INTER-HEMISPHERIC INTEGRATION OF EMOTIONAL INFORMATION IN THE FACE: BEHAVIORAL AND ELECTROPHYSIOLOGICAL DATA

Telmo Pereira[1,2], Armando Oliveira[1], Isabel B. Fonseca[3]
[1] *Institute of Cognitive Psychology, University of Coimbra, Portugal*
[2] *Superior College of Health Technology, Polytechnic Institute of Coimbra, Portugal*
[3] *Faculty of Psychology and Educational Sciences, Lisbon, Portugal*
telmo@estescoimbra.pt

Abstract

A lateralized emotion perception task with 1 second exposure durations was used involving the presentation of two emotional faces, one on each visual hemi-field, rather than the typical emotion-neutral arrangement. The two faces characteristically belonged to two distinct emotion categories (joy-fear, joy-anger, fear-anger), and varied along 3 levels of expression (obtained through morphing). Factorial combinations among the levels of the emotions were used for each pair, and subjects were required to rate the overall affective intensity of the pairs. Davidson's framework for the cerebral lateralization of emotions according to an approach-withdrawal axis was provisionally adopted (approaching-inducing emotions lateralized on the left, withdrawal-inducing emotions lateralized on the right). Rating data displayed factorial patterns consistent with inter-hemispheric cooperation (adding or averaging). EEG data (event-related-alpha-desynchronization) clearly supported Davidson's claim. EEG factorial patterns were suggestive of both inter-hemispheric cooperation and competition when visual-field lateralization agreed with preferential cerebral lateralization of emotions.

The cerebral lateralization of emotions has been for long now a topic of dispute. Three major views have shared the arena: (1) the right hemispheric theory (Borod et al, 1998) defends an overall privilege of the right hemisphere in emotional processing; (2) the valence theory (Reuter-Lorenz & Davidson, 1981) argues for a differential lateralization of positive and negative valenced emotions; (3) the approach-withdrawal theory (Davidson, 2004) maintains that emotional lateralization is done according to an approach-withdrawal axis (approach-inducing emotions, such as joy and anger, left-lateralized; withdrawal-inducing emotions, such as fear and sadness, right-lateralized). This latter theory has received the most support in recent literature and is provisionally adopted in the current study as a framework for predictions.

Most studies of cerebral lateralization have attempted to isolate the work of one hemisphere as an approach strategy, either through unilateral stimulation or through bilateral stimulation in which one of the stimulus corresponds simply to a neutral or control condition. The importance of the divided visual field paradigm comes from there. However, even if it has provided useful data concerning functional asymmetries, it has not afforded much as to how the two hemispheres work together. In its standard form, requiring very brief exposure durations (around 150 ms), the divided field paradigm also confines the study of cerebral organization to relatively simple tasks, compatible with tachistoscopic presentations (for all these aspects, cf. Anderson, 1989). The possibility of obtaining sound lateralization results in free-viewing conditions has meanwhile been shown by Jansari, Tranel & Adolphs (2000), and soon after replicated by Rodway, Wright, & Hardie (2003). This opens up the possibility of using more complex tasks, requiring the collaboration of both hemispheres, to address the issues of cerebral asymmetry and organization, as proposed in Anderson, 1989.

The present study reports a preliminary attempt at addressing both the hemispheric lateralization and the inter-hemispheric integration of emotional information conveyed by faces. It uses bilateral stimulation with two emotional faces in an integration task which requires both informers to be used jointly in determining a response (overall emotion intensity of the two faces). Besides behavioral responses (ratings), brain responses were also recorded through EEG. This latter circumstance required that a selective hemispheric stimulation be actually achieved. The found compromise between this requirement, which led us to embrace a divided visual field technique, and the requirement for longer exposure durations, given the nature of the task, was to set the stimuli presentations at 1 second.

Method

Participants

30 graduate students (19F, 11M; mean age: 21 + 1,2 years) volunteered to participate in the experiment. They were all right-handed, with normal or corrected to normal vision, and naïve regarding the topic under study.

Stimuli

Pictures of emotional faces selected from the databases JACFEE and JACNeuF (Matsumoto & Ekman, 1988). Faces were picked up by pairs, comprising a neutral and a very high intensity expression of a given emotion by the same individual. Intermediate levels of intensity were obtained by digital morphing at equal 33% steps between neutral and high intensity expressions. The first and second morphs were used to represent low and intermediate intensity levels of a given emotion. Three emotions from Ekman’s taxonomy (Ekman, 1993) were considered: fear, joy and anger. Stimuli composed of two emotion expressions at variable intensities were built for use in the experiments. The entire set of stimuli (each consisting of a pair of faces) covered all factorial combinations of the intensity levels of emotions taken two by two.

Design and Procedure

A lateralized emotion perception task with exposure durations of 1 sec. (cf. Jansari, Tranel & Adolphs, 2000; Rodway, Wright, & Hardie, 2003) was used involving the presentation of two emotional faces, one to each visual hemi-field. One single experiment was used involving the three possible pairings of emotions (anger-joy; anger-fear, fear-joy). Each pairing of emotions gave rise to a 3(emotion1) x 3(emotion2) x 2(visual hemifield) factorial design. Pairs of faces expressing a same emotion at variable intensities were also used (so that each emotion was associated with a 3 x 3 supplementary design). In total, the experiment comprised 81 randomized experimental trials.

Participants were run individually, after a variable number of training trials, and instructed to judge the overall intensity conveyed by each pair of expressions on a graphic rating scale, while keeping their eyes at the fixation point. They sat in a recliner in a dimly lit room, in front of a VGA monitor, with line sight leveled to the center of the display. Observer’s distance to the screen was set at 50 cm, which ensured the visual angles needed to implement the divided-half-field technique (e.g., around 10º subentending the separation between both faces, equidistant from the fixation point). All aspects of presentation were managed with SuperLab 4.07, which also triggered the recording of EEG data.

EEG data collection assemblage and analysis

Six EEG leads (locations F3, F4, T3, T4, P3, P4 on the 10-20 IS) were used, all referenced to Cz. Ag-AgCl electrodes were used. Data were collected at a sample rate of 150 Hz through EEG 100B Biopac amplifiers with a band-pass filter of 0.1-35 Hz.

After visual inspection for artifacts, waves were edited according to each of the experimental conditions defined by the 3 x 3 x 2 factorial design. Each time epoch included a 2 s baseline period and extended for 10 s after stimuli onset.

EEG spectral analysis was performed via a fast Fourier transform over the first second following stimuli onset, and α-power was estimated (mean value on the α-band 8.0 – 13.0 Hz). Event-related-alpha-desynchronization (ERD) was then calculated for each epoch, as [(stimulus α-power) - (baseline α-power)]/ (baseline α-power), which reflects the percentage of brain activation in each scalp lead location. To ease up the reading and interpretation of plots ERD is presented as - (ERD), which results in a positive scale.

Results

Hemispheric lateralization - Electrophysiological and behavioral data

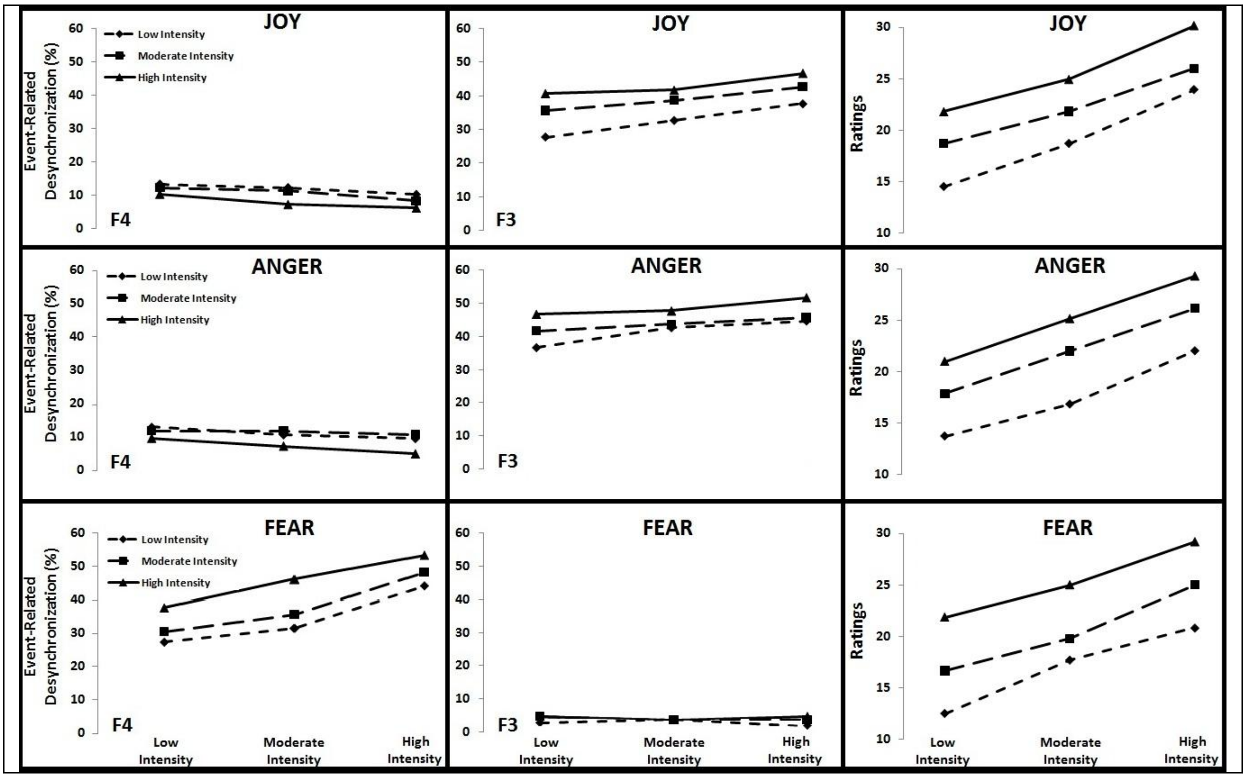

Figure 1. Factorial plots for the α-band ERD at Right (F4) and Left (F3) Hemispheres (left and middle columns) and for mean ratings of Intensity (right column). Brain activity and ratings collected for pairs of faces expressing the same emotion (joy, anger and fear, from top to bottom) with varying intensities. EEG results presented for the Frontal Lobe.

Figure 1 presents the factorial plots for EEG data at frontal lead locations (left and middle columns) and for the ratings given by participants (right column) to pairs of faces expressing the same emotion. The patterns for ratings exhibit near-parallelism, supported by a lack of statistically significant interactions. This is the sign of an adding-type integration obtained across hemispheres, and thus of cooperative hemisphere joint functioning. This adding-type rule should allow quantification of each hemisphere's contribution to the overall response (see Anderson, 1989).

Outcomes for cortical activation are consistent with Davidson's proposals for emotion lateralization. ERD values are significantly higher in the F3 lead (left hemisphere) for Joy ($F(1,29)=296.551$; $p<0.001$) and Anger ($F(1,29)=357.633$; $p<0.001$). The opposite is true for Fear, where F4 shows much higher ERD ($F(1,29)=292.833$; $p<0.001$). Concerning the graphical patterns, near parallelism is also the prevailing rule in the hemisphere corresponding to the preferred lateralization of a given emotion (derivation F3 for Joy and Anger; derivation F4 for Fear). As for ratings, these data are consistent with inter-hemispheric cooperation. However, an inverse functioning of the intensity levels (which associate with decreased cerebral activation) can be observed for Joy and Anger in F4, reaching statistical significance for Joy. This points towards some degree of inter-hemispheric competition, such that increased activation in one hemisphere is accompanied by decreased activation in the other.

