



Review

Mirrors and feelings: Have you seen the actors outside?

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ABSTRACT

Primary-process experiences, both raw affects and perceptions, are self-creating processes, and the associated motoric-action tendencies serve survival values, providing the raw materials for learning. Actions seem to play a key role in providing 'meaning' for the primary sensations and associated feelings. We suggest, that one important type of action are those that can promote on-going maintenance of sensory invariance, especially when other actions would remove animals from their affective comfort zones. The epigenetic determinants of such developmentally emerging states of 'feeling', especially when the alternatives are experienced as aversive or threatening, arise from these sensory invariant principles. In accordance with this view, a number of recent studies also suggest that experiences require reproducible neuronal response patterns to sensory stimuli to gain 'meaning' or conscious awareness of sensory states. We demonstrate some of these aspects by a standard precocial avian model of social attachment. The behaviour of isolated chicks in a polarized maze effectively reveals motoric patterns that serve the establishment of perceptual invariance. Chicks actively and spontaneously seek for and explore ways to maintain invariance of internal affective-perceptual states. In the following work, we summarize behaviour patterns that display the ongoing dynamics of internal states as newborn chicks seek proximity to other friendly beings in the world, in this case, the 'actor outside' that is used to access this process is their own mirror image.

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1. Introduction

Though once highly controversial, it is now becoming generally accepted that progress in neuroscience cannot avoid challenging questions such as how the brain is capable of generating subjective experience. The relation of consciousness and its associated bodily phenomenology to brain processes cannot easily be avoided if we wish to understand how the brain works. The problem with the study of subjective experience is however, that there is always more to it than meets the eye of an (external) observer. In the context of

an evolutionary based 'continuum hypothesis of subjective experience' (Panksepp, 1998a,b; Bekoff and Sherman, 2004) two sets of questions have become critical: (i) Are there common criteria for mechanisms that qualify for a decisive role in subjective experience? And (ii) if that is the case, can these criteria become accessible from a third persons perspective? Or, put in other words, are there observables that qualify as unique signatures for subjective experience? This has been achieved with primary-process emotions, since evocation of instinctual emotional patterns with brain stimulation generates various types of rewards and punishments (Panksepp, 1998a, 2005a).

This paper will treat these questions from the view of a behavioural analysis that is based on a well-established neurochemical and neurophysiological background. The background is

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provided by measures of social attachment in general and a long sequence of studies employing the precocial juvenile avian model in particular (Panksepp, 1982; Panksepp et al., 1988; Bernroider et al., 1996a). This model offers two facets of motoric expressions that together may help to elucidate the intimate connection between the motoric expressions behind adaptive action tendencies (e.g. such as seeking behaviour) on one hand and the motoric patterns associated with an 'internal state' on the other (e.g. isolation induced calling following social deprivation). However, in order to relate these double-aspect behaviours to the challenging questions of experience an additional perspective is required: a specific role of context and action. We suggest a contextual property that is designed in a way so that action can generate and maintain a specific sensory input that signals the interoceptive state of the subject.

The contention of this paper is, that certain observable behaviour patterns, which inform about sensory invariant action guidance, can inform about the internal states of a perceiving agent. This proposal gains considerable support by a sequence of studies on the nature of neural correlates of consciousness (NCC). These studies strongly suggest that it needs reproducible (Schwarzkopf and Rees, 2010) and sustained (Libet, 2004; Edelman, 2003) neuronal response patterns to sensory stimuli to gain 'meaning' or 'conscious awareness' of sensory states. Here we will argue that sensory-invariant motoric expressions can precisely host these properties emerging from NCC studies and reflect signatures behind affective-regulatory 'attending'.

