Original Article

Differential processing of visual information from right and left central hemifields during binocular viewing

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ABSTRACT

This study was conducted to examine the effect on performance of laterality in target presentation in central visual field under conditions of binocular viewing. The study was in the form of performance analysis in a working memory task. The subjects were to identify a target stimulus in an array of similar stimuli and to indicate, by different key presses, if the target appeared in the right or the left of the array or it did not appear in the array, at all. Three experiments were conducted. Experiment-1 was a cross sectional evaluation (n=198); in experiment-2, the task was repeatedly administered to a group of individuals (n=40) for six consecutive days and experiment-3 involved administration of three task variants with different difficulty levels (n=46). Significant effect of laterality in the presentation of target on response accuracy was observed in experiment-1, accuracy was significantly more when the target appeared in the right of the array compared to when it appeared in the left or when it did not appear, at all. Experiments-2 and 3 demonstrated non-susceptibility of this effect to practice and task difficulty. Results demonstrate significant differences in information processing from right and left central hemi-fields in binocular viewing.

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Differences in the processing of information from right and left central hemi-fields during tachiestoscopic presentation are well documented. For example, during presentation of unilateral targets for lexical decision by right handed subjects, a right visual field/left hemisphere advantage is noted in accuracy and/or latency. This is considered to reflect left hemisphere specialisation for linguistic information processing. On the other hand, left visual field/right hemisphere superiority is seen in the processing of non-verbal information. To the best of our knowledge and belief, such effects are not reported in binocular viewing. In this paper, we present certain interesting observations, which were made, retrospectively, from a fairly large data derived from a series of experiments conducted earlier. We noted significant effects of laterality in the presentation of target on response accuracy under binocular viewing in the central visual field.

Material and Method

In these experiments, subjects were to identify a target stimulus in an array of similar stimuli. The stimulus was one of the 90 geometrical figures of

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different shapes and of the size of approximately 3.8 x 2.5 cm. The arrays comprised 4 such stimuli (two on the left and the other two on the right of the array) arranged horizontally with an inter-stimulus separation of 0.6 cm. One of these stimuli might be (or might not be) the target stimulus. Distance of the screen was approximately 75 cm from the nasion of the subject. At this distance, the array (with a total width of 11.8 cm) subtended an angle of approximately 10° at the nasion. The subjects were asked to respond and tell, by different key presses, if the target appeared in the right or the left of the array or it did not appear in the array, at all. All these occurrences were kept equi-probable in the task programme. Intrinsic task characteristics (viz. pre-target delay, pre-array delay, inter-stimulus delay and exposure time of the target) were varied to manipulate the time compression and/or memory loads.

Number of correct and incorrect responses, total number of stimuli presented and response time for the instances wherein the target appeared in the right or left of the array or when the target did not apear in the array, were computed automatically by the programme and displayed at the end of task.

There were two unique features of the tasks: first, the subject had to wait till the disappearance of both the target and the array before executing a response (otherwise the response was not accepted by the programme) and secondly, the next target appeared only when the subject had responded.

Experiment - 1 : Only one task (Task-1) was administered once (no repetitions) to a cross section of subjects (n=198).

Experiment - 2 : The above task (as in experiment-1 i.e., Task-1) was administered repeatedly for 6 consecutive days to a group of 40 subjects.

Experiment - 3 : Three tasks (Tasks-2, 3 and 4) with varying level of difficulty were administered to 46 subjects. All three variants were administered on the same day in the same order. The order of administration was Task-2 followed by Tasks-3 & 4. Difficulty/memory load in Task-3 was increased by decreasing the exposure time of target and array.

Each task was administered for about 5 minutes. However, to account for the minor variations, correct responses were standardised for a total of 75 attempts. Therefore, correct responses presented in results, below, are - correct responses x 75 / number of attempts. Subjects were not allowed to 'practice' the tasks. They were only 'familiarised' with the procedure. Task characteristics are presented along with the performance data in the 'RESULTS'. Subjects were, however, significantly younger in experiment-3; age of the subjects being 32 ± 6 yrs, 30 ± 6 yrs and 24 ± 6 yrs (all values Mean $\pm$ SD) in the experiments 1, 2 and 3 respectively. In Experiments -1 and 3, subjects were Armed Forces personnel and in Experiment-2, they were technical graduates. These differences precluded any inter-experiment comparisons, which in any case, were not intended.

