THE OBSERVABLE *R* AND THE UNOBSERVABLE *r*: BRAIN AND RATING RESPONSES IN AN INTEGRATION TASK WITH PAIRS OF EMOTIONAL FACES

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Abstract

Participants in this study judged on a graphic rating scale the joint affective intensity conveyed by two emotional faces selectively presented to a single brain hemisphere via a Divided Visual Field technique (DVF). While they did that, EEG was recorded from 6 scalp locations. The emotions considered were joy, fear and anger, varied along three levels of intensity, and each pair of faces might express the same or two distinct emotions. The patterns of integration of the two sources of information were examined both at the level of the ratings and of the brain response (event-related-α-desynchronization:ERD) at each EEG lead. Additive and equal-weighting averaging rules were found, respectively, for the ratings of same-emotion and different-emotion pairs. Additive integration was the predominant finding for α-ERD. Outcomes are discussed with a link to the lateralization of emotional processing and the possible relations between the observable R (ratings) and the implicit neural r.

Information Integration theory (Anderson, 1981; 1982) posits a processing chain whereby observable stimuli (S_i) are turned into their subjective counterparts s_i, which give rise by integration to an implicit response r, which is mapped onto an observable R [$r \rightarrow$ R]. In this study we assume that one of the bottom line meanings of r might be a neural representation, plausibly in the brain. Perception of facial expressions has been heavily implicated in the debate over hemispheric lateralization of affect/emotion, with almost exclusive reliance on selective unilateral stimulation of one hemisphere by one piece of emotional information (e.g., one emotional face). As suggested by N. Anderson (1996), using tasks requiring the combination of several pieces of information, either provided to a single hemisphere (within-hemisphere integration) or separately to each of the two hemispheres (inter-hemisphere integration) should afford a more natural view of cerebral organization than standard lateralization tasks. This suggestion was taken up in the current study, which used an adapted DVF paradigm with presentation durations (1 sec) allowing to perform the integration task (for DVF paradigms with long exposure durations, see Jansari et al., 2000 and Rodway et al., 2003). However, while Anderson's proposal concerned rating responses in adapted DVF settings, we added to that the simultaneous recording of brain responses (EEG), thus opening up the possibility for a comparison between the observable R and the neural, implicit r.

Method

Participants

15 volunteer graduate students (10F, 5M; mean age: 21 + 1.6 years), all of them right-handed, with normal or corrected to normal vision, and naïve regarding the topic under study.

Stimuli

Pictures of emotional faces selected from the JACFEE and JACNeuF databases (Matsumoto & Ekman, 1988). The neutral and highest intensity expression of a given emotion by a same individual were taken as the end poles for a digital morphing at equal 33% steps, providing two intermediate intensities for all the emotions considered: fear, joy and anger (Ekman, 1993). The first and second morphs were used to represent low and intermediate intensity levels of expression. Emotions were taken two by two: each pairing of emotions gave way to 9 stimuli embodying the factorial combination of their intensity levels (3 × 3). The entire set of stimuli also included the 3 x 3 combinations arising out of same-emotion pairs of faces, as well as pairs involving one neutral face and one emotional face (one-factor subdesigns).

Design and Procedure

All stimuli were randomly presented in one single block, using unilateral selective stimulation of one hemisphere at a time (both faces presented to the same visual hemi-field). For each pair of emotions, the overall design corresponded to a full factorial 3 (emotion A) × 3 (emotion B) × 2 (visual hemi-field).

Participants judged 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 at a distance of 50 cm from a VGA monitor. The visual angles subtended allowed implementing the divided-half-field technique (5º between the fixation point and the inner edge of the faces pair). All aspects of presentation were managed with SuperLab 4.07, which also triggered the recording of EEG data.

EEG assemblage, data collection and analysis

Six EEG leads (locations F3, F4, T3, T4, P3, P4 on the 10-20 IS) were used, all referenced to Cz. Data were collected at a sample rate of 150 Hz with a band-pass filter of 0.1-35 Hz. Waves were edited offline according to the experimental conditions defined by the factorial designs. Each time epoch included a 2 s baseline period and extended for 10 s after stimuli onset.

A spectral analysis was performed via a fast Fourier transform over the first second following stimulus onset, and α-power was estimated (mean value on the α-band 8.0 – 13.0 Hz). Event-related-α-desynchronization (α-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 lead location. To ease up the reading and interpretation of plots, ERD is presented as - (ERD), which results in a positive scale.

Results

Data for pairs of faces expressing the same emotion

The factorial plots obtained from ratings of same-emotion pairs are presented in the two leftmost columns of Figure 1, with left visual field (LVF) presentations on the left and right visual field (RVF) presentations on the right. Overall near-parallelism can be seen in the graphs, supported by lack of statistically significant interactions ($p \geq .242$). This signals an adding-type integration irrespective of the stimulated hemisphere – which, assuming preferential and different lateralization for some of these emotions, would in itself indicate the involvement of inter-hemisphere cooperation.

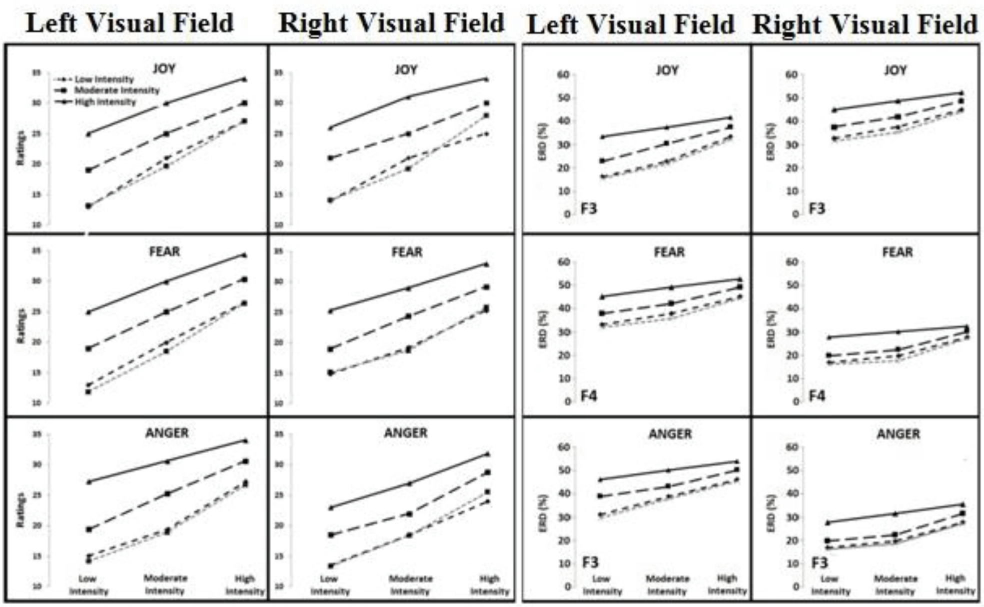

Figure 1. Factorial plots obtained from mean ratings of intensity (left panel) and mean α-ERD at the Frontal Lobe (right panel) for same-emotion pairs (top to bottom: joy, fear, anger). EEG results are given for the lead showing the highest cortical activity for each emotion (Joy and Anger – F3; Fear– F4). The gray line corresponds to the factorial subdesigns (emotional-neutral pairs).

Outcomes for cortical activation are consistent with Davidson's (2004) predictions of a preferential left lateralization of approach-related emotions (higher ERD for Joy and Anger in F3) and a right lateralization of withdrawal-related emotions (higher ERD for Fear in F4) in the Frontal lobe. Concerning the factorial patterns, near parallelism is also prevalent, as in the case for ratings, again supported by non significant interaction terms. Both for ratings and ERD the line corresponding to the subdesigns is also parallel to the lines of the main design, meaning that the intensity of expression of one face is being added to the intensity of the other. An isomorphic adding rule has thus similarly been found at the level of ratings and cortical activation.

Data for pairs of faces expressing different emotions

The factorial patterns obtained from ratings of Joy-Fear pairs (here representing the different-emotion faces pairs) again disclose near-parallelism irrespective of the presentation hemi-field (see Figure 2, top row), well supported by the absence of statistically significant interactions ($p \geq .893$).

However, a clear crossover can now be observed between the lines standing for the one-factor subdesigns, with a much steeper slope, and those corresponding to the main design. The same was observed for all other different-emotion pairs (Fear-Anger and Anger-Joy). This crossover rules out adding and establishes equal-weighting averaging as the integration rule at work in this case (Anderson, 1981, 1982, 1996). As might be expected from an averaging operation, mean ratings in Figure 2 are less extreme and more concentrated around the centre of the response scale than those in Figure 1.

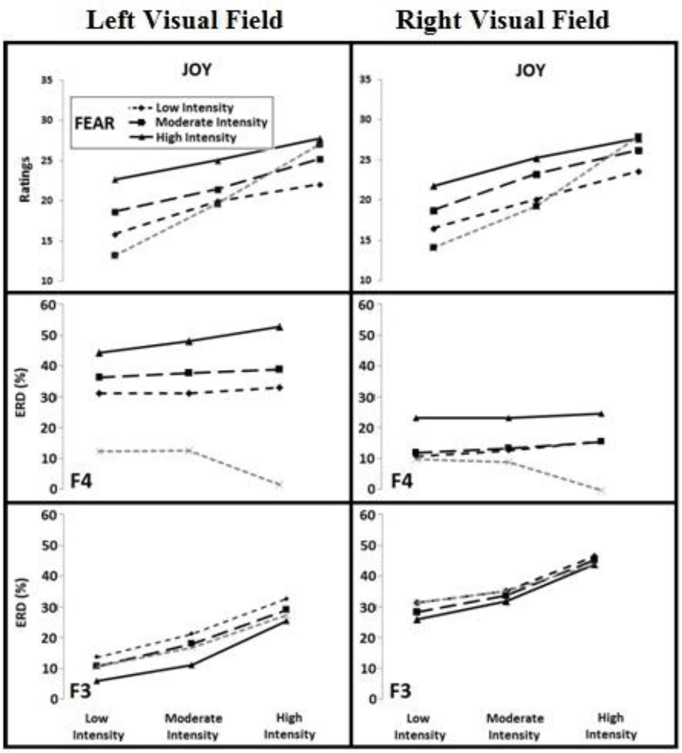

Figure 2. Factorial plots obtained from mean ratings of intensity (upper row) and mean α-ERD at the Frontal Lobe (middle and bottom rows). Data collected for Joy-Fear pairs unilaterally presented to the right or left visual field. In all graphs fear intensity is the curve parameter. Gray lines stand for the factorial subdesigns (emotional-neutral pairs).

As for the patterns of cortical activation involving Joy-Fear pairs, Joy (in the abscissa) presents a rather small effect (though significant) in F4, while the same happens with Fear (which even becomes ns. in the LVF) in F3. A reversal in the functioning of intensities of Fear in F3 is also observed which raises the suggestion of some degree of competition or reciprocal activation between hemispheres (Joy subdesigns, it may be noted, conversely present a diminishing effect in F4). Summing up, each emotion appears to be preferentially treated in a distinct hemisphere, and hemispheres seem to deploy some degree of functional competition among themselves.

Considering both ratings and ERD together, it seems clear that no single hemisphere could support the averaging integration observed in the ratings. Patterns in the ratings and in cortical activation are also not isomorphic, given the different profile evidenced by subdesigns (indicating averaging for the ratings and adding for the ERD). Nevertheless, averaging is an adequate rule to harmonize opposite trends (means are always higher than smaller contributing values and lower than higher contributing values), and could thus well be supported by a trans-hemispheric pattern of collaborative competition (or adversarial collaboration) between the two hemispheres. The major implication for the implicit *r* in this case is that it should be conceived less as a circumscribe neural correlate than as a distributed representation across a bi-hemispheric system.

Discussion

The results presented above concerning cortical activation are partial in two major ways. On the one hand, they do not include the data for temporal and parietal leads, which provided important indications both regarding the dynamics of lateralization and intra-hemispheric organization. On the other hand, they were only presented here for one of the three different-emotion pairs. Nevertheless, despite differences in detail and supplementary conclusions, the missing outcomes do not question the three main provisional conclusions that can be put forward: (1) Additive-type patterns for the combination of emotional information conveyed by faces are prevailing in both ratings and local cortical activation (α-ERD); (2) Evidence of ongoing collaboration, even if sometimes adversarial, between the two hemispheres, is prevailing, and provides the frame for functional lateralization; (3) the implicit r in the [$r \rightarrow$ R] mapping posited by IIT may well sometimes, if not often, correspond to a distributed brain dynamics rather than to a specific neural correlate.

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