasco, William, & Yeshurum, 2002), as well as reduced interference exerted by flanking stimuli (Carrasco, Penpeci-Talgar, & Eckstein, 2000; Facoetti, & Molteni, 2000; Boyer, & Ro, 2007).

It has also been demonstrated that, compared to normally reading subjects, poor readers were not able to rapidly focus visuo-spatial attention (Brannan & Williams, 1987) which allows decisions to be based on information at the selected location alone, while disregarding any distracting stimuli which may be present (Braun, 2002; Dosher, & Lu, 2000). Several studies have reported improved word recognition in the presence of valid spatial cues in different variations of the Posner cuing paradigm (McCann, Folk, & Johnston, 1992; Mondor & Bryden, 1991; Siéroff, Pollatsek, & Posner, 1988).

In visual word recognition, the spatial attention requirements involved in visual word processing have been a topic of considerable debate. Visual- spatial attention is likely to be engaged at many levels of the process of recognizing printed words (McCandless, 2003), yet there is no emergence of a unanimous view regarding this issue. Numerous investigators conform to the view that visual word process does not require spatial attention (Brown, 1996; Brown, Gore, & Carr, 2002; Lachter, Ruthruff, Lien, & McCann, 2008; Shaffer, & LaBerge, 1979). At variance with this, are the investigators with the opinion that holds spatial attention as a necessary preliminary to visual word processing (Besner, & Humphreseys, 1990; Besner, Risko, & Sklair, 2005; Bonnel, Possamai, & Schmitt, 1987; Lachter, Forster, & Ruthruff, 2004; McCann, Folk, & Johnston, 1992; Risko, Stolz, & Besner, 2005; Stolz & McCann, 2000; Stolz, & Stevanovski, 2004).Therefore, the inconsistencies among the researches depict the possibilities of exploration of interrelationship of the spatial attention and visual reading and utilizing different contextual, stimuli and variables related manipulations.

Method

Participants

Twenty participants with age range from 18 to 29 years (M= 22.27, SD= 03.34) of Banaras Hindu University took part in the study. Participants with any kind of known psychological or neuropsychological disorders were excluded from the sample. Prior to the assigning of participants to the task, it was assured that their visual acuity had normal (6/6) or corrected to normal (6/9) level.

Tools and apparatus

DirectRT v12.1 software was used to design the task and for obtaining the details of reaction time and correct and incorrect responses. A Dell Inspiron (Machine Inspiron 580s with Intel i3 processor) with 15 inch color monitor was used for the presentation of stimuli. To design the task, Posner's cueing paradigm was used. Herein, a visuo-spatial cue was manipulated as valid, invalid and no cue conditions, with the aim of locating attention differently for the processing. Screening questionnaire was used to derive information about language acquaintance, knowledge and usage. A total of 180 stimuli categorized into words and non-words were used. Twenty stimuli were used in practice session and 160 stimuli in main experimental task session.

Experimental task

The experimental task began with the display of a fixation (+) in the middle of the screen and participant was instructed to concentrate at it. Fixation (+) was of 500 ms, followed by the spatial cue for 50 milliseconds (ms). After 30 ms of delay (i.e., cue target interval is 80ms), the target string was presented for 80 ms .Then, a window appeared on the screen for response with maximum 5000 ms time limit. Response screen had four options out of which one could be correct, the participant was required to choose the corresponding string, using the computer keyboard with designated keys for responses. The experiment was of 16 minutes. The ratio of 20:80 for the target and non-target was maintained. A stimulus of diamond shape made up with asterisk sign, in white color was used as exogenous cue. Ratio for valid cue, invalid cue and no cue conditions was kept 60:20:20 across the blocks. The flow chart of experimental task is given in Figure 1.

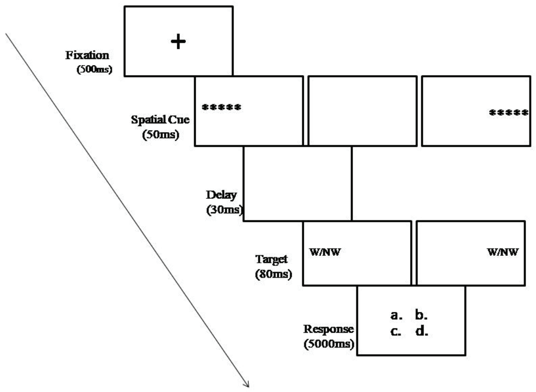

Figure-1 - The Flow Chart of the Experimental Task

Experimental Design

A 2 (Letter String: word and non-word) × 3 (Cue: valid, invalid and no cue) repeated measure factorial design was used. A low event rate of 10 events per minute in each trial was used. The cue informed about the probable location of the target. Cue validity was manipulated as valid, invalid and no cue. Correct detection and reaction time were used as dependent measure in the study.

Procedure

Firstly, rapport was established with the participant to make them comfortable in the laboratory setting then an instruction sheet was provided to the participant. The participant was then given a screening questionnaire to collect the details of language knowledge and acquaintance. After clearing the doubts and queries of the participant related to experiment, consent form was signed and biographical data was taken from participant. During the Experiment, participants received a 2 min demonstration of the experimental task and then a 2 min. practice followed by final session of 16 min. The experimental event started with a fixation point (+ sign) at the center of screen for 500 ms followed by a cue. Cue was presented for 50 ms followed by a delay screen of 30 ms. After which appeared, one of the two target stimuli (words/ non-words) in random order. Next to it came a response screen, with maximum 5000 ms, that ends the single trial of the experiment. Four participants could not meet the performance criteria therefore dropped from the experiment.

Results

Mean scores and SDs were calculated for all performance measures (i.e. accuracy for valid, invalid, no cue words/ non-words and reaction time for words and non-words) for each experimental condition. Two way analysis of variance (ANOVA) was computed to examine the main and interaction effects of independent variables.

The alpha level of 0.05 was used for all statistical analyses unless otherwise stated.

Reaction Time Performance (RTs)

The mean and SD scores of reaction time performance indicates the better processing of words as compared for non-words for the valid and no cue conditions but where the cue was invalid deflecting the attention words took more time to be processed (fig.no.2). For words no cue conditions had highest mean reaction time performance (M= 3024.92; SD=378.12) when compared to the mean reaction time performance for invalid (M= 2649.45; SD=835.93) and valid (M=2924.40; SD=378.12) cue conditions. For non-words valid cue conditions had the highest mean reaction time performance (M=3201.56; SD= 534.8) when compared to the mean reaction time performance for invalid (M=2107.40; SD=) and no cue conditions (M= 3108.03; SD= 618.25).

The mean reaction time performance for words cued validly (M=2924.40; SD=378.12) was lower than mean reaction time performance for non-words cued validly (M=3201.56; SD= 534.81). For invalid responses the mean reaction time score for words (M= 2649.45; SD= 835.93) was higher than that of non-words (M= 2107; SD=1094.86). In conditions when there was no cue, there as well words (M= 3024.92; SD=410.74) had lower reaction time performance than non-words (M=3108.03; SD= 618.25).

Also, the reaction time performance for words with valid cues (M=2924.40; SD=378.12), was better than reaction time performance for words with no cue conditions (M= 3024.92; SD=410.74). When there was no attentional cue, the processing time for non-words (M=3108.03; SD= 618.25) was higher as compared to that of words (M= 3024.92; SD=410.74. These both findings indicate towards the utility of attentional cue while processing letter strings.

The mean reaction time performance while presented with invalid cue conditions for words ((M= 2649.45; SD= 835.93) as well as non-words (M= 2107; SD=1094.86) was lower than valid cue conditions for both the type of stimuli i.e. words and non-words.

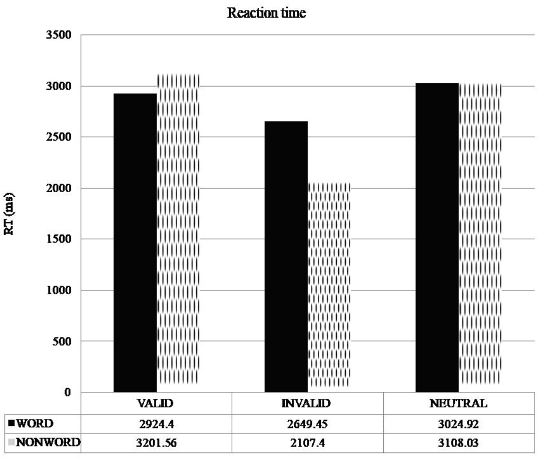

Figure 2 - Reaction Time Performance as a function of Letter String and Cue Type

The simple main effect analysis for mean reaction time performance showed no difference between stimulus as words and non-words F (1,10) = 2.81; p = .12. Although for cue validity main effect was found significant F (2, 20) = 8.32; p= .00 indicating towards the unalike effect that valid, invalid and no cue have on letter string recognition. Also, the interaction effect for letter strings (words & non-words) and cue (valid, invalid and no cue) was found significant F(2,20)=5.51.

Accuracy measures

Correct Detection (Hit Rates)

The mean and SD scores of correct detection indicates the better processing of words as compared for non-words for all the three conditions. For words valid cue conditions had highest mean and SD for correct detection (M= 85.71; SD=10.59) when compared to the mean correct detection for no cue condition (M= 54.54; SD=23.81). Correct detection was lowest for conditions where the cue was invalid (M= 20.00; SD=12.64). For non-words valid cue conditions had highest mean and SD for correct detec2tion (M= 64.93; SD=12.14) when compared to the mean correct detection for no cue condition (M= 43.63; SD=19.63). Correct detection was lowest for conditions where the cue was invalid (M= 5.45; SD= 9.34)

The mean and SD for correct detection for non-words cued validly (M= 85.71; SD=10.59) was higher than mean correct detection for non-words cued validly (M= 64.93; SD=12.1). The mean and SD for correct detection for words cued invalidly (M= 20.00; SD=12.64) was higher than that of non-words (M= 5.45; SD= 9.34). In conditions when there was no cue, there as well words (M= 54.54; SD=23.81) had higher mean and SD for correct detection than non-words (M= 54.54; SD=23.81).

Also, the mean and SD for correct detection for words with valid cues (M=85.71; SD=10.59), was better than correct detection for words with no cue conditions (M= 54.54; SD=23.81). The mean and SD for correct detection for words with valid cues (M=85.71; SD=10.59), was better than correct detection for words with no cue conditions (M= 54.54; SD=23.81). These both findings indicate towards the utility of attentional cue while processing letter strings.

The mean correct detection while presented with invalid cue conditions for words (M= 20.00; SD= 12.64) as well as non-words (M= 5.45; SD=9.34) was lower than valid cue conditions for both the type of stimuli i.e. words and non-words.

The simple main effect analysis for mean correct detection revealed that words were processed with significant accuracy as compared to non-words. F (1,10)= 25.34; p =0.00. Also, the

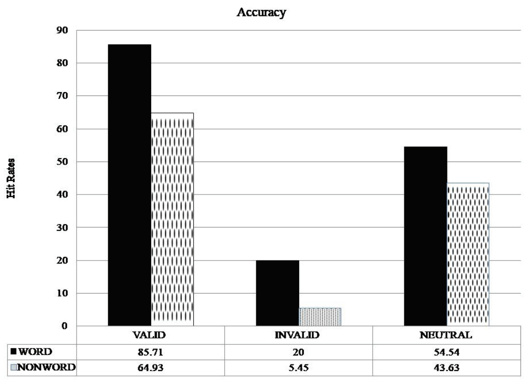

Figure 3 - Correct Detection as a function of Letter String And Cue Type

main effect of cue validity was found significant F (2,20) = 21.94; p = 0.00 indicating significant difference in the means for valid, invalid and no cue condition. The interaction effect of validity of the cue and letter string types i.e. words and non-words was found significant F (2, 20) = 78.60; p = 0.00,

Discussion and Conclusion

The present investigation was conducted with the purpose of exploring possible functional interaction between visual spatial attention and reading. One of the most significant parts of the study is about the response mechanism. Earlier studies have often used verbal response recordings by reading out the presented words. By far through review this is the first time that the response slide had noise strings along with target strings and the response had to be made by acknowledging or rejecting the presence through visual search, making it more of visual recognition task. Attention was manipulated in terms of spatial cues and lexicality was manipulated in terms of words and non-words. The relationship between visual spatial attention and visual letter string processing has been described basically on either of the two grounds. One that utilizes late selection theory and states that it can operate after letter string selection (Sieroff, Pollastek, & Posner, 1988) and the other that follows early selection model stating the utility of visual spatial attention before the lexical access or the final attainment of lexicality. Current findings are in line with the early selection model of Broadbent. It gives further evidence that word processing is sensitive to variation in the distribution of visual spatial attention across visual spaces. However, compared to words, non-words showed more sensitivity towards the spatial allocation of attention.

The findings of present study reported superior processing of words as compared to non-words as time taken to process as well accuracy in recognition were both better for words. It was found that for both words and non-words when the stimulus was preceded by a valid cue the reaction time taken to respond was much lower than the conditions when there was no cue, indicating the facilitating effect of cue as a medium of attention allocation. Moreover, for words the reaction time was lower for valid cue condition along with better accuracy while selecting the target word from noise strings. This establishes the valid cue as significantly being in role for affecting reading as for invalid and no cue conditions accuracy was lower for words. Interestingly, the invalid cue conditions reported of lowest time for the processing irrespective of stimuli being word or non-word. The reasons come into light when undertaking the accuracy which was extremely low for invalid cued conditions, indicating towards incorrect responses due to diverted attention as a result of cue appearing in opposite direction of target stimuli, which prompts to the utility of attention while the process continues. Herein, semantics proved to be important for correct recognition while processing as accuracy was higher for words in comparison to non-words. Another major finding was in terms of significant interaction between semantics and attentional processes. Results showed that attention facilitates when correctly located or focused while processing written material. Also, it becomes more effective if the matter of reading is meaningful as compared to meaningless non-words. In conclusion, the experiment conducted shows that a spatial precue can effect visual processing for both words and non-words significantly and thus attention is necessary for reading.

Implications and future direction

Reading being one of the most frequently performed behavior has manifold effects on our everyday lives. Complexities generating inefficient reading pose several issues for an individual, right from academics to everyday information comprehension and absorption to synthesis of ideas, everything in the continuum gets taxing and negatively affected. In particular, for the students, as for them academic performance highly correlates with self esteem and social evaluation. The results of this experiment have several implications, foremost, being able to define the significance of visual spatial attention while reading, for both meaningful and meaningless contents as attention utility in reading is a complex and vexed endeavor. Also, the most significant contribution study could make lies in the betterment of understanding the indepth issues of reading disorders. Often attentional issues hamper academics more than other factors so this study contributes to the basic correctional mechanisms for devising strategies and interventions for students dealing with reading and attention issues like learning disorders, ADHD and dyslexia. The study holds its future implications by studying orthographies other than English.

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