Hedonia: TrygFonden Research Group

The importance of the parent-infant relationship

by Morten L. Kringelbach and Alan Stein

Hedonia: TrygFonden Research Group is based both at CFIN and University of Oxford, UK. We are interested in understanding the functional neuroanatomy of pleasure (Figure 1), and in particular the brain mechanisms underlying the lack of pleasure, anhedonia, which is found in a range of disorders including depression, eating disorders and obesity. Our research is being carried out using a combination of neuroimaging methods in normal, neuropsychiatric and other clinical populations. The hope is that this research may help to improve the quality of life of affected patients.

In last year’s report we described the progress in the part of our research linked to restoring normal function using deep brain stimulation. Deep brain stimulation is an exciting approach which has shown remarkable promise in alleviating the symptoms of these debilitating disorders and bettering the lives of the sufferers. This research is carried out in collaboration with Professor Tipu Aziz who has recently become an adjunct professor at Aarhus University. In the coming years we plan to extend the deep brain stimulation service to include Danish patients. At the same time we continue to write and lecture on the importance of the ethical considerations, and especially how we should be careful not to regress to the errors of psychosurgery (Kringelbach and Aziz, 2009).

This year we are focusing on describing a complementary part of our research which is related to understanding the development of pleasure, and in particular the functional neuroanatomy of the early interactions between parents and infants. This research is carried out in collaboration with Professor Alan Stein who has helped pioneer this field of research. Such research is not just for select patients but has the potential to better the lives of future generations. At the same time we have a moral obligation to expand this research beyond our European context and also try to help children in places such as Africa. Our collaborators have shown that some of the new insights can make a big difference in developing countries and we are committed to continuing this research by collecting further neuroscientific evidence (Cooper et al., 2009).

![Figure 1](image)

**Figure 1**

Adult brain systems from sensation to basic pleasures and higher-order social processing.

The schematic figure shows the approximate sensorimotor, pleasure and social brain regions in the adult brain. (a) The processing linked to the identification of and interaction with stimuli are carried out in the sensorimotor regions of the brain, (b) which are separate from the valence processing in the pleasure regions of the brain. (c) In addition to this pleasure processing, there is further higher-order processing of social situations (such as theory-of-mind) in widespread cortical regions. (d) The hedonic mammalian brain circuitry can be revealed using behavioural and subjective measures of pleasures in rodents and humans (Berridge and Kringelbach, 2008).
Early parent-infant interactions

Early relationships between infants and parents are of fundamental importance for the survival and development of one’s own infant, and ultimately ensure the survival of the species. Humanity is a very social species that invests heavily in nurturing and protecting the young. Accumulating evidence indicates that early life experiences have a major impact upon adult mental and physical health.

These important early parent-infant interactions are central to understanding human nature and have over the years been the subject of a large body of behavioural research. However, it has only recently become possible to link aspects of these interactions to brain activity in both infants and parents using advanced neuroimaging techniques. Affective and social neuroscience have begun to emerge as exciting disciplines characterising the brain networks involved in the processing of reward, pleasure, emotion and related behaviours. While a substantial amount of evidence has served to elucidate the intricacies of the social and affective brain in adults, less is known about its development in the early years.

Our focus is on understanding the development of the functional neuroanatomy of the evolving parent-infant relationship (Parsons et al., 2010). We try to extend our knowledge of what is known about the construction of the infant brain and the emerging abilities used to process uni- and multimodal sensory stimuli. Over time, these fundamental abilities allow infants to engage in complex social relationship with parents, caregivers and others. In the first instance we are interested in investigating how the complementary parental responses change over the course of infant development, and the neural basis of such responses.

The first 18 months form, in many respects, a developmental landmark which signifies the end of infancy (see Figure 2). While the first few years are particularly important because vital development occurs across all domains, major elements of the social and affective brain continue to develop well past early childhood. The fundamental research has important clinical applications because disturbances to normal early interactions, particularly in the context of parental psychological disorder, increase the risk of difficulties in child development. A better understanding of the development of the functional neuroanatomy of the early parent-infant relationship could thus have direct implications for enhancing affective development and experience.

Tools for understanding social attachment

We are using a number of scientific paradigms to study the nature of the social pleasures. We are using MEG to investigate how the adult brain reacts to baby faces and sounds. In the following we present some our recent findings using baby and adult faces.

The scientific interest in the cuteness of infant faces started with Charles Darwin who pointed out that in order for infants to survive and to perpetuate the human species, adults need to respond and care for their young (Darwin, 1872). The Nobel Prize-winner Konrad Lorenz proposed that it is the specific structure of the infant face that serves to elicit these parental responses (Lorenz, 1971), but the biological basis for this has remained elusive.
A parental signature? Early adult brain responses to infant faces.

Significant activity was present from around 130 ms in the right fusiform face area which did not discriminate between adult and infant faces, while the medial orbitofrontal cortex showed significant activity around the same time when viewing infant faces but not when viewing adult faces. The rows show time-frequency representations of the normalised evoked average group responses to baby and adult faces from the virtual electrodes, showing that the initial response to infant faces in the orbitofrontal cortex is present in the 12-20 Hz band from around 130 ms - and not present to adult faces (Kringelbach et al., 2008).

Lorenz argued that infantile features serve as “innate releasing mechanisms” for affection and nurturing in adult humans and that most of these features are evident in the face including a relatively large head, predominance of the brain capsule, large and low lying eyes and bulging cheek region (Lorenz, 1971). Thus it is argued that these “babyish” features of infants increase the infant’s chance of survival by evoking parental responses, and the parents’ ability to respond is important for the survival of the species (Darwin, 1872).

While a considerable body of research has focussed on how the human brain processes adult faces, much less research has investigated the processing of infant faces. We used MEG to investigate the temporal and spatial distribution of the brain activity in response to infant faces.

Using MEG in adults, we recently found that highly specific brain activity occurred within a seventh of a second in response to (unfamiliar) infant faces but not to adult faces. This activity occurred in the medial OFC, an area implicated in reward-related behaviour (Kringelbach, 2005), identifying for the first time a neural basis for this vital evolutionary process (see Figure 3) (Kringelbach et al., 2008).

Figure 3
A parental signature? Early adult brain responses to infant faces.

More information is needed about the longitudinal structural changes in the infant brain. (a) An example is shown of using diffusion tensor imaging to track the development of the main fibre pathways (Dubois et al., 2006). Similarly more information is needed about the fine-grained temporal information of infant functional brain activity. (b) An example is shown from an ERP study of the infant’s phonetic processing (Dehaene-Lambertz et al., 2006).
underlying neural systems for these facial responses in 12 adult human participants. Consistent with previous findings, we found that face processing of both adult and infant faces elicits a wave of activity starting in the striate cortices and spreading along ventral and dorsal pathways.

In addition, however, we found that at around 130 ms after presentation of the infant faces, activity occurred in the medial OFC. This was not evident in response to the adult faces. These specific responses to unfamiliar infant faces occur so fast that they are almost certainly quicker than anything under conscious control suggesting that they are automated.

Further investigations

We are currently extending these findings to further characterize these responses in parents with post-natal anxiety and depression. We are also further investigating the roots of neoteny by studying the brain responses in normal participants to infant and adult animal faces. We are also investigating how babies with cleft palate affect normal brain responses, given that we know that these facial abnormalities can negatively affect the long-term outcome of the babies (Murray et al., 2008). In future, we are planning to extend this further to look at the infant brain responses (see Figure 4).

Overall, we continue to study important aspects of the fundamental parent-infant relationship which may ultimately help generate much improved interventions. This in turn may help the well-being of future generations.

Selected references


