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Perceptual Asymmetry in Depression: Do Information Processing Demands and Methodologies have any Role?

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The researchers have tried to examine the nature of hemispheric asymmetry in depression, but did not reach consensus. It is speculated that failure to be unanimously agreed upon any view could be due to several reasons. Thus, with this background, the present study aims at exploring the nature of hemispheric asymmetry in depression while examining the influence of information processing demands or method of presenting stimuli. Emotional and non-emotional information were presented in split-field and free-viewing paradigm to sub-clinically depressed as well as age and gender matching non-depressed individuals. The findings revealed that both groups showed significant left visual field (i.e. right hemispheric) advantage in processing of emotional and non-emotional information irrespective of depression level. However, this enhanced left visual field bias for processing of emotional information was greater in the depressed group. The findings suggest that anomaly in hemispheric asymmetry in depression is task specific or restricted to information processing demands.

Keywords: Perceptual, Hemispheric Asymmetry, Depression, Emotional.

The nature of hemispheric asymmetry has been the interest of researchers from several years. Various attempts have been made to examine the altered pattern of hemispheric asymmetry in depression and have ultimately arrived on the unanimously agreed upon thought. The evidences accumulated from clinical, EEG/brain imaging and experimental-behavioral method have suggested four different hemispheric hypothesis of depression such as “left hemispheric hypo-activation, right hemispheric hyper-activation, right hemispheric hypo-activation and simultaneous left hemispheric hypo-activation and right hemispheric hyper-activation hypothesis of depression”. Further, the initial evidences of anomalous hemispheric asymmetry in depression came from clinical observations and studies from stroke patients, who reported a high incidence of a “catastrophic reaction” and depressed state in patients with left hemispheric lesions (Gainotti, 1972; Gasparrini, Satz, Heilman, & Coolidge, 1978; Robinson & Price, 1982) while people with right hemispheric lesions demonstrated feeling of indifference or mania (Gainotti,1972; Sackeim et al., 1982). Similarly, bulk of EEG/brain imaging studies have also extended LH hypo-activation to be associated with depression, while others have provided empirical evidences in support of a RH hyper-activation and RH hypo-activation hypothesis of depression (see Davidson & Henriques, 2000; Hecht, 2010; Pandey & Gupta, 2009 for reviews). The findings become further complicated by those observations that have reported enhanced right hemispheric performance or bias in processing of emotional information (Atchley, Ilardi, & Enloe, 2003; Atchley et al., 2007; Bruder, et al., 2002) using perceptual asymmetry. Similar to EEG studies, perceptual asymmetry studies have demonstrated reduced right hemispheric bias in processing of emotional (Moretti, Charlton, & Taylor, 1996) and in non-emotional information (Okubo, 2010). Further, reduced left hemispheric advantage in processing of verbal information has also been noted using dichotic listening task (Pine et al., 2000). Hence, it is speculated that the observed hemispheric activity (hypo or hyper) or bias in depression is likely to be influenced by several factors other than depressive state such as variations in the symptomatic manifestation of depression, co-morbid presence of anxiety, methodological problems associated with EEG and variation in the task/information processing demands. However, attempt to explore the nature of hemispheric asymmetry in depression while controlling for these probable confounding variables is very limited.

Therefore, taking this need into account the present study aims at exploring the type of information processing of presenting information on the nature of hemispheric asymmetry in depression while controlling for the heterogeneity of depression. To control the potential effect of wide heterogeneity in the symptomatology of depression, rather than using clinical group of depression, the study was performed on a sub-clinical sample, differing in the self-reported symptoms of depression on Beck Depression Inventory (BDI). Further, behavioral measures of hemispheric asymmetry were used because of its reported advantage in studying affect and affective disorders as compared to electrophysiological and functional brain imaging techniques (see Papousek & Schulter, 2006 for a review). For instance, researchers have often noted that the preparation procedure of EEG studies are perceived as emotionally arousing and aversive by the participants and thus, so-called baseline recording condition in such studies may in fact give the recording of stressful condition (Blackhart, Kline, Donohue, LaRowe, & Joiner, 2002).

Most of the perceptual asymmetry studies providing direct or indirect evidences for an altered pattern of hemispheric asymmetry in depression that requires processing of emotional and non-emotional information have provided inconsistent findings. Furthermore, studies utilizing dichotic listening technique for processing of verbal stimuli and non-verbal have also yielded different findings. For example, studies on dichotic listening test using verbal stimuli (a left hemispheric task), in general, have reported reduced left hemispheric (LH) functioning in depression (Pine et al., 2000) right hemispheric (RH) functioning in depression using non-verbal stimuli (Bruder, et al., 1996; 2004). For example, most of the studies that have used verbal emotional tasks (e.g., judgment of valence of emotional words) using split-field method have demonstrated an enhanced right hemispheric bias for processing of negative, but not for positive emotional words (Atchley et al., 2003; 2007; Walsh McDowall, & Grimshaw, 2010) and also for processing of facial emotions (Bruder et al., 2002). On the other hand, using same methodology (split-field), studies examining processing of emotional information (facial expressions of emotions) have showed that depression is associated with reduced RH functioning in processing of negative emotions and no asymmetry found for positive emotions (Moretti et al., 1996). It is evident from the aforesaid observations that difference in hemispheric asymmetry for processing of negative emotional valence in depression depends on the nature of the stimuli (verbal versus non-verbal). For verbal negative emotional stimuli, enhanced RH performance was noted (Atchley et al., 2003, 2007). Whereas for non-verbal emotional information reduced RH performance has been noted (Moretti et al., 1996).

In contrast, to the aforesaid findings for emotional information (processing of facial expression or words) studies utilizing processing of non-verbal and non-emotional information have yielded inconsistent findings. For example, Okubo (2010) have demonstrated reduced RH performance in depression in processing of luminance of unevenly shaded horizontal bars in free-viewing condition. Contrary to it, Bruder et al. (1992) have reported enhanced RH performance in bipolar depressed individuals using dot enumeration task in split-field design. The aforesaid differences in the findings of Okubo (2010) and Bruder et al. (1992) highlighted both role of task variation and methodological variations. The former used a free-viewing method while latter used split-field technique. Perceptual asymmetry studies in nature of the information processing or task demand suggest that findings differed for different types of tasks or stimuli. However, it is difficult to conclude how far difference in methodology and how far difference in task demands contributes to the observed variations in findings and it has several reasons. First, there is a dearth of attempts to assess these two aspects of perceptual asymmetry in same study. Secondly, the visual split-field studies in depression involving use of non-emotional non-verbal information are less. Moreover, sufficient empirical evidences are not available using non-emotional tasks (particularly non-verbal non-emotional) to make comparison for drawing a conclusion. These limitations have been taken care of while designing the present study.

Method

Sample:

The present study was carried out on the 29 right-handed sub-clinically depressed participants and 29 age and gender matched non-depressed (score on BDI for depressed was 19-29 and less than nine for non-depressed). Participants who showed any history of present or past psychiatric mental illness, neurological disorder and/or brain injury were excluded.

Materials and Procedure:

For assessment of hemispheric asymmetry chimeric face test, emotion discrimination, valence judgment tasks were used in processing of emotional information whereas object identification task and grey scale was used for processing of non-emotional visual-spatial configuration.

Each participant was given practice trials before the actual experimental task. The emotional and non-emotional stimuli were presented briefly and laterally. When the participants learned how to perform on emotional discrimination, valence judgment, object identification task, then actual experimental tasks were administered individually to each participants. The response of each participant was scored and saved in the computer through the same computer programme used to administer the experimental tasks. Chimeric face test and grey scale was administered in free-viewing condition. The scoring was done for each VF separately.

Chimeric Face Test: It is similar to that proposed by Campbell (1978), which was used to assess hemispheric asymmetry in processing of facial expressions of emotions. In this test, half happy and half neutral face composites (chimeras) of the same poser is paired with its mirror reversed image and are presented in top-bottom fashion. There are 32 pairs of chimeric faces in this test. The respondents were asked to indicate which of the two faces of a pair appears to be happier. The responses were coded as leftward or rightward according to the side of the happy hemi-face.

Emotion Discrimination task: The photographs of facial expressions of six universally recognized emotions (happy, sad, fear, anger, disgust and surprise) were used. The task was designed in split-field method using Super lab 4.0. On each trial, subjects were shown an unilateral presentation of photograph of facial expression of emotion (target emotion) followed by another photograph either with the same or different facial emotions (test emotion) on the center of the screen. The participants' task was to judge whether the target and test facial expressions of emotions were same or different. A central fixation dot with an arrow inside for 500 milliseconds appeared and after that a photograph of facial expression either to the left visual field (LVF) or right visual field (RVF) was presented for 150 milliseconds. The third event recognition slide appeared immediately containing facial expression of emotion (either emotion same to the target or different emotion) posed by a different expresser. The recognition slide was replaced by the fourth event- the response recording screen in which the response 'Same" and "Different' appeared at the center of the screen along with the numeric response code 1 (same) and 2 (different). The final (fifth) event was a presentation of blank white screen. A block of 48 trials [6 (emotions: happy, sad, anger, fear, disgust and surprise) X2 (gender of posers: male and female)X2 visual-field (left and right)X2 response (same and different)] were used.

Valence Judgment Task: In this task, a set of 12 positive and negative emotional words were used. The experimental arrangement of presentation of stimuli for emotional valence judgment task was also the same as earlier tasks except for the nature of stimuli and response. Positive or negative emotional words were presented laterally and the required response was the judgment of valence of the words. Following the earlier experimental procedure a block of 48 trials [24 (stimuli: 12 positive and 12 negative)X2 visual-field (left and right)] were used.

Object Identification task: Sixteen geometrical shapes/figures (for example, triangle, rectangle, square, circle etc.) were used. Using the similar experimental procedure of presentation of stimuli, the participants were shown on each trial a target geometrical figure either to the LVF and RVF followed by the presentation of a test slide in which six geometrical figures (one target and five distracters) were presented. The participant's task was to identify that target figure in the test slide. A block of 32 trials [16 (geometrical figures) X 2 visual-field (left and right) were created.

Grey scale: Grey scale (Nicholls et al., 1999) is a free-viewing measure that requires participants to make a forced two choice discrimination of the relative brightness of two simultaneously presented horizontal bars in top-bottom fashion. There are total 40 pairs of bars. The participants were required to judge which bar appears to be darker. Their judgment of darkness is coded as LVF response if they judge that bar as darker in which the dark shade appears to their left side (left hemi-space) and RVF when they judge the bar as darker in which the dark shade appears to their right side (right hemi-space). The LVF bias or advantage indicates a right hemispheric advantage while, RVF advantage suggests a left hemispheric asymmetry.

Results

The obtained data on emotion intensity judgment task was analyzed in a 2 (groups: depressed and non-depressed) X 2 (visual-fields: left and right) ANOVA with repeated measure on the last factor and findings revealed significant main effect of VF [F(1, 56) = 34.673, p = 0.0001, (p2 = 0.382]. However, the main effect of group was not found to be significant. In fact, a null main effect (F = 0) has been obtained for the group. Though, this is a statistical artifact resulting from the perfectly correlated and complementary nature of the LVF and RVF responses. Since, there is no correct/incorrect response in this test and the participants are required to show their preference for chimeric faces with 'happy hemiface' in either the left hemispace (LVF preference) or in the right hemispace (RVF preference) the sum of LVF and RVF response for each participants will always be constant for each and every individual (32 in the present cases). Due to constancy of scores (zero variation) a null effect is quite natural.

The mean preference score for happy hemiface in LVF and RVF was compared, which revealed that the participants frequently judged those chimeric faces as happier where happy face was presented to LVF (mean preference = 19.241) than that appeared in RVF (mean preference = 12.759). The findings suggest that participants, irrespective of their depression level, have shown an LVF (right hemispheric) advantage in processing of facial expression of emotions.

The significant interaction of Group X VF [F(1, 56) = 9.810, p = 0.003, p2 =0.149] suggests that the perceptual asymmetry across two groups differed significantly. It is apparent from Figure 1 that both depressed and non-depressed participants have shown LVF advantage in processing of facial expressions of emotions, however, this LVF advantage (enhanced right hemispheric asymmetry) was higher in depressed as compared to non-depressed group. To examine the difference between mean LVF and RVF scores, simple main effects were computed, which revealed that it was higher and statistically significant in depressed [mean score in LVF = 20.966 and RVF = 11.034; F(1, 27) = 52.012, p = 0.0001] as compared to the non-depressed group [mean LVF = 17.517 and RVF = 14.483; F(1, 27) = 3.118, p = 0.088].

The data obtained on emotion discrimination task was analyzed using similar ANOVA design and findings revealed that main effect of VF [F(1, 56) = 35.019, p = 0.0001, p2 = 0.385] as well as interaction of Group X VF were found to be significant [F(1, 56) = 8.386, p = 0.005, p2 = 0.130]. The main effect of the group, however, was found to be non-significant [F(1, 56) = 0.511, p = 0.478].

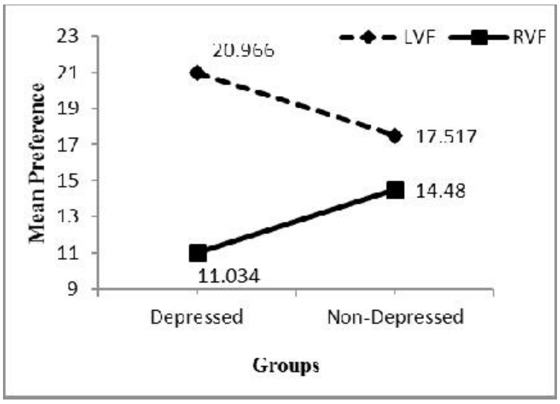

Figure 1. Mean preference score for judging the emotional intensity (happiness) of happy-neutral chimeric faces with happy hemi-face presented in left and right visual-fields to depressed and non-depressed groups

The comparison of the mean accuracy on this task was compared in LVF and RVF which revealed that participants discriminated facial emotions more accurately when they were presented the LVF (mean accuracy = 17.345) than RVF (mean accuracy = 14.914). Thus, when participants were shown an LVF (RH) advantage in processing of facial expressions of emotions irrespective of their depression level.

The significant interaction of Group X VF suggests that the nature of hemispheric (perceptual) asymmetry obtained for depressed individuals differed significantly from non-depressed. The significant interaction has been plotted in Figure 2, which suggests that though, both groups have shown LVF (right hemispheric) advantage in discrimination of facial expressions of emotions, the depressed as compared to the non-depressed have shown significantly higher accuracy in LVF than in RVF. In other words, the right hemispheric asymmetry was found to be more pronounced in depressed as compared to non-depressed counterparts. However, simple main effect analysis revealed that while the depressed group showed a statistically significant LVF (RH) advantage [$F(1, 27) = 69.995$, $p = 0.0001$], the observed trend towards LVF (RH) advantage in non-depressed group was not statistically reliable [$F(1, 27) = 3.164$, $p = 0.086$]. This pattern of findings suggests that in discriminating facial expressions of emotions, though, a general trend of LVF advantage was noted in both depressed and non-depressed individuals, this advantage was larger and statistically reliable only in the depressed group. Thus, depression is linked with enhanced right hemispheric asymmetry (LVF advantage) for emotion discrimination as well as judgment of emotional intensity of happy faces.

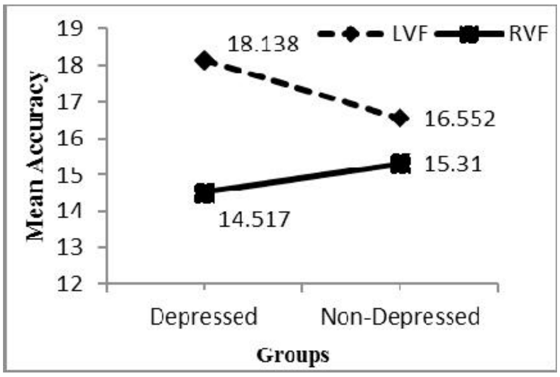

Figure 2. Mean emotion discrimination accuracy of depressed and non-depressed groups across two visual-fields

The data obtained on valence judgment task was analyzed using 2 (groups: depressed and non-depressed) X 2 (visual-fields: left and right) X 2 (emotions: positive and negative) ANOVA with repeated measures on the last two factors. Only the interaction of Group X VF was found statistically significant [$F(1, 56) = 4.476$, $p = 0.039$, p2 = 0.074] which suggests that perceptual (hemispheric) asymmetry obtained for two groups is significantly different. To uncover the nature of interaction, the mean scores of depressed and non-depressed participants across two VF was plotted graphically (Figure 3) and simple main effects were calculated as a follow-up test.

Examination of Figure 3 revealed that non-depressed individuals have shown RVF (LH) advantage, whereas the depressed have shown an LVF (RH) advantage in processing of words regardless of emotional valence. The simple main effect analysis revealed that the observed LVF advantage in depressed group (greater mean score in LVF = 9.6207 as compared to RVF = 9.4483) was statistically non-significant [$F(1, 27) = 0.5867$, $p = 0.450$], whereas the RVF advantage observed in non-depressed (greater mean score in RVF = 9.9138 as compared to LVF = 9.431) was statistically significant [F(1,

27) = 5.512, p = 0.031]. Thus, this interaction suggests that while non-depressed individuals showed a left hemispheric (RVF) advantage or asymmetry in processing of words regardless of their emotional valence, such asymmetry was absent in the depressed individuals.

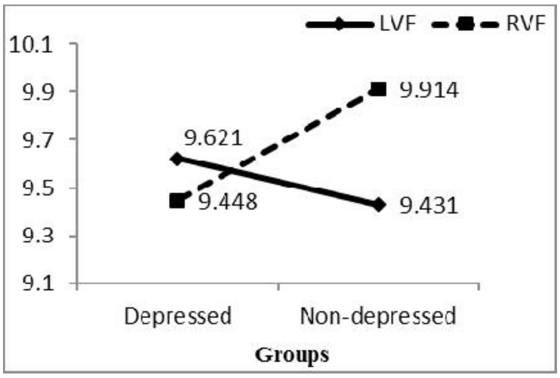

Figure 3. Mean Accuracy in processing of emotional words shown by depressed and non-depressed group across two visual-fields

Overall, this significant interaction of Group X VF brings to fore that anomaly in processing of emotional words was found for depressed group, evident by the fact that non-depressed have shown a LH asymmetry in processing of words (irrespective of its valence), whereas the depressed group has not shown any asymmetry and have shown a non-significant trend towards RH asymmetry. The statistical absence of asymmetry in processing of words among sub-clinically depressed participants is a significant departure from LH asymmetry that is usually found for such a task among normal right-handed individuals.

Hemispheric asymmetry in processing of non-emotional visual-spatial configuration under free-viewing condition was assessed using Grey Scale. Data was analyzed in a two-way ANOVA with repeated measure on the last factor. The findings revealed significant main effect of VF [F(1, 56)= 8.305, p=0.006] with moderate effect size (p2= 0.129) and rest of the main and interaction effects were found to be insignificant (p > .05). Since, this task was similar to that of chimeric face test a null main effect (F = 0) of the group was obtained because of invariance of total score on this task for each participant.

The mean preference for judgment of the luminance of bars presented to the LVF and RVF was compared and the comparison revealed that participants judged frequently those horizontal bars as darker, which were on the left side (LVF mean preference = 23.328) than on the right side (RVF mean preference = 16.672). This pattern of findings suggests that participants irrespective of their depression level have shown an LVF advantage in processing of non-emotional visual-spatial configuration.

A non-significant interaction of Group X VF [F(1, 56)=0.006, p=0.941] was observed for processing of non-emotional visual-spatial configuration, which is a theoretically significant information, which suggests that right hemispheric asymmetry is present in both depressed and non-depressed groups. This finding implies that depressed individuals did not show anomaly in hemispheric asymmetry in processing of non-emotional information.

Overall, the finding suggests that the participants have shown right hemispheric advantage in processing of non-emotional visual-spatial configuration (irrespective of their depression level), but group specific difference in hemispheric asymmetry was not observed. Thus, perceptual asymmetry task involving processing of non-emotional information appears to be less sensitive to detect hemispheric anomaly in depression.

To cross-validate the finding that depressed and non-depressed groups have shown similar right hemispheric asymmetry in processing of non-emotional visual-spatial configuration, the hemispheric asymmetry in depressed and non-depressed group was compared on a different non-emotional task (identification of geometrical shapes) using a different methodology (split-field technique). The obtained data was analyzed similarly with the two way ANOVA design with repeated measure on the last factor and the findings revealed that main effect of VF [F(1, 56)=13.955, p=0.0001, p2 = 0.199] was noted as significant, while remaining all other main and interaction effects as non-significant (p>.05). The comparison of the perceptual accuracy in identification of geometrical figures presented to LVF and RVF revealed that the participants showed greater perceptual accuracy in identification of non-emotional geometrical shapes when presented to LVF (mean accuracy = 12.000) as compared to RVF (mean accuracy = 10.948). This pattern of VF differences in perceptual accuracy of geometrical figure identification suggests a LVF advantage in processing of non-emotional visual-spatial configuration. However, the obtained non-significant interaction of Group X VF suggests that this pattern of perceptual asymmetry (i.e., right hemispheric advantage) in identifying geometrical figures (shapes) were equally evident in both depressed and non-depressed groups. The absence of group specific differences in hemispheric asymmetry for processing of non-emotional stimuli (geometrical figures) implies that both depressed and non-depressed groups have shown similar pattern of right hemispheric asymmetry and therefore, this task seems to be less sensitive in uncovering hemispheric anomaly in depression.

Discussion

The objective of the present study was to examine the nature of hemispheric asymmetry in depression while controlling the methodological variations. The findings revealed that depression is associated with enhanced right hemispheric asymmetry in processing of emotional information especially in processing of facial expressions of emotions, but not for processing of non-emotional information. This implies that enhanced right hemispheric asymmetry observed in depressed individuals is task specific and this anomaly was evident for emotional tasks especially in judging the emotional intensity of happy-neutral chimeric facial expression or discriminating facial expression of emotion and not for processing of non-emotional information (luminance of evenly shaded horizontal bars or identifying laterally presented geometrical shapes). The task specificity in detecting the anomalous hemispheric asymmetry in depression becomes further evident by the observation that sub-clinically depressed individuals of the present study showed anomaly in hemispheric asymmetry for processing of words, but not for its emotional valence. Thus, the findings of the present study also help to resolve the observed inconsistency regarding the nature of functional hemispheric asymmetry in depression by demonstrating that in sub-clinical depression, the anomaly in functional hemispheric asymmetry depends on the nature of the information-processing task. However, such anomaly in hemispheric functioning among depressed individuals will remain undetected if they are required to process non-emotional/ non-facial information in perceptual asymmetry task. The present finding corroborate the earlier finding that depression is linked with enhanced right hemispheric performance in processing of emotional (facial expressions) (Bruder et al., 2002; Gupta & Pandey, 2011) information and no asymmetry for processing of non-emotional information (Bruder et al., 1992). However, direct empirical evidences to support the present findings are limited.

Overall, these observations of the present study suggests that anomalous pattern of hemispheric asymmetry observed in depression is task specific, but not method specific. Variations in information though, differentially influences the pattern of hemispheric asymmetry in depression, however, variation in the assessment methodology does not influence the pattern of hemispheric asymmetry in depression. The present deduction that pattern of hemispheric asymmetry is not influenced by variation in methodology of assessing hemispheric asymmetry, however, it should be interpreted with great caution since the two methods used in the present study were very similar to each other. Both free-viewing and split-field methods are the index of hemispheric asymmetry by assessing the perceptual bias towards a visual hemi-field or hemi-space (LVF or RVF space) and is based on the same psycho-physiological assumption that stimuli presented to one visual hemi-field or hemi-space is projected to or processed by the contralateral hemisphere (see Bryden, 1982 for a review of these methods). There is a need to validate the said conclusion using perceptual asymmetry tasks involving the processing of emotional and non-emotional information presented in a different sense of modality.

Researchers have demonstrated that emotional and non-emotional both stimuli are better processed by RH (Borod, Zgaljardic, Tabert, & Koff, 2001; Nicholls et al., 1999; Nicholls & Roberts, 2002; Rhodes, 1993) and depressed individuals are likely to demonstrate over-activation of RH not only in resting state EEG (Bruder et al., 1997; Reid et al., 1998), but also in brain imaging studies too (Grimm et al., 2008; Janocha et al., 2009). Thus, it is reasonable to assume that if depression is associated with over-activation of RH then enhanced RH performance should be observed for all tasks demanding RH capabilities i.e. processing of emotional stimuli, non-emotional visualspatial configuration, human face etc. However, contrary to the expectations, the present finding suggests that enhanced RH asymmetry in depression is not observed for all the RH tasks. The enhanced RH performance in depression is found for processing of facial expressions of emotions and is absent for processing of non-emotional visualspatial configurations.

Thus, the hypothesis extended on the present research findings is more related to functional capacity of the RH (selective enhancement for certain functions like processing of emotions), which is more linked with the structural model of hemispheric specialization (Bryden, 1982). Hence, the major issue is to explain why the RH shows selective enhancement of functioning for processing of emotional stimuli, but not for non-emotional visual-spatial configuration. Since, this is, perhaps, the first time that some evidence has been obtained for 'selective functional facilitation of right hemisphere' in depression, only conjectural explanations can be given. According to the dynamic model, participation of the brain hemispheres in the different cognitive functions is modulated by the brain's "functional states", which are coupled with the perceptual attention processes of the hemispheres. One of the functional states that involve intra-hemispheric activation mechanisms that is responsible for spreading the activation to the whole hemisphere. According to this view, whenever a function is initiated within a given hemisphere, the activity of the activated brain areas spread to the rest of that hemisphere (Kinsbourne, 1970), which results in greater functional availability of other hemispheric functions and enhanced attention (an "attentional bias") in favor of the sensory hemispace contralateral to the activated hemisphere (Querne & Faure, 1996). This model suggests that the basal level over arousal of the RH would lead to greater allocation of attentional resources to the aroused hemisphere (Moscovitch, 1976) and an attentional bias towards the contralateral left VF (Querne & Faure, 1996) and thereby facilitating RH functioning for processing of various stimuli. This theoretical speculation, though, appears to be promising in explaining the enhanced RH performance in depression; it does not explain the differential enhancement of RH functioning. Thus, some alternative theorization is required to explain the present observation of differential RH performance enhancement as a function of nature of the task or information processing demand.

Overall, the findings of the present study though seem to have a promising implication for diagnostic assessment of depression from neuropsychological perspectives. The findings imply that the perceptual asymmetry tasks involving processing of emotions (particularly facial expressions of emotions) may be used for diagnostic assessment of depression inasmuch as enhanced RH asymmetry on such tasks has been found to be linked with depression.

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