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The Role of the Right Hemisphere for Processing of Social Interactions in Normal Adults Using Functional Magnetic Resonance Imaging

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Key Words

Right hemisphere · Social interactions · Adults · Functional magnetic resonance imaging

Abstract

Objective: The main purpose of this study was to evaluate whole-brain and hemispheric activation in normal adult volunteers to videos depicting positive and negative social encounters. There are few studies that have utilized dynamic social stimuli to evaluate brain activation. ***Method:*** Twenty young adults viewed videotaped vignettes during an functional magnetic resonance imaging procedure. The vignettes included positive and negative interaction scenes of social encounters. ***Results:*** Significant right greater than left activation for positive and negative conditions was found for the social interaction videos in the amygdaloid complex, the inferior frontal gyrus, the fusiform gyrus, and the temporal gyri ($p < 0.0001$). ***Conclusion:*** These findings support the hypothesis that the regions of the right hemisphere are more active in the interpretation of social information processing than those regions in the left hemisphere. This study is a first step in understanding processing of dynamic stimuli using ecologically appropriate stimuli that approximate the real-time social processing that is appropriate for use with populations who experience significant social problems.

With the advent of functional magnetic resonance imaging (fMRI), it is now possible to evaluate brain activation and to isolate structures that may be involved in social perception [1]. fMRI research using facial photos found activation in the amygdala when emotional pictures were viewed with increased activation seen in the superior temporal sulcus and visual cortex [2] and bilaterally in the fusiform face area [3] and in the bilateral amygdala [4] in healthy controls and in adults with autism.

Hemispheric Effects

While photographs have been frequently studied to examine a participant's interpretation of facial expressions, social communication occurs in a dynamic and fluid setting. The use of videotaped vignettes that convey social interactions may be sensitive to the participant's ability to understand context as well as changing situations. Using fMRI, increased activation was found in the frontal-cingulate-parietal connections when faces which were morphed from a neutral emotion to fear or anger were viewed [5]. An additional study utilizing a more fluid form of nonverbal communication using fMRI found more activation in the right hemisphere for social interaction scenes compared to the left, particularly in the amygdala and frontal lobe [6].

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A study which utilized videotapes of humans portraying happy and sad emotions found widespread regional brain activation differences that were specific to the type of emotion portrayed [7]. Multiple and widely distributed networks were activated particularly for the sad stimuli in the right parietal and frontal regions with fewer activations found for the happy stimuli, which were generally in the temporal lobe. Human-like interactions have also been studied using geometric shapes that were animated to resemble human-like interactions with more right hemispheric activation found compared to left [8]. Similar findings have been present for cartoons [9] and live actors [10, 11].

The current study was part of a larger investigation on social perception that included both video (dynamic) and photographic (static) stimuli during an fMRI scan procedure. Based on photo and cartoon data, we hypothesized that there would be more activation in the frontal medial regions and in the right hemisphere, particularly in the right amygdala region, for the negative compared to the positive videos.

Materials and Method

Participants

There were 20 subjects in this study with 10 females and 10 males (mean age of 22.1; standard deviation 1.69). There were 19 Caucasian subjects and 1 Hispanic. No subject had any psychiatric diagnosis (depression, anxiety, attention deficit hyperactivity disorder, etc.) and all were screened using a semistructured clinical interview prior to beginning the study. All participants were right-handed and were reported to be in good health. None had a history of neurodevelopmental delays, head injuries, seizures, or metal in any part of the body. No participant was prescribed any psychotropic medication. All were undergraduate students at a large Midwestern university. This study was conducted under the auspices of the Institutional Review Board and all participants provided informed consent.

Procedure

Each participant completed a phone interview screen for possible psychiatric and learning problems. Following this screening, the participants completed an hour of psychological screening measures including the ability, achievement, and emotional stability. Each subject needed at least average ability (85 or higher) and average achievement with no significant indications of anxiety or depression. Table 1 provides the means and standard deviations of the scores for each of the measures administered. The participants scored within the average range on all measures.

Table 1. Means and standard deviations (SD) on the measures for the group

Measure	Mean ± SD
Age	22.11 ± 1.69
WASI FSIQ	114.94 ± 6.41
WASI VIQ	114.22 ± 8.06
WASI PIQ	113.33 ± 9.30
WJ Letter Word ID	98.78 ± 8.05
WJ Calculation	103.33 ± 11.31
WJ Spelling	100.39 ± 11.31
Beck Depression Inventory	3.78 ± 3.83
Beck Anxiety Inventory	4 ± 4.85

Stimuli. To provide stimuli that are dynamic in nature, short scenes of positive (happy) and negative (angry) events were written. Additional scenes were selected from previously published scenes [12]. The actors were Caucasian, Asian, and Hispanic. The actors in each vignette were varied across vignettes. Written consent was obtained from each participant. Typical examples of positive scenes included a child opening a desired birthday present with friends, a group of adolescents celebrating completion of a class project, a child finishing homework early and getting to go out to play, a mother working with a child, and a father talking to his son. Typical examples of negative scenes included a child being excluded from a game, a teen being teased by other adolescents, and a child being denied an activity by his father.

Functional Scans. The experiment was divided into four functional runs each lasting 6 min and 40 s. In each run, subjects were presented with 12 blocks of stimulation after an initial 10-second 'resting' period in a baseline condition (a white screen with a black fixation cross at the center). In each block, 17.5 s of stimulation was presented. A 15-second baseline condition followed each block. To ensure attention to the stimuli, participants were required to make a button press at the moment of change to fixation from a block of stimulus.

Image Acquisition. The experiment was conducted on a 3T GE Signa EXCITE scanner (GE Healthcare, Milwaukee, Wisc., USA) with an 8-channel head coil. To study brain function, echo-planar images, starting from the most inferior regions of the brain, were then acquired with the following parameters: 34 contiguous 3-mm axial slices in an interleaved order, TE = 27.7 ms, TR = 2,500 ms, flip angle = 80°, FOV = 22 cm, matrix size = 64 × 64, voxel size = 3.44 × 3.44 × 3 mm, ramp sampling, and with the first four data points discarded. After functional data acquisition, high-resolution volumetric T_1-weighted spoiled gradient-recalled images with cerebrospinal fluid suppressed were obtained to cover the whole brain with 120 1.5-mm sagittal slices, 500 ms time of inversion, 8° flip angle and 24 cm FOV. These images were used in Talairach transformation and to identify anatomical locations in both individual and group analyses.

fMRI Data Preprocessing and Analysis. All fMRI data preprocessing and analysis was conducted with AFNI software. Monte Carlo simulation of the effect of matrix and voxel sizes of the imaging volume, spatial correlation of voxels, voxel intensity thresholding, masking and cluster identification was applied to estimate overall statistical significance with respect to the whole brain with the 'AlphaSim' software in AFNI [13]. This simulation allowed the following active voxel selection criteria to achieve a whole-brain corrected $p \leq 0.022$: the voxels need to have voxel-

Table 2. Brain regions showing significant activation related to videos based on the contrast of negative minus positive stimuli (video interactions)

Region/condition	Voxels mm³	Maximum t value in cluster	Coordinates of maximum t value in largest cluster[a]	Mean t value[b]	Mean % signal change negative video	Mean % signal change positive video
R amygdaloid complex[1]	309	−8.116	(R36, P34, I11)	−3.927	0.256	0.328
L amygdaloid complex	163	−5.304	(L34, P33, I14)	−3.639	0.149	0.222
R fusiform gyrus	1,092	−6.855	(R32, P38, I12)	−3.822	0.640	0.765
L fusiform gyrus	981	−5.513	(L25, P69, I8)	−3.639	0.752	0.903
R inferior temporal gyrus	805	−6.867	(R46, P66, S2)	−4.374	1.024	1.231
L inferior temporal gyrus	898	−8.360	(L47, P72, S1)	−4.343	0.683	0.853
R middle temporal gyrus	4,187	−9.605	(R44, P68, S7)	−4.338	0.725	0.869
L middle temporal gyrus	4,583	−8.001	(L43, P56, S7)	−4.391	0.557	0.703
R superior temporal gyrus	107	−3.947	(R52, P37, S17)	−3.537	0.834	0.941
L superior temporal gyrus	740	−6.251	(L53, P36, S14)	−3.801	0.908	1.058
R inferior frontal gyrus	743	−5.928	(R44, A5, S31)	−4.027	0.407	0.530
L inferior frontal gyrus	615	−6.914	(L33, A7, S29)	−4.298	0.137	0.2580
L inferior frontal gyrus	303	4.514	(L37, A23, I10)	3.493	0.458	0.2578
R superior frontal gyrus	176	4.596	(R3, A51, S28)	3.697	0.610	0.421
L superior frontal gyrus	359	5.218	(L3, A47, S33)	3.699	0.402	0.225
R medial frontal gyrus	329	4.555	(R2, A48, S30)	3.913	0.355	0.217
L medial frontal gyrus	1,016	5.518	(L2, A46, S32)	3.886	0.503	0.269

[a] Location in Talairach coordinate with R = right, L = left, A = anterior, P = posterior, S = superior, and I = inferior.
[b] Amygdala + parahippocampus.

based $p \leq 0.005$ and were nearest-neighbor and within a 248-mm³ cluster.

Whole-Brain Group Analysis. The ANOVA results were used to extract the activated voxels for all pairwise condition contrasts, based on specific active voxel selection criteria that resulted from the Monte Carlo simulation discussed in the previous paragraph.