Although the relation of attention, subliminal processing and the role of vigilance to conscious perceptions are complex (Dehaene et al., 2006), there is strong evidence that attended perceptions generally qualify as conscious perceptions (e.g. Prinz, 2007). If these conscious perceptions pertain to the bodily phenomenology they qualify as 'feelings'. We will outline this conjecture in four steps. First we will review and discuss some landmarks that set the frame for a continuum hypothesis of self-referencing. We will then define and analyse the structure and Bayesian background behind sensory invariant driven action and discuss the operant and rewarding role of mirrors. By combining two sets of behavioural observables within place preference studies, one informing about action tendencies associated with adaptive sampling of the environment ('comfort – seeking behaviour') and the other one informing about the emotional state of the subject (social isolation induced distress calling), we will have identified a behavioural context that can inform about the experiential state of a subject. Finally our conclusion will be that a specifically designed behavioural context that implements measures for differences between stimulus expectation and stimulus observation, is in line with recent NCC studies and can give us an indication about 'the inner states' of an experiencing agent.

2. Experience and self-reference

We experience the world by observing our own body changes responding to the environment. According to the neural doctrines as formulated about forty years ago by Horace Barlow (1972), this experience builds on the spatio-temporal variation of membrane potential oscillations provided by nerve cells. Ever since, a long chain of scientific efforts to uncover the coding principles underlying these activity patterns has strongly enhanced our understanding about the structure that encodes the physical information behind these observations (for example see Bialek et al., 1991; Laughlin and Sejnowski, 2003).

We now know that our perception of the world around us and the perception of our own body conditions come from real-time

observations of our own neuronal activity pattern. A view that has already been anticipated by the founders of physiology in the 19th century, for example by Müller (1838). We can look back on an enormous development of ever more sophisticated techniques of anatomical and functional localization studies and their behavioural correlations (for a remarkable historical journey, see Gross, 1998). What has emerged are some of the salient questions that have previously resided within the realm of philosophy, the questions about the 'meaning' behind the physical part of information that the brain seems to cultivate so well: The phenomenon of how it feels to have experience (Chalmers, 2003), the enduring puzzle of 'the self' (Gallagher and Shear, 1998/1999), the 'feelings' (Prinz, 2005) behind emotions (Panksepp, 1998a; Damasio, 1994; LeDoux, 1996; Ekman, 1999; reviewed by Dalgleish, 2004), the embodiment of self-experience in general (Panksepp, 2005a,b; Northoff and Panksepp, 2008).

However, the questions behind subjective experience naturally must embrace 'dual aspect' notions of brain and mind functions that are educible from their dualistic philosophical background and proved difficult to integrate into standard science. We can however discern the following points that have emerged from studies about the neural correlates of experience: From the view of an observing agent, the environment accommodates the organism. Adaptive re-sampling of the environment by the organism leads to those action tendencies that host the role of evolutionary principles and go back the Charles Darwin's founding work on emotions in man and animals (Darwin, 1872/1965). These actions are reflected by an appropriate organization of highly conserved brain structures and (LeDoux, 2000) networks that have been at the centre of 'Affective Neuroscience' and have been analysed in great detail by one of the authors (e.g. Panksepp, 1982, 1991, 1998a, 2005a). But there is more to experience, related to various sensory-perceptual inputs, that is only accessible to the experiencing subject. There are the 'inner states' that perceptually mark or label these actions, the states of experience of an organism that co-notate the somatic expressions of this organism as it adaptively re-samples the environment via the exteroceptive sensory portals and Jamesian states of interoceptions (James, 1884). However, what makes these 'inner states' somehow accessible, at least in an inferential way, is that *the states of experience explicate as graded degrees of self-reference*, ranging from the more primitive phenotypic matching strategies in the sense of Hauber and Sherman (2001), reviewed by Bekoff and Sherman (2004) to the highest, rather abstract levels of self-consciousness, as seen from a cognitivist view (e.g. Strawson, 1997). This conception puts the 'self' precisely and consequently into the type of continuum that was at the centre of Charles Darwin's work: Differences between organism are '... of degree and not of kind ...' (Darwin, 1872/1965).

The continuum hypothesis of self-reference abandons dichotomic classifications of the self ('to have or not to have') and relaxes the long standing dispute between higher order thought (HOT) interpretations of the self on one hand and the more biologically grounded 'affective expressions' of the self on the other (Panksepp, 1998b). On both ends of the scale of self-referencing, we may find those situations that only poorly qualify as perceptual demonstratives of self-experience. At the lowest level of phenotypic matching it is more an apprehension of contact that bears the 'seeds of experience' (Simons, 2006), the type of 'causal efficiency' that Whitehead has suