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Asymmetries in face and brain related to emotion

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Research on the neural substrates of emotion has found evidence for cortical asymmetries for aspects of emotion. A recent article by Nicholls *et al.* has used a new imaging method to interrogate facial movement in 3D to assess possible asymmetrical action during expressions of happiness and sadness. Greater left-sided movement, particularly during expressions of sadness was observed. These findings have implications for understanding hemispheric differences in emotion and lend support to the notion that aspects of emotion processing might be differentially localized in the two hemispheres.

The study of facial expressions of emotion has a long and venerable history. Modern research on this topic was catalyzed by the publication of Darwin's *Expression of Emotion in Man and Animals* [1]. A celebration of 130 years of research on expression and emotion since Darwin was just recently published [2]. One of the abiding themes in research on facial expression since Darwin has been the observation of asymmetries in facial movement that accompany facial expression of emotion. Much attention over the past twenty years has been devoted to understanding the measurement, origins and significance of these asymmetries. The recent report by Nicholls and coworkers [3] is part of this ongoing effort and offers some promising methodological innovations. It also raises several important conceptual and methodological questions. In this brief commentary, we will first situate the Nicholls *et al.* report within the larger context of research on cerebral lateralization and emotion. We will then consider what Nicholls *et al.* did and what they found and will end with a brief discussion of why lateralization for affective processes might have evolved and what future research is suggested by these findings.

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Affective processes are asymmetrically represented in the brain

Using a variety of methods to make inferences about regionally specific patterns of activation, many investigators have now reported systematic asymmetries in patterns of activation in specific brain regions in response to certain types of positive and negative affective challenges (for reviews, see [4,5]). Despite the complexities associated with aggregating studies with vastly different experimental designs, a recent meta-analytic review has also supported the notion that certain forms of positive and negative emotion exhibit different patterns of functional brain asymmetry, particularly in prefrontal cortical territories [5]. Complementing this work, Heller and colleagues have proposed that asymmetries in parietal cortex may be associated with arousal such that greater right-sided posterior activation is associated with higher arousal emotion [6]. Our own work has also highlighted the importance of considering individual differences and has consistently found that subjects exhibit stable differences in asymmetric patterns of activation in prefrontal brain regions that predict various features of affective reactivity [7].

This asymmetrical organization of affect in the two hemispheres of the brain forms the conceptual backdrop to investigations of how emotion acts asymmetrically on the two sides of the face. However, the control of the facial musculature is complex, with different patterns of neural innervation present for the upper versus lower face (e.g. [8]). Most of the extant literature broadly suggests that the lower face is predominantly under contralateral control compared with the upper face (e.g. [8,9]; but see [10]). We would therefore expect to find evidence of asymmetrical facial expression more in the lower face compared with the upper face, although this distinction was not examined by Nicholls and co-workers. Based upon research that has measured regional brain activation during emotion, one would be led to make the following predictions, particularly for the lower facial region: (i) overall, emotional expressions should be more left-sided compared with non-emotional expressions since arousal would be assumed to be more elevated during the former compared with the latter states; and (ii) that negative emotions should exhibit the greatest left-sidedness in light of the role of right prefrontal regions in negative affect. Of course, these hypotheses are predicated on the view that both prefrontal and parietal activation asymmetries will modulate activation in premotor regions that innervate the facial nucleus. The extent to which this is true remains to be empirically verified.

The Nicholls *et al.* study

There are several notable features of the recent report by Nicholls *et al.* (compare with [11,12]) that represent a potentially significant advance over other efforts in the past (for reviews, see [13,14]).

First, they used a sensitive 3D imaging technique to capture facial behavior. This method measures movement that is perpendicular to the facial surface and could detect movement in this plane to an accuracy of 0.16mm, relative to a neutral face baseline. Second, they had observers rate facial expressions that were digitally rotated 35° to the right (so that the left side of the face is featured) or 35° to the left (so that the right side of the face is featured) to examine the differential impact of exposure to the left versus right side of the face on emotion judgments. Third, to disentangle the impact of physiognomic asymmetries from perceptual biases to left and right hemispace, they had observers rate both original and mirror-reversed facial expressions.

Sixteen models posed neutral expressions and also the most intense displays possible of happiness and sadness. Consistent with literature suggesting that there are asymmetric representations of certain components of emotion in particular cortical regions (e.g. [4,5]), Nicholls *et al.* found that their objective 3D measurement procedure detected greater movement on the left than on the right side of the face, which was more pronounced for sad compared with happy expressions (see Figure 1). Interestingly, greater left-sided movement for facial expressions has even been reported in non-humans (e.g. chimpanzees; [15,16]).

When observers viewed these faces in left- versus right-rotated orientations, they rated right-rotated faces happier and left-rotated faces sadder, an effect that was attenuated for mirror-reversed expressions. These data complement recent findings by Jansari, Tranel and Adolphs [17] concerning the free-field viewing of negative and positive expressions and suggest that head orientation, or the lateralized placement of features, is sufficient to alter one's perception of an expression's emotional intensity. Furthermore, the impact of mirror-reversal on the interaction of head orientation and expression adds to a growing literature that suggests the left and right sides of the face convey somewhat different affective signals (e.g. [10,18]).

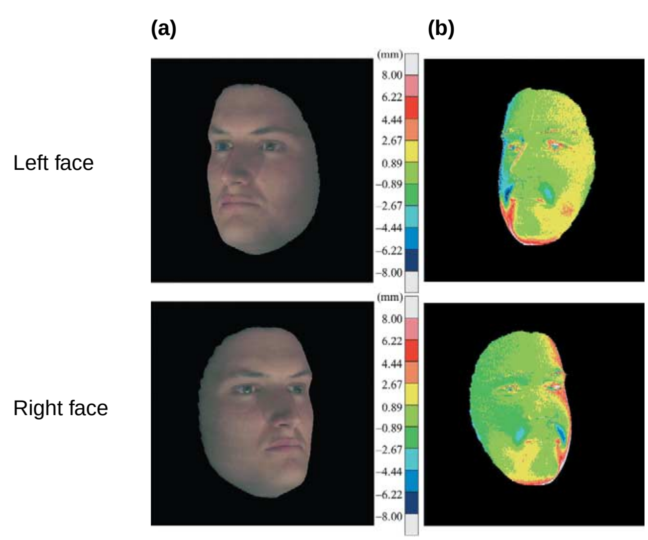

Figure 1. (a) Examples of the images used by Nicholls *et al.* to determine the perceptual effects of asymmetries in the expression of emotion. The upper image is rotated 35° to the right so that the left side of the face is featured, and vice versa for the lower image. The image depicts a model expressing sadness. **(b)** Maps showing the amount of inward and outward movement perpendicular to the surface of the face (measured in mm, relative to the baseline condition of no emotion). Sadness results in more movement of the left face. Reproduced with permission from [3].

However, before concluding that Nicholls and colleagues' data lend strong support to the notion of hemispheric differences for positive versus negative affect, several limitations of this study are important to consider. First, the facial stimuli were posed by actors and it is likely that the sad faces were more difficult to produce than the happy faces. Second, the stimuli were not matched in intensity or systematically coded (cf. [19]). Rather posers were simply instructed to 'show the most intense expression they could'. In light of these two facts, it is possible that at least some of the differences between the happy and sad conditions are produced by variations in difficulty level of the production and/or in intensity of the production. Nevertheless, the findings are innovative and provocative and at the very least, underline the fact that facial expressions are not objectively symmetric and that the left and right sides of the face convey somewhat different emotional information to naïve viewers.

Why should affect be asymmetrically organized?

Much has been written on the possible adaptive significance of an asymmetrically organized brain (see [20,21] for recent reviews). In a series of articles, Davidson [7,22,23] has suggested, based upon a diverse corpus of literature, that a fundamental dimension along which certain prefrontal regions are specialized is the approach–withdrawal dimension. Approach-related positive affect, particularly those forms of positive affect that involve the implementation of appetitive goals, are preferentially represented in specific left-sided dorsolateral prefrontal territories, whereas withdrawal-related negative affect, particularly those forms of negative affect that involve heightened vigilance toward threat-related cues in the environment, are preferentially represented in specific right-sided lateral prefrontal territories. Segregating these functions in separate hemispheres could minimize competitive interaction between these systems and facilitate adaptive responding to biologically salient reward and punishment stimuli. To the extent that the generation of facial expressions recruits affect-related circuitry (and some recent evidence implies that this is the case (e.g. [24,25]), we might expect functional cortical asymmetries to be produced in prefrontal territories that could then result in the slight but influential facial asymmetries detected by both the objective methods and the observer ratings in the Nicholls *et al.* report. The findings from the Nicholls *et al.* report clearly underline the pervasive influence of cerebral asymmetries in emotion processing. It will be important in future research to monitor brain function directly, both in the individuals posing the emotional expressions as well as in the subjects asked to judge these expressions. In this way, we can begin to examine more directly the brain bases of these fascinating facial asymmetries.

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