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Recall of Visual and Auditory Stimuli as a function of Hemispheric Dominance and Preferred Modality in Learning

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In the present experiment, an attempt was made to find whether the recall of visually and auditorily presented, meaningful and meaningless materials, are dependent on the levels of hemispheric dominance and preferred modality of 60 males and females. Another twenty post-graduate students were involved during the preparation of materials for auditory presentation. The tools used were (i) Test of Hemispheric Dominance, (ii) Sensual Modality Preference Instrument, (iii) personal computer with multimedia & speakers, and (iv) program for visual, and auditory presentation of meaningful, and meaningless materials. The subjects were visually, and auditorily presented lists of triagrams as well as words, in batches of 2 or 3 and respective recall scores were taken. Three-way analysis of variance found gender differences in the recall of visually presented words, and second order interaction effect in the recall of visually presented triagrams.

Keywords: Hemispheric dominance; Recall; Auditory; Visual; Modality; Learning style; Asymmetry; Verbal memory; Cognitive neuroscience

By 1864, Paul Broca brought out the importance of the left hemisphere involving Broca's area in speech, and thus the speech dominant left hemisphere was considered as the dominant hemisphere. The split-brain research that won Roger Sperry the 1981 Nobel Prize in Medicine showed that the right and left hemispheres had distinctly different functions that were not readily interchangeable. The concept of hemisphericity or hemispheric dominance is that an individual relies more on one mode or cerebral hemisphere than on the other. A tendency to use verbal or analytic approaches to problems is seen as evidence of left side hemisphericity, whereas those who favor holistic or spatial ways of dealing with information are seen as right-hemisphere dominant. The right hemisphere gathers information more from images than words (Springer & Deutsch, 1981). Right hemispheric dominance is associated with intellectual giftedness in verbal reasoning (Halpern, Haviland & Killian, 1998). Tucker et al. (1999) found that subjects show right hemisphere superiority for spatial memory task. Jung and Dietz (1976) found differences in the dominant and the non-dominant side in trained and untrained persons in motor learning effects. During dichotic extinction, the left hemisphere dominant group showed learning effects in both the attended and non-attended conditions, whereas the right hemisphere dominant group demonstrated conditioning only in the attended condition (Saban et al., 1997).

Though each hemisphere has its own set of functions in information processing and thinking, these functions are not exclusive to anyone hemisphere. According to Corballis (1998), Sperry attributes a holism and reductionism distinction to right vs. left-brain

mode of thoughts that are fundamentally unified in the normal brain specialization does not mean exclusivity. Logic is not confined to the left hemisphere and creativity or intuitions not solely in the right hemisphere. Creativity can remain, though diminished, even after extensive right hemisphere damage. There is no evidence that people are purely left or right brained. One hemisphere may be more active in most people, but only in varying degrees. Moreover, one hemisphere can takeover the jobs of the other when the latter is severely damaged or surgically removed. Although the two are specialised in the normal brain, each one seems to retain the capabilities of the whole brain.

In a normal individual, the results of the separate processing are exchanged with the opposite hemisphere through the corpus callosum so that there is integration and harmony in the goals of the two hemispheres to complement each other in almost all activities. Coney and Evans (2000) propose that the right hemisphere plays a supportive role in language comprehension by making available a set of alternative and less probable word meanings. Thus, the individual benefits from the integration of the processing done by each hemisphere and is afforded greater comprehension of the situation that initiated the processing. Thus, the dominance of either hemisphere does not mean that we do not use both hemispheres; it suggests that when we are faced with a task that requires a good deal of thought, we tend to shift to the dominant hemisphere. In a single task, we use the hemisphere that will accomplish it more efficiently. Doing two or more functions of the same hemisphere is very difficult when they interfere with each other. Sergent (1982) argues that each hemisphere can process verbal and visuo-spatial information, and that the left hemisphere may be preferentially sensitive to high-resolution information and the right hemisphere to low-resolution information. Using the Cognitive Laterality Battery to measure the student's hemispheric dominance, Yeap (1989) has found that it is in the psychological domain of student's learning styles, in terms of their hemispheric dominance that secondary students in three achievement levels are distinctly different. Polich (1980) found no support for a serial vs. parallel hemispheric processing distinction was obtained, but strong support for overall left hemisphere superiority for visual search was found. The left hemisphere is more able to detect the temporal structure of auditory and tactile stimuli than the right hemisphere (Nicholls, Whelan & Brown, 1999). In a study by Beer (1988), right-dominant subjects located more embedded figures and made fever errors on the finger maze then did left dominant subjects. Kanno et al. (1996) found right dominance in the auditory evoked magnetic fields for pure tone stimuli. A study by Bachtold, Brugger and Regard (2000) on the functional differences in the visual modality between the two hemispheres, it was found that the positions of the figures initially memorized in the left hemi-space were recalled faster than figures initially memorized in the right hemi-space.

According to Jaegor et al. (1998) gender differences in functional cortical organization exist in the absence of significant behavioral differences. This increases the probability of gender difference in memory for verbal stimuli. Traditional studies in cognitive psychology also support that women may have a slight advantage in verbal fluency. There is gender difference in the lateralized perception of an illusion also (Rasmjou, Hausmann & Gunturken, 1999). A study by Borod et al. (1998) involving both males and females yielded no systematic asymmetry patterns as a function of gender.

Individuals use different modes of communication processing as visual and non-visual. Non-visual modality includes auditory and kinesthetic modes. In a study 144 sonar operators were questioned in the areas of preferred work schedule, general modality preference and modality preference for sonar

operation, which showed that 57% of the sonar operators rely on or feel they are better at utilizing visual information (Kobus & Lewandowski, 1992). The results of an experiment by Juttner (1981) with 60 university students show that recognition depends neither on the specific sense modality (visual or verbal) through which the person has experienced the event nor on the modality on which the recognition is based. Ohlsoon and Ronnberg (1981) designed a 'processing distribution mode1', to explain the modality effect (i.e., superior short-term retention of auditory, as opposed to visually, preferred information) using a distracter technique. Subjects were 6 Swedish students and words from each 'to-be-remembered' list were auditorily or visually presented; auditory and visual distracters were assumed to allocate extra processing to a superficial or modality -specific level. In addition, information load was manipulated by varying word-list lengths and by varying the compatibility between mode of presentation for both distracters and to-be-remembered items. Modality-specific distractions effects were obtained for both auditory and visual modalities. A study by Wright (1998) found that auditory and visual serial position functions obey different laws.

In a study by Gadzella and Whitehead (1975), ten experimental conditions were used to study the effects of auditory and visual (printed words, uncolored and colored pictures) modalities and their various combinations with college students. Analysis of data showed the auditory modality was superior to visual (pictures) one but was not significantly different from visual (printed words) modality. The visual modality preferring type of person sees the event, auditory type hears the event and kinesthetic type feels the event. Persons relying more on the visual mode have great visual memories. They remember colours, shapes, forms and think in terms of pictures. They use words like bright, see, visual, look, colourful etc. more in their sentences. People relying more on auditory mode listen to the sounds for information. They give emphasis to voice, diction, and accent. The kinesthetic mode relying persons primarily process information through emotions and feelings. They use words like handle, grab, grip etc. more in their sentences. Conjugate Lateral Eye Movement is also related to preferred modality. Visual persons look to their right when creating images and to the left when remembering pictures. Auditory persons look to the right while using new words and to the left for recalling words. Kinesthetic persons look right downwards during conversations and to left downwards when listening. An individual with a particular modality preference while learning may be having better capability for processing information presented in that modality. And this faster processing may be reinforcing his usage of that particular modality due to the support of better modality specific memory.

In visual presentation using tachistoscope, for letters and words, there was left hemisphere dominance. In auditory presentation involving dichotic listening, for words and nonsense syllables there was left hemisphere dominance (Kolb & Whishaw, 1996). This indicates that hemispheric dominance may probably influence the memory for meaningful as well as meaningless verbal stimuli. Schmidt & Lechelt (1981) examined tactual vs. visual presentation, dynamic vs. static presentation of tactual stimuli, learning, and gender in relation to cerebral hemispheric differences. No reliable laterality differences were obtained with the tactual-static condition, owing to a significant interaction between learning and side of stimulus presentations, positions were reported reliably more accurately when presented in a dynamic fashion (i.e., scanned by S to the right hand). Hatta (1979) observed differences in hemispheric dominance of visual function, which was attributed to culturally based experience of Japanese and American subjects. There is no adequate study to conclude whether visual presentation or auditory presentation is more efficient.

Individual differences in the preferred modality in learning, are present and differences in the learning styles of the two hemispheres are evident, as a successive processing left hemisphere prefers to learn in a step-by-step sequential format beginning with details leading to a conceptual understanding of a skill whereas, a simultaneous processing right hemisphere prefers to learn by beginning with the general concept and then going on to specifics. A left hemispheric advantage for verbal materials can be expected. This effect may be prominent for female participants. The preferred modality of the participants may influence their memory for the verbal meaningful as well as meaningless stimuli presented.

The present study aims to investigate the effect of hemispheric dominance and preferred modality in learning independently and collectively on recall of visually and auditorily presented, meaningful and meaningless verbal stimuli, and whether the findings are similar for both the gender.

Method

Experimental Design:

The influence of three independent variables (viz., gender, hemispheric dominance, and preferred modality), simultaneously on each of the dependent variables concerned is examined in this experiment. The dependent variables are (1) the recall scores of auditorily presented triagrams, (2) recall scores of visually presented triagrams, (3) recall scores of auditorily presented words, and (4) recall scores of visually presented words. The three factors with two levels for each, comes under the general category of 2 x 2 x 2 factorial design.

Sample:

*List Preparation:*10 male and 10 female postgraduate students were included in the study to select 15 triagrams and 25 words for auditory presentation, which could be recognized by Indians while presented using text reading software pronouncing in American accent.

Main Study: 30 males and 30 females in which 30 were right dominant and 30 left dominant were selected from 132 postgraduate students who volunteered to co-operate with the study. The total sample of 60 postgraduate students had eight sub-groups on the basis of three classificatory variables called 'gender', 'dominant hemisphere' and 'preferred modality' in learning. Among the 30 male participants, 17 had right hemispheric dominance (of which 10 had preference for visual modality in learning, and 7 had preference for non-visual modalities) and 13 had left hemispheric dominance (visual=8, and non-visual=5). Among the 30 female participants, 13 were right hemisphere dominant (visual=9, and non-visual=4) and 17 were left hemisphere dominant (visual=14, and non-visual=3).

***Tools*:**

Test of Hemispheric Dominance: It was developed by Sousa (1995) is a test to assess an individual's functionally dominant hemisphere. The test has 21 items. Each item has two statements of which one represents an aspect of right hemisphere, and the other represents an aspect of left hemisphere. The individual subject is instructed to respond by putting a circle around the alphabet across either one of the statements.

Sensual Modality Preferences Instrument: It was developed by Sousa (1995) is a test to assess an individual's preferred modality in learning. The test has a total of 33 items. Each item in the form of a statement has two response categories. The individual can circle 'A' if he/she 'Agrees' with the statement or circle 'D' if 'Disagrees' with the statement. The test has 11 items for visual modality and 22 items belonging to non-visual modalities (viz., auditory, and kinesthetic).

Personal Computer with Programs and Materials for Visual and Auditory Presentation of Triagrams and Words

(i) A multimedia installed personal

computer having two speakers, Microsoft Power Point and Talk It application software.

(ii) List A -a Microsoft Power Point file containing a list of 15 triagrams in the form of 15 slides to be presented one by one on the computer screen

(iii) List B -a list of 15 triagrams in the form of Notepad text to be presented one by one through the speakers using the text reading software -Talk It.

(iv) List C - a Microsoft Power Point file containing a list of 25 English words in the form of 25 slides, to be presented one by one on the computer screen.

(v) List D -a list of 25 English words in the form of Notepad text, to be presented one by one through the speakers using the text reading software -Talk It.

(vi) Four sheets of paper, and a pencil for each subject to write down recalled items.

Procedure:

Preparation of program for visual presentation of triagrams: For the visual presentation, a list of 15 triagrams (List A) was constructed. Using Microsoft Power Point, each triagram was made in the form of a slide. The whole list was presented one by one as a succession of slides. The time interval between each successive triagrams was fixed at one second. The total time for a single presentation of List A on the computer screen was 29 seconds.The triagrams used in List A for visual presentation were; FKN, LSB, JQW, RKZ, CYG, PZM, NHT, QBK, VFJ, GCL, TRD, MJV, ZNH, SKB, and TPX.

Preparation of program for auditory presentation of triagrams: 'Talk It' is an English text reading software which spells triagrams in American accent. 15 triagrams having accent recognizable to Indian students was required for List B. For this purpose, a list 60 triagrams was prepared and 20 Post Graduate students (10 were male and 10 were females), after getting their consent to participate in this study, were selected. The 60 triagrams were presented one by one in a serial manner to each subject by announcing them through the speakers of the computer. The triagrams were presented to 2 or 3 subjects at a time. The subjects were given 2 seconds after each triagram to write it on the sheet of paper provided. The subjects were instructed as follows; 'You will hear a series of 60 triagrams one by one. A triagram is a group of three alphabets. When you hear a triagram, please write it on the paper. Do not talk to anybody or look into another person's paper. You will be given 2 seconds for writing each triagram. Try to write as many triagrams as possible'.

The 60 triagrams were presented auditorily through the speakers once. After the presentation was over, the papers were collected back. This was repeated for all the 20 subjects. From the response sheets, 15 triagrams that were correctly written by maximum number of subjects were selected, and taken as List B. List B was made in the form of Notepad text in such a way that the total time for a single auditory presentation takes 29 seconds. The triagrams used in List B for auditory presentation were; HYR, FHS, TOR, SDL, CDQ, FSK, LFR, WXC, HSK, QRL, TKW, LTR, FHK, SFC, and HKT.

Preparation of program for auditory presentation of words

The words used in List C for visual presentation were; Knife, Lever, Magic, Onion, Plant, Quake, Saint, Train, Zebra, Royal, Habit, Index, Fruit, Eagle, Denim, Negro, Clear, Badge, Floor, Wheat, Album, Mouse, Night, Valve, and Toast. The total time for a single presentation of List C was 47 seconds.

Preparation of program for auditory presentation of words

The 20 students who participated in the display of program for auditory presentation of triagrams participated in the preparation of program for auditory presentation of words also. The text reading software was used.

Since the text reading software (Talk It) pronounced English words in American accent, 25 words that when pronounced could be recognized by Indians were taken as List D. To select the 25 words, 20 students comprising of 10 males and 10 females were presented 100 English words, each having 5 alphabets, one by one through the speakers of the computer.

The words were presented to 2 or 3 subjects at a time. After each word, 3 seconds were given to write it down on the sheet of paper provided. The subjects were instructed as follows; "You will now hear a series of 100 English words one by one. When you hear a word, please write it on the paper. Avoid asking or looking into another person's paper. You will be given 3 seconds for writing each word. Try to write as many words as possible".

After the presentation of 100 words, paper sheets were collected back and correctly written words were marked. This was done for all the 20 subjects. The correctly written words were entered into a separate sheet. From the sheet, 25 words that were correctly written by maximum number of subjects were selected and taken as List D. List D is made in the form of Notepad text in such a way that the total time for a single presentation takes 47 seconds. The words used in List D for auditory presentation were; Empty, House, Fifty, Ocean, Music, Stand, Diary, Avoid, Dance, Honey, Clash, Basic, Women, Guest, Plate, Shade, Piece, Cycle, Glass, Lemon, Adult, Noble, Bible, Label, and Scale.

Assessment of Hemispheric Dominance: The test of Hemispheric Dominance (Sousa, 1995) was administered to a sample of 132 willing postgraduate students comprising both males and females. After scoring, 30 right dominant and 30 left dominant individuals were selected for the main study in such a way that there were 30 males and 30 females.

Assessment of Preferred Modality in Learning: The sample of 60 students of which 30 were right and 30 were left hemispheric dominant, was seated in the experimental room in batches of 2 or 3. The Sensual Modality Instrument was administered to each subject and collected back. After scoring, the preferred mode of each subject for learning was ascertained.

Recall of Visually and Auditorily Presented Triagrams, and Words: The subjects, after the administration of sensual modality preferences instrument, were seated in batches of 2 or 3 in front of the computer screen. Care was taken to ensure that the subjects could comfortably sit and clearly see the screen.

The subjects were instructed as follows; 'You will see a list of 15 triagrams one by one on the screen. A triagram is a group of three alphabets. Please attend to it carefully. You will see the list four times. When the fourth presentation is over, you will be given a sheet of paper on which you may write down the triagrams you saw. Please avoid asking anything during the presentation of triagrams, or looking into another person's paper. Try to write down as many triagrams as possible. You may write it in any order. You will be given 2 minutes to write. Any questions?'

After clearing doubts, if any, List A having 15 triagrams was presented on the screen at the rate of one triagram at a time. The list was presented for four times. After the fourth presentation, the subjects were given sheets of paper and pencil to write. After 2 minutes, these were collected back.

The subjects were instructed as follows; 'You will hear a list of 15 triagrams one by one through the speakers. Please listen to it carefully. You will hear the list four times. After the fourth presentation is over, you will be given a sheet of paper on which you may write down the triagrams you heard. Please avoid asking anything during the presentation of triagrams, or looking into another person's paper. Try to write down as many triagrams as possible. You may write it in any order. You will be given 2

minutes to write. Any questions?'

After clearing doubts, if any, List B having 15 triagrams was announced through the speakers of the computer, each triagram at a time. The list was read four times. After the fourth presentation, the subjects were given sheets of paper and pencil to write. After 2 minutes, these were collected back. During auditory presentation, monitor screen was kept invisible to the subjects.

The subjects were instructed as follows; 'You will now see a list of 25 words, one by one on the screen. Please attend to it carefully. You will see the list four times. When the fourth presentation is over, you will be given a sheet of paper on which you may write down the words you saw. Please avoid asking or looking into another person's paper. Try to write down as many words as possible. You may write it in any order. You will be given 2 minutes to write'.

Then, List C having 25 words of each five alphabets is presented on the screen at the rate of one word at a time. The list was presented four times. After the fourth presentation, the subjects were given sheets of paper and pencil to write. After 2 minutes they were collected back.

The subjects were then instructed as follows; 'You will now hear a list of 25 words one by one through the speakers. Please listen to it carefully. You will hear the list four times. Then you will be given a sheet of paper on which you may write down the words you heard. Please avoid asking or looking into another person's paper. Try to write down as many words as possible. You may write it in any order. You will be given 2 minutes to write'.

Then, List D having 25 words of each five alphabets is announced through the speakers of the computer, each word at a time. During the auditory presentation, the monitor screen was kept invisible to the subjects. The list was presented four times. After the fourth presentation, the subjects were given sheets of paper and pencil to write. After 2 minutes they were collected back.

The same procedure was observed for all the 60 subjects. The recall score for each list was the number of items correctly recalled.

Results

Table 1: F-values for each of the different DV measures

	Visually presented triagrams	Auditorily presented triagrams	Visually presented words	Auditorily presented words
Gender	2.081	2.562	5. 778*	1.486
Hemispheric Dominance	1.116	0.771	2.926	0.070
Preferred Modality	0.0389	0.182	0.507	0.461
Gender x HemisphericDominance	3.601	0.210	0.001	1.695
Gender x Preferred Modality	0.255	0.923	3.782	0.999
Hemispheric Dominancex Preferred Modality	0.104	0.409	1.488	0.057
Gender x HemisphericDominance x Preferred Modality	4.532*	0.432	0.170	1.952

* $p<0.05$

The F-ratio relating to interaction effects of gender, hemispheric dominance and preferred modality alone is significant. No other F-ratio presented in the table is significant.

Discussion

The present experiment found (Table-1) that gender has a significant effect on the recall scores of visually presented words. Female participants had better recall for visually presented words. This occurred in the absence

of significant gender difference in the recall scores of visually presented meaningless items. Hemispheric dominance and preferred modality did not had any independent effect on verbal memory. Though an earlier study by Siegal and Allick (1973) had reported that recall of visual stimuli was markedly superior to that of auditory stumuli, when visual stimuli were pictures of common animals and objects, and auditory stimuli were the tape-recorded names of these animals and objects, the gender effect in the present study is unique.

Wright (1998) suggests that auditory and visual serial position functions obey different laws. Auditory or visual stimuli differentially activate modality-specific sub regions in the inferior parietal lobule (IPI) (Nishitani, Nagamine and Shibasaki, 1998), and that sex hormones have a significant role during the development of the human brain is a well-documented fact. Along with the female advantage in verbal fluency, this difference in activation of the sub regions may have influenced the learning of meaningful materials, which are having associate value, and their recall. Visual stimuli may invite thematic interpretation, verbal labeling, and produce emotional responses etc. (Gregg, 1986). In addition, the presence of meaning perhaps have contributed to recall of such stimuli depending on information other than purely visual as like pictures of words or meaningless triagrams.

Auditory (dichotic listening) presentation as against tachistoscope presentation of words has indicated a left hemispheric dominance for them (Kolb & Whishaw, 1996). The present results do not yield significant effect of hemispheric dominance on memory. The utilization of cognitive neuroscience methods like fMRI (functional magnetic resonance imaging) will be able to give conclusive findings due to its inherent paradigm advantages. The limitations of the present study such as usage of self-report measures than performance techniques to ascertain dominant hemisphere as well as preferred modality in learning may also have influenced the lack of other effects. The present findings also indicate that preferred modality may be independent of inter-modal relationship and memory, temporally or spatially, which is reflected in the lack of difference in recall scores. Another interesting finding of the interaction between gender, dominant hemisphere, and preferred modality further suggests the need for a better paradigm-based investigation. This is partially supported by the finding of Jaeger, et. al.(1998) that in basic reading strategies, gender differences in functional cortical organization exist in the absence of significant behavioral differences.

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