Hemispheric Integration - Electrophysiological and behavioral data

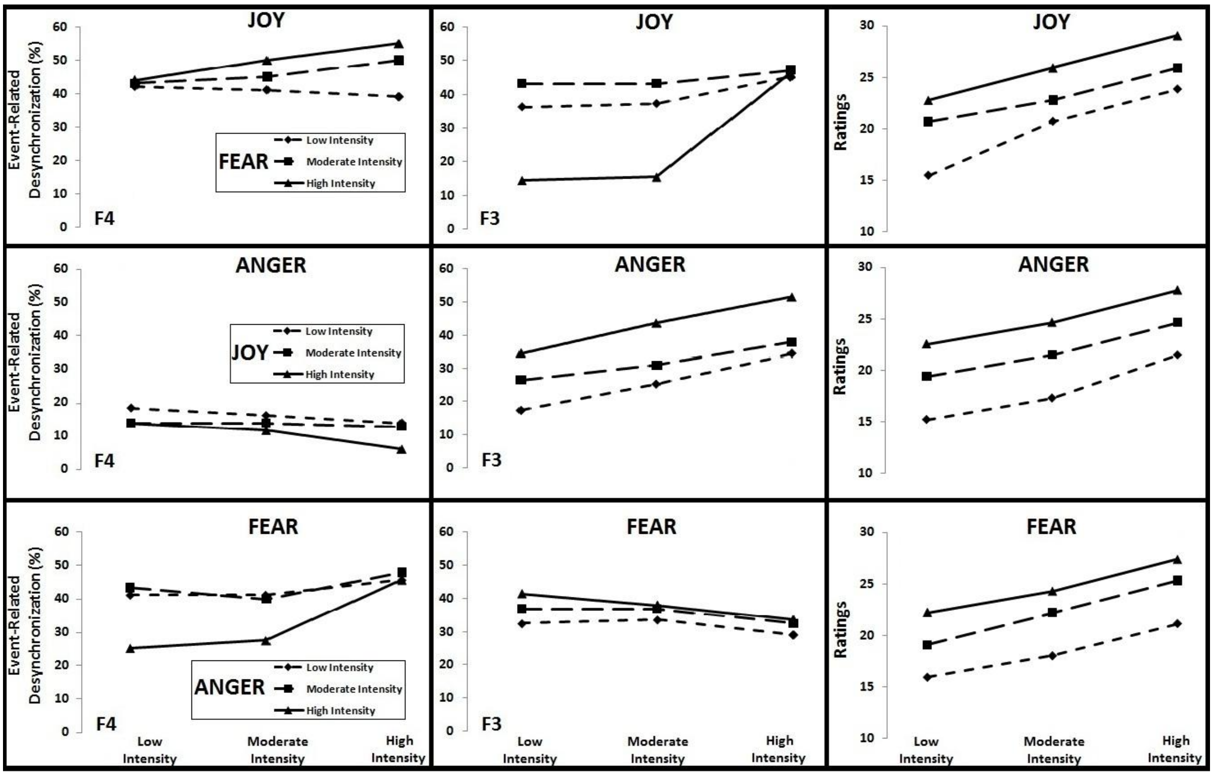

Figure 2. Factorial plots for the α-band ERD at Right (F4) and Left (F3) hemispheres (left and middle columns) and for mean ratings of Intensity (right column). Brain activity and ratings collected for pairs of faces expressing different emotions with varying intensities. EEG results presented for the Frontal Lobe. *Upper Row:* Joy (right visual field)-Fear (left visual field); *Middle Row:* Joy (right visual field)-Anger (left visual field); *Bottom Row:* Fear (left visual field)-Anger (right visual field)

Figure 2 presents the factorial plots for EEG data at frontal lead locations (left and middle columns) and for the ratings given by participants (right column) to pairs of faces expressing different emotions (from top to bottom: Joy-Fear, Anger-Joy, Fear-Anger). As before, the behavioral data disclose parallelism, buttressed by null interaction terms. Cooperative inter-hemispheric relations complying with an adding-type rule seem thus to be at work also for distinct, and distinctly lateralized emotions.

Parallelism is however no longer the rule for cortical patterns (except for Anger-Joy, a pair comprising to similarly lateralized emotions). Evidence for inter-hemispheric competition is available not only in the inverse functioning of the intensity levels as in the distinctive effect of the high intensity level of the competing emotion (cf. top panel in the middle column and bottom panel in the left column), when each of the presented emotions is "inputted" to its preferred hemisphere (according to Davidson's predictions). This offers a further, independent confirmation of the approach-withdrawal view of emotion lateralization, now resting on the interplay of the hemispheres rather than on their separate functioning.

Discussion

The reported outcomes are, as mentioned before, preliminary. EEG data for temporal and parietal sites (also collected) contain important indications to the issues not only of inter- as of intra-hemispheric integration. Other data, both behavioral and electrophysiological, are in the process of being collected from experiments with unilateral double stimulation, which should on its turn highlight not just within-hemisphere integration as, through the asymmetrical processing of different emotions, further aspects of the interplay of the two hemispheres.

As major warranted conclusions: (1) emotion lateralization according to an approach-withdrawal axis is well supported; (2) the involvement of frontal territories in this functional asymmetry is beyond doubt; (3) the intensity of facial emotional expressions modulates both the subjective judgments and the cortical responses; (3) behaviorally, inter-hemispheric cooperation according to an adding-type rule is soundly established for this task; (4) cortically, both cooperation and competition between the two hemispheres underlie the joint use of emotional information with both similarly and differently lateralized emotions (even if competition takes the lead in the later case); (5) Conjoining integration tasks with a divided visual field technique by using longer durations than those allowed for in standard use is a feasible paradigm, which allows to simultaneously address and contrast behavioral and physiological data.

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