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## What's in a baby-cry? Locationist and constructionist frameworks in parental brain responses

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### Abstract

Parental brain responses to baby stimuli constitute a unique model to study brain-basis frameworks of emotion. Results for baby-cry and picture stimuli may fit with both locationist and psychological constructionist hypotheses. Furthermore, the utility of either model may depend on postpartum timing and relationship. Endocrine effects may also be critical for accurate models to assess mental health risk and treatment.

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To differ with Lindquist et al., perhaps both locationist and constructionist frameworks for the brain basis of parental emotion have utility, depending on stimulus parameters, timing, and relationship. For example, consider the baby-cry, a single primal signal that for an infant, not capable of complex interactive social signaling, must serve to attract the attention of new parents at the risk of adverse parental responses or drawing predators (Soltis 2004; Swain et al. 2004). Thus far, there is evidence that the parental brain basis of baby-cry-elicited emotions may fit with locationism; involving a simple set of circuits, including the amygdala and insula. Several groups have been studying the brain basis of maternal response to baby-cry and related behaviors within a relatively locationist framework (Swain et al. 2007). Initially, the thalamocingulate circuit for emotion response and regulation in mammals was supported (Lorberbaum et al. 2002; MacLean 1990), but several other brain regions, including parts of the amygdala, insula, and striatum/nucleus accumbens (NA) have also been shown to respond to baby-cry (Swain et al. 2011). Responses in the medial frontal cortex and striatum also predict parental mood and anxiety (Swain et al. 2008).

However, as the infant develops nuanced social signals in the context of a growing attachment, psychological constructionist frameworks to understand parental brain responses to baby stimuli, in accordance with Lindquist et al., may be more appropriate, in which emotions can be elicited that are intimately tied to prior experiences and conceptualization. For example, early life events may influence current brain activity in cortical regions, that have not been the subject of rodent literature. Some such connections have recently been discussed with respect to maternal sensitivity. (For thorough reviews, see Barrett & Fleming 2011; Swain 2011). In support of such early-life effects on complex brain functions, a recent study has shown that maternal brain structure and functional responses to the mother's own baby's crying in the early postpartum period varied according to mothers' perceived maternal care quality in their own childhood in accord with a constructionist framework (Kim et al. 2010b). In this study, mothers who reported having received greater maternal care in childhood showed higher gray matter density, in a range of higher cortical and

executive function areas, including the insula, superior and middle frontal gyri, orbital gyrus, superior temporal gyrus, and fusiform gyrus.

Strikingly, some of these morphological and functional changes in the maternal brain are also associated with the concurrent conceptualization of positive maternal thoughts toward their babies (Kim et al. 2010a). In this first prospective longitudinal study, gray matter volume increased over the first few months postpartum (from 2–4 weeks to 3–4 months) in the insula, pre-frontal cortex, parietal lobes, and midbrain areas. Further work is required to elaborate the constructionist framework of relation between concurrent positive thoughts about one's baby and increased gray matter volume in multiple core affect regions of the hypothalamus, substantia nigra, and amygdala, or to support locationist approaches for certain experimental paradigms (Kim et al. 2010a).

In evaluating locationist versus constructionist frameworks of the brain basis of emotion, a meta-analysis of brain imaging studies may be informed by the critical contributions of certain hormones just beginning to be included in such studies. For example, we contend that multiple hormonal systems related to parental motivation, including oxytocin, must be considered in frameworks of the brain basis of emotion. The neurohormone oxytocin, for example, is one of the major factors that accounts for variations in regulating parental emotions during parent–infant interactions (Feldman et al. 2010). Another aspect of a new mother's emotion regulation is her recent mode of delivery, such that vaginal versus cesarean deliveries are associated with higher oxytocin (Marchini et al. 1988). Consistent with this, mothers who have had vaginal deliveries show greater brain responses to baby-cries in the insula, striatum, and anterior cingulate cortex (Swain et al. 2008) than do mothers who have had cesarean deliveries. Furthermore, regardless of delivery type, mothers known to show higher oxytocin during breastfeeding (Nissen et al. 1996), also have higher brain responses to their own baby's crying than do formula-feeding mothers, in the insula, striatum, amygdala, and superior frontal gyrus (Kim et al. 2011). Although requiring replication, these experiments support a constructionist framework that includes hormone levels – in addition to maternal brain responses in the cingulate, striatum, and hypothalamus when shown baby pictures, some of which responses vary with individual differences in oxytocin and concurrent attachment (Strathearn et al. 2009).

Indeed, the key dimension of hormone responses in developing a comprehensive framework for understanding the brain basis of emotions is underlined by a causal relationship between oxytocin and women's brain responses, in two recent studies. First, in a randomized control trial (Riem et al. 2011), experimentally elevated oxytocin versus placebo resulted in increased responses to the cries of unrelated babies, in the inferior frontal gyrus and insula, and decreased responses in the right amygdala. This study shows that oxytocin may modulate maternal behaviors, that is, enhance positive motivation by sensitizing care-related insula activity and reduce negative motivation by desensitizing anxiety-related amygdala responses. Second, in a study by Naber et al. (2010), administration of oxytocin increased sensitive parental emotions and behaviors, assessed by videotaped play session. In fact, infant pictures by themselves have been shown to exert similar modulation of maternal brains (Bartels & Zeki 2004; Strathearn et al. 2008).

The use of baby-cry to stimulate emotions in parents may present some challenges to the psychological constructionist framework, and require locationism for certain paradigms. Perhaps then also, locationism may still be useful in understanding the effects of interventions – such as for complex multi-system and time-delayed effects. Indeed, some recent studies interpret brain imaging data on basic face responses (Canli et al. 2005) or intervention effects in emotion response circuits according to a locationist model, whether using structural or functional approaches (Chua et al. 2011; Peterson & Weissman 2011). Ultimately, more research, probably including endocrine parameters, is needed to clarify the utility of locationist versus constructionist frameworks according to different paradigms.

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