

## Functional specialization does not require a one-to-one mapping between brain regions and emotions

(commentary to Kristen A. Lindquist, Tor D. Wager, Hedy Kober, Eliza Bliss-Moreau, and Lisa Feldman Barrett (in press), “The brain basis of emotion: A meta-analytic review,” *Behavioral and Brain Sciences*)

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**Abstract:** Lindquist et al. have assumed that functional specialization requires on a one-to-one mapping between brain regions and discrete emotions. This assumption is in tension with the fact that regions can have multiple functions in the context of different, possibly distributed, networks. Once we open the door to other forms of functional specialization, neuroimaging data no longer favor constructionist models over natural kind models.

According to *natural kind models*, discrete emotions “exist in the brain or body and cause changes in sensory, perceptual, motor, and physiological outputs” (Barrett 2005, p. 257).

According to *psychological constructionist models*, discrete emotions lack neural and bodily signatures, and “do not have ontological status as causal entities” (Barrett 2006, p. 46). Lindquist et al.’s specific proposal is that emotions emerge when a more basic state of core affect – a blend of hedonic and arousal values – is conceptualized as an instance of a discrete emotion category such as fear or anger.

The two models make different predictions concerning the relation between brain and emotions. Natural kind models posit functionally specialized brain systems responsible for the production of the outputs of distinct discrete emotions. Constructionist models do not posit such functionally specialized brain systems, assuming that emotions

emerge from brain systems dedicated to more basic psychological processes (e.g., core affect, categorization).

Lindquist et al. take neuroimaging data to favor constructionist models over natural kind models. This is because they consider the latter to be committed to what I call *radical locationism*, the hypothesis that discrete emotions consistently and specifically correspond to distinct brain regions. A brain region corresponds to an emotion *consistently* just in case it shows increased activation for every instance of that emotion, and *specifically* just in case it shows increased activation only for instances of that emotion. This amounts to positing a *one-to-one mapping* between single brain regions and discrete emotion categories.

Lindquist et al. have argued that there is no one-to-one mapping between single brain regions and discrete emotions such as fear, disgust, anger, and others. For example, the amygdala does not show increased activation in all and only cases of fear, the anterior insula does not show increased activation in all and only cases of disgust, the orbitofrontal cortex does not show increased activation in all and only cases of anger, the pregenual anterior cingulate cortex and subgenual anterior cingulate cortex do not show increased activation in all and only cases of sadness. At the same time, brain regions can be functionally *selective* for certain discrete emotions: they can occur *preferentially* – rather than *exclusively* – when a particular discrete emotion occurs.

I agree that *radical locationism* is false, and that regions consistently activated by discrete emotions are, at best, functionally selective for them. But I do not consider this to be a fatal strike against natural kind models, and a reason to become a constructivist.

Natural kind models can endorse hypotheses about functional specialization other than radical locationism which are compatible with the neuroimaging data.

My central suggestion is that we should focus on networks rather than on single brain regions. This is because brain regions do not have functions in isolation, but rather in the context of the networks to which they belong (cf., Pessoa 2008). Furthermore, we should not expect functionally specialized networks to be neatly localizable anatomically. Functional specialization can be *multilocal* (Mundale 2002) rather than *radically localized*: the brain regions whose joint activation plays a given function can, in principle, be distributed across the brain.

Lindquist et al. are open to the possibility that there may be “widely distributed” networks for discrete emotions, but argue that their existence “would be consistent with a psychological constructionist ... view” (p. 49). I strongly disagree. Constructivism posits that discrete emotions are not causal entities in their own right, but rather effects of more basic psychological processes. The existence of networks for discrete emotions would strike at the heart of this idea, vindicating instead the natural kind proposal that discrete emotions have ontological status as causal entities and are driven by distinctive, although distributed, neural mechanisms.

Once we shift to a networks approach, a one-to-one mapping between single brain regions and discrete emotions is no longer the litmus test for functional specialization. Understood broadly, functional specialization has to do with the existence of physically discrete regions in the brain – possibly distributed – that play at a time a function that is not played by other physically discrete regions. The point is that a functionally specialized brain region X can play more than one function, depending on which other

regions it is co-activated with, without this calling into question that X fulfills a specific function in the context of a given network at a given time.

Even brain regions commonly considered to be paradigms of functional specialization can fulfill multiple functions depending on the networks with which they are affiliated. For example, Broca's area has long been considered functionally specialized for language, but it is also involved in other functions, such as movement preparation and action sequencing (cf., Anderson 2007). As Lindquist et al. point out, even the primary visual cortex contains "neurons that participate in different neural assemblies associated with different functions" (p. 47). Yet, we still consider it functionally specialized for vision.

This leads me to question the principle that "[s]upport for a psychological constructionist view... would be found if the same brain region(s) were involved in realizing instances of several emotion categories – and, furthermore, if the brain region(s) are more generally important to realizing a basic psychological operation" (p. 14). If a brain region can have a function in a network at a particular time without being exclusively dedicated to that function at all times, it is hard to see why some region X could not be *functionally specialized* for, for example, disgust – good candidates for this role would be regions consistently and selectively activated by disgust – despite the fact that X is not *functionally specific* to disgust. The fact that a brain region may be involved in networks associated with other discrete emotions and with more basic psychological processes is compatible with the fact that *at a specific time* it is functionally specialized in producing disgust (or another discrete emotion).

These remarks seem to suggest that proponents of natural kind models should hypothesize a *one-to-many* mapping between single brain regions and fear, anger, disgust, and other emotions. Things are, in my view, more complicated, because our current ontology of discrete emotions is most likely inappropriate for the study of functional specialization. I have argued elsewhere that *folk emotion categories* are too heterogeneous for scientific purposes, and should be split into more homogenous subcategories that capture theoretically distinct types of emotion, types of fear, types of anger, and types of other emotions (Scarantino, in press).

This is to say that the mapping between single brain regions and fear, anger, disgust, and other emotions may ultimately turn out to be *many-to-many*. Not only the (possibly distributed) networks functionally specialized for a given discrete emotion could include brain regions that play other functions in other emotional and non-emotional networks (the one-to-many aspect), but also there could be multiple brain networks functionally specialized for anger, for fear, for disgust, and for other emotions (the many-to-one aspect). This would call into question the opportunity of using folk emotion categories for the study of discrete emotions.

Whether these speculations will prove to be correct remains to be empirically determined. What we can say at this stage is that neuroimaging data have yet to tip the balance for either constructivist or natural kind models, and that both approaches continue to be worth pursuing in our efforts to understand the brain basis of emotions.

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## REFERENCES

- Anderson, M. L. (2007) The massive redeployment hypothesis and the functional topography of the brain. *Philosophical Psychology* 20(2):143–74. [AS]
- Barrett, L. F. (2005) Feeling is perceiving: Core affect and conceptualization in the experience of emotion. In: *Emotions: Conscious and unconscious*, ed. L. F. Barrett, P. M. Niedenthal & P. Winkielman, pp. 255–84. Guilford. [AS]
- Barrett, L. F. (2006) Are emotions natural kinds? *Perspectives on Psychological Science* 1:28. [AS]
- Mundale, J. (2002) Concepts of localization: Balkanization in the brain. *Brain and Mind* 3:313–30. [AS]
- Pessoa, L. (2008) On the relationship between emotion and cognition. *Nature Reviews Neuroscience* 9(2):148–58. [AS]
- Scarantino, A. (in press) How to define emotions scientifically. *Emotion Review*.