Statistical Analysis : Friedman's ANOVA & Wilcoxon Matched Pairs Test were used throughout in the analysis due to major departures of data from normality. The latter was examined using Shapiro Wilk's 'W' statistic. All the data are presented as mean $\pm$ SD.

Results

Experiment - 1 : Reaction time and correct responses were found to be different for the three situations (viz, when target appeared in the right or the left of the array or it did not appear in the array at all); Table-1 refers.

Table - 1 : Task characteristics and performance in experiment-1 (n=198)

Task Characteristics	
Pre-target delay	700 ms
Exposure time of target	800 ms
Pre-array delay	700 ms
Exposure time of array	800 ms
Inter-stimulus delay	100 ms
Performance	
Reaction Time (Right)	1.582±0.254 sec
Reaction Time (Left)	1.452±0.275 sec
Reaction Time (Absent)	1.798±0.368 sec
Correct Responses (Right)	21+3
Correct Response (Left)	19±3
Correct Responses (Absent)	21±3

Comparisons ['p' values using Wilcoxon Matched Pairs Test]

	Reaction Time	Correct Responses
Right vs Left	0.000	0.000
Right vs Absent	0.000	0.796
Left vs Absent	0.000	0.000

Experiment - 2 : The laterality differences in correct responses and reaction time persisted across the six days when the same task was administered, repeatedly, to a group of 40 subjects (Table-2A, 2B, 2C). Improvement in performance (as evident from increase in correct responses and reduction in reaction time) was, however, noticeable from 2nd to 3rd day onwards. Results of latter analysis are not presented.

Table - 2 B : Result of individual comparisons of Correct Responses [p values using Wilcoxon Matched Pairs Test]

	D1	D2	D3	D4	D5	D6
Right vs Left	0.020	0.000	0.001	0.001	0.000	0.000
Right vs Absent	0.126	0.074	0.830	0.844	0.008	0.449
Left vs Absent	0.000	0.000	0.000	0.000	0.000	0.000

Table - 2 C : Result of individual comparisons of Reaction Time [p values using Wilcoxon Matched Pairs Test]

	D1	D2	D3	D4	D5	D6
Right vs Left	0.001	0.066	0.038	0.017	0.005	0.018
Right vs Absent	0.008	0.000	0.000	0.000	0.000	0.000
Left vs Absent	0.000	0.000	0.000	0.000	0.000	0.000

Experiment-3 : Subjective appreciation of workload and performance were different across the three variants of the task. Laterality differences in correct responses persisted in all the three tasks. However, differences in the reaction time were obvious only with the difficult task variant i.e., Task-3 (Table-3A, 3B).

Discussion

There are three important observations in the study :

(a) The study notices significant difference in correct responses in detecting the presence of a target appearing in the right or in the left of the array or its non appearance, at all. Accuracy was significantly better when the target was presented

Table - 2 A : Performance in Experiment-2

(Task used in Experiment-1 was administered repeatedly for 6 consecutive days)

(n=40)

	D1	D2	D3	D4	D5	D6
Correct Responses (Right)	21 ± 3	23 ± 3	23 ± 3	23 ± 2	24 ± 2	24 ± 1
Correct Responses (Left)	19 ± 4	20 ± 4	21 ± 2	22 ± 2	22 ± 2	22 ± 2
Correct Responses (Absent)	21 ± 4	22 ± 4	23 ± 2	23 ± 2	23 ± 2	24 ± 1
Reaction Time (Right)*	1.583 ± 0.258	1.436 ± 0.222	1.400 ± 0.178	1.379 ± 0.171	1.370 ± 0.128	1.370 ± 0.218
Reaction Time (Left)*	1.452 ± 0.253	1.381 ± 0.162	1.335 ± 0.145	1.318 ± 0.114	1.326 ± 0.142	1.330 ± 0.171
Reaction Time (Absent)*	1.764 ± 0.427	1.630 ± 0.357	1.546 ± 0.246	1.518 ± 0.199	1.500 ± 0.177	1.484 ± 0.179

*in sec

Table - 3 A : Task Characteristics and Performance in Experiment-3 (Three test variants were administered) (n=45)

	Task-2	Task-3	Task-4
Pre-target delay in ms	500	500	200
Exposure time of target in ms	500	200	500
Pre-array delay in ms	500	500	500
Exposure time of array in ms	1000	400	1000
Inter-stimulus delay in ms	500	500	200
Weighted Workload*	33.7 ± 15.2	40.9 ± 16.5	33.4 ± 16.9
Correct Responses (Right)	24 ± 2	23 ± 2	25 ± 1
Correct Responses (Left)	22 ± 1	20 ± 2	22 ± 1
Correct Responses (Absent)	23 ± 2	22 ± 2	23 ± 1
Reaction Time (Right) in sec	1.653 ± 0.199	1.103 ± 0.297	1.565 ± 0.226
Reaction Time (Left) in sec	1.620 ± 0.218	1.045 ± 0.269	1.562 ± 0.244
Reaction Time (Absent) in sec	1.674 ± 0.267	1.178 ± 0.286	1.590 ± 0.274

Table - 3 B : Result of individual comparisons [p values using Wilcoxon Matched Pair Test]

	Correct Responses			Reaction Time		
	Task-2	Task-3	Task-4	Task-2	Task-3	Task-4
Right vs Left	0.000	0.000	0.000	0.038	0.000	0.825
Right vs Absent	0.001	0.004	0.000	0.604	0.002	0.263
Left vs Absent	0.184	0.000	0.012	0.011	0.000	0.064

on the right side or when it did not appear at all compared to when it was presented on the left side. These differences were not susceptible to practice and intrinsic task characteristics.

(b) Opposite effects were seen in reaction time, which was significantly shorter when the target appeared in the left of the array compared to when it appeared on the right side or when it did not appear at all. These differences were not susceptible to practice. However, they exhibited some susceptibility to task difficulty.

(c) All the above inferences were drawn from binocular viewing in central field of vision.

Task characteristics in Experiment-3 need some elaboration. It is to be appreciated that difficulty/memory load in Task-3 was increased by decreasing the exposure time of target and array to 40% of the corresponding values in Task-2; pre-target and inter-stimulus delay were not changed. The manipulation amounts to an effective degradation of stimulus quality and absence of preview- the two variables reported to increase the task difficulty and complexity, respectively [1]. Target and array in these tasks inflict concurrent and mutually interfering loads on working memory and, therefore, can be considered analogous to classical 'concurrent working memory load methods'. Recall of target(s) is expected to be influenced by the viability of rehearsal in the early retention interval. A much reduced exposure time of target in Task-3 permitted less time for such rehearsals and resulted into less efficient recall (accuracy was significantly less in Task-3). However, response time was significantly reduced in Task-3 compared to that in Task-2 because the subject had to wait for a shorter time before responding. This was an inherent feature in these tasks that the subject had to wait till the disappearance of both target and array before executing a response (otherwise the response was not accepted by the programme). In Task-4, time compression was increased by decreasing the pre-target and inter-stimulus delay to 40% of the

corresponding values in Task-2. Despite this reduction in pre-target and inter-stimulus delay in Task-3, accuracy was preserved (was not different from that in Task-2, statistically) due to a comparable time span available for rehearsals because exposure time of target, array and pre-array delay was not changed. As a matter of fact, the intrinsic attributes of the task, which could influence loads on the working memory were identical. The apparent time compression (due to reduction in pre-target and inter-stimulus delay) was not appreciated by the subjects because of the unique feature of the tasks (the next target appeared only when the subject had responded). This interpretation is supported from subjective workload scores derived through NASA Task Load Index. Details of procedure for the derivation of scores are given elsewhere [2].