Region of Interest Brain Analysis. Regions of interest (ROI) were defined anatomically in the Talairach coordinate space with AFNI, and were limited to the areas hypothesized as involved in social perception. They included the temporal gyri, fusiform gyri, cingulate gyrus, amygdala, as well as the medial, inferior and superior frontal gyri.

Results

Whole-Brain and ROI Analysis

The whole-brain analysis for the videos showed several regions with significant activation with overall increased activation to positive social interactions compared to negative social interactions (see table 2, note t values are for negative-positive, thus, negative t values reflect more activation to positive videos). Online supplementary figures 1a and b (for online suppl. material see www.karger.com/doi/10.1159/000325075) show activation above baseline (orange) in the positive (a) and sad (b) conditions in the frontal gyri, and online supplementary figures 1c and d show the same in the temporal gyri. The ROI analysis compared hemispheric differences between right and left to provide an index of laterality for the analysis. Table 3 provides the results of these paired t tests for videos.

Videos Right and Left Activation. ROI analysis of hemispheric effects for the videos for positive interactions found higher activation in the right compared to left in the amygdala/parahippocampal region ($p < 0.0001$), anterior cingulate ($p = 0.045$), fusiform gyrus ($p = 0.03$), inferior frontal gyrus ($p < 0.0001$), inferior temporal gyrus ($p = 0.001$), medial temporal gyrus ($p < 0.0001$), and superior temporal gyrus ($p < 0.0001$). For the videos depicting negative interactions, significantly stronger right compared to left activation was found in the amygdala/parahippocampal region ($p < 0.0001$), fusiform gyrus ($p = 0.041$), inferior frontal gyrus ($p = 0.001$), inferior temporal gyrus ($p < 0.0001$), medial temporal gyrus ($p < 0.0001$), and superior temporal gyrus ($p < 0.0001$). Additional information can be found in online supplementary figures 1–3.

Table 3. Hemispheric differences to videos

Region	Mean ± SD	t	Significance (two-tailed)
Video positive			
Amyg R – Amyg L	0.414 ± 0.038	4.930	0.000
ACG R – ACG L	–0.016 ± 0.033	–0.210	0.045
Fusi R – Fusi L	0.094 ± 0.179	2.345	0.030
ITG R – ITG L	0.106 ± 0.115	4.098	0.001
MTG R – MTG L	0.142 ± 0.114	5.536	0.000
STG R – STG L	0.107 ± 0.108	4.442	0.000
Video negative			
Amyg R – Amyg L	0.042 ± 0.037	5.125	0.000
Fusi R – Fusi L	0.089 ± 0.183	2.191	0.041
ITG R – ITG L	0.100 ± 0.095	4.769	0.000
MTG R – MTG L	0.139 ± 0.113	5.538	0.000
STG R – STG L	0.954 ± 0.095	4.512	0.000

SD = Standard deviation; Amyg = amygdala; R = right; L = left; ACG = anterior cingulate gyrus; ITG = inferior temporal gyrus; Fusi = fusiform gyrus; MTG = medial temporal gyrus; STG = superior temporal gyrus.

Discussion

The main purpose of this study was to investigate the nature of neural processing of dynamic stimuli depicting positive and negative social encounters using fMRI. Using whole-brain analysis, we found that the areas showing activation above threshold for positive compared to negative vignettes were generally bilateral and in the amygdaloid area, fusiform gyrus, and inferior, middle, and superior temporal gyri. Negative stimuli showed more activation in the bilateral superior and medial frontal gyri as had been predicted. To more fully understand the relation of positive and negative social stimuli to brain activation, hemispheric differences were evaluated and it was found that significantly more right hemispheric activation for positive and negative vignettes compared to homologous regions in the left hemisphere consistent with our main hypothesis (table 3).

The finding of increased activation in the amygdaloid area and fusiform gyrus for the vignettes is consistent with previous findings using photos [4, 14]. These regions are also activated for dynamic stimuli likely because identifying the emotions requires analyzing the facial expressions present in the vignettes. Additional brain regions were activated for the vignettes which required not only processing of facial expressions but also of context and movement. Thus, the basic structures involved in identifying facial expressions are activated for the vignettes with more widespread activation present when complex information is presented for processing.

Hemispheric Effects

The findings of the current study are consistent with previous studies that have utilized animated shapes in investigating brain regions responsive to social interactions [15] as well as videotapes of humans dynamically expressing sadness or happiness [7]. In that study the superior temporal gyri and medial prefrontal areas were activated when objects were depicting more negative actions (fighting, chasing, tricking). To some extent those findings are consistent with the current study in that these right-hemisphere regions were activated for the videos showing social interactions depicting angry scenes.

Anterior Cingulate. Consistent with our predictions, the right anterior cingulate was found to be more activated for videos showing positive interactions. It may be that processing of the context for the videos required additional checking of the presented information to determine what emotions are present. This processing required additional areas of the brain and thus, resulted in brain activation that was more widespread. Thus, the vignettes require additional networks for understanding of context and movement compared to the understanding of facial expressions portrayed on still photos and required determination of the valence of the emotion portrayed in a social context [16]. These findings and earlier results indicate that the amygdala is important for understanding and processing of positive and negative situations and works in a neural network with structures important for quick processing of complex and dynamic situations [17].

Differences were present between the Prohovnik et al. [7] study and the current one, particularly in higher activation present in the amygdala for our study likely due to stimuli differences. In the Prohovnik et al. [7] study actresses discussed their feelings while evidencing appropriate facial expressions while our study used more contextual inferences for the emotions and emotions were not labeled. In both studies widespread networks particularly in the right hemisphere were activated to process the stimuli.

Limitations

Several factors may have influenced our findings. First, we presented social vignettes only rather than including stimuli which were nonsocial or which were neutral in nature. While we did not conduct a study utilizing nonsocial stimuli, the current study begins to explore how the brain processes social information which is positive and negative. Second, we repeated a minority of the videos. This repetition was added after the videos had been taped in order to increase statistical power for fMRI with 7 positive and 5 negative vignettes were randomized and repeated once.

Conclusion

In conclusion, we sought to evaluate the processing of video vignettes that depicted positive and negative social encounters in typical adults using fMRI. Dynamic (videos) were utilized to determine whether findings previously limited to pictures or animated objects would translate into more naturalistic videos. Findings included activation of many of the areas of the brain previously found to be involved in processing of social information (amygdala, temporal gyri, frontal gyri). It was also found that the right hemisphere showed higher activation compared to the left particularly in the areas of the superior temporal gyrus, medial frontal gyrus, and amygdala, confirming our hypothesis that the right hemisphere would be more involved in social processing. In addition, we found that ventromedial regions appeared to be more activated for videos showing negative interactions compared to more significant activation found in the temporal lobes for the videos showing positive interactions.

References

1. Dunbar RIM: Cognitive constraints on the structure and dynamics of social networks. Group Dyn Theory Res Pract 2008;12:7–16.
2. Norris CJ, et al: The interaction of social and emotional processes in the brain. J Cogn Neurosci 2004;16:1818–1829.
3. Platek SM, et al: Neural substrates for functionally discriminating self-face from personally familiar faces. Hum Brain Mapp 2006;27:91–98.
4. Ashwin C, et al: Differential activation of the amygdala and the 'social brain' during fearful face-processing in Asperger syndrome. Neuropsychologia 2006;45:2–14.
5. Pelphrey KA, et al: Perception of dynamic changes in facial affect and identity in autism. Soc Cogn Affect Neurosci 2007;2:140–149.
6. Lawrence EJ, et al: The role of 'shared representations' in social perception and empathy: an fMRI study. Neuroimage 2006;29:1173–1184.
7. Prohovnik I, et al: Functional MRI changes before and after onset of reported emotions. Psychiatry Res 2004;132:239–250.
8. Schultz RT, et al: The role of the fusiform face area in social cognition: implications for the pathobiology of autism. Philos Trans R Soc Lond B Biol Sci 2003;358:415–427.
9. Mar RA, et al: Detecting agency from the biological motion of veridical versus animated agents. Soc Cogn Affect Neurosci 2007;2:199–205.
10. Pelphrey KA, et al: Brain activity evoked by the perception of human walking: controlling for meaningful coherent motion. J Neurosci 2003;23:6819–6825.
11. Pelphrey KA, Morris JP, McCarthy G: Grasping the intention of others: the perceived intentionality of an action influences activity in the superior temporal sulcus during social perception. J Cogn Neurosci 2004;16:1706–1716.
12. Corbett BA: Video Modeling Emotion Program. MIND Institute, Davis, 2002.
13. Ward BD: Simultaneous Inference for fMRI Data. Milwaukee, Biophysics Research Institute, Medical College of Wisconsin, 2000.
14. Kesler-West ML, et al: Neural substrates of facial emotion processing using fMRI. Cogn Brain Res 2001;11:213–226.
15. Castelli F, et al: Movement and mind: a functional imaging study of perception and interpretation of complex intentional movement patterns; in Cacioppo JT, Berntson GG (eds): Social Neuroscience: Key Reading. New York, Psychology Press, 2005, pp 155–169.
16. Davidson RJ, Jackson DC, Kalin NH: Emotion, plasticity, context, and regulation: perspectives from affective neuroscience. Psychol Bull 2000;26:890–909.
17. Hare TA, et al: Contributions of amygdala and striatal activity in emotion regulation. Biol Psychiatry 2005;57:624–632.