These results demonstrate differences in information retrieval ffom right and left central hemi-fields even in binocular viewing conditions. This inference is based, primarily, on differences noted in response accuracy. A question arises; why the reaction time exhibited laterality effects, which were opposite to those of this laterality on response accuracy? It is our appreciation that this variance is attributable to relative position of the response keys. The subject was instructed to respond, using different key presses, as follows :

(a) 'Insert' key and 'space bar' for the apearance of the target in the right or left of the array, respectively .

(b) 'Carriage return' for the non appearance of the target in the array.

(c) Right hand was to be used to press both 'insert' key and 'carriage return' and left hand was to be used for responding with 'space bar'. Thus, two events viz, non appearance and appearance of the target in the right of the array, were associated with the movement of right hand. On the other hand, only one event viz, appearance of the target in the left of the array, was associated with the movement of left hand. This explains why the reaction time was significantly shorter when the target appeared in the left of the array compared to when it appeared on the right side or when it did not appear, at all.

There are reported differences in visual perception between the two sides of the brain, Research efforts using tachiestoscopic presentation have identified asymmetries in different types of visual perception. It manifests as a better recall of words and letters in the right visual hemifield and performance in visuo-spatial tasks in the left hemifield. Discrimination of curvature and perception of the spatial orientation of a single line are also reported to be better in left than right field [3]. Right visual hemifield, on the other hand, has been demonstrated to have superiority for non-verbal stimuli when presented unilaterally [4]. Left visual hemifield appears to dominate in task, which stress the spatial arrangement of elements in a display [5].

It is an interesting observation that first graders display a left visual field superiority for single letter recognition (the reverse of the pattern is observed in adults), which is thought to represent the non verbal processing strategy utilised by young children.

A similar pattern is seen in adults analysing letters in unusual typeface. Superiority of right visual field in recognising words has been detected as early as 8 years of age. This asymmetry increases with age, to adulthood [6].

Contrary to above, no consistent hemifield superiority has been demonstrated in recognition of geometric shapes [3].

These visual laterality effects in the normal brain probably arise because one hemisphere is relatively inefficient at processing the stimulus presented to it and may have to transmit the information across the corpus callosum to the opposite hemisphere. Right hemisphere has been shown to be faster than the left at the initial coding [7]. Left hemisphere of brain has been described to initiate and to guide verbal, sequential, analytical, logical, rational and temporal fine movements and to the other side, right hemisphere has been shown

to deal with the components like synthetic, visual, spatial, emotional and visuo-spatial tasks [8]. To support this, there had been a finding that, in split brain patients, right hemisphere superiority has been seen for visual, tactile perception and memory [9].

Findings of the present study demonstrate differential processing of visual information from right and left central hemifields under binocular viewing conditions. Display systems in modern aircraft present information in both verbal and non verbal forms. Relative position of this information on the screen may influence its accurate processing. Observations of the present study are, thus, conceived to have important implications on the presentation of information on various display systems.

Limitations of the study

Even though all the subjects were right handed, no evaluation of eye dominance was done. This might have resulted into inclusion of a few subjects with left eye dominance.

References

1. Wickens CD. Attention. In: PA Hancock (Ed), Advances in Psychology-Vol 47-Human factors psychology. Amsterdam: Elsevier Science Publishers BV, 1987.
2. NASA Task Load Index (TLX) version 1.0 Manual. Human Performance Research Group. NASA Ames Research Centre, Moffett Field, California.
3. Beaton A. Left side, Right side: A review of laterality research. New Haven: Yale University press, 1985.
4. Kershner JR, Jeng AG.. Dual functional hemispheric asymmetry in visual perception: Effects of ocular dominance and postexposural processes. Neuropsychologia, 1972; 10:437 - 45.
5. Pitblado C. Visual field differences in perception of the vertical with and without a visible frame of reference. Neuropsychologia, 1979; 17:381-92.
6. De Renzl E. Disorders of space exploration and cognition. New York. John Wiley & Sons, 1982.
7. Hellige JB. Right hemisphere superiority for initial stages of letter processing. Neuropsychologia,1979; 17: 129-34.
8. Merrell DJ. Dominance of eye and hand. Human Biol,1957 ; 23: 314-328
9. Nebes RD. Hemispheric differences in commisurotomiszed man. Psychological Bulletin, 1974; 81: 1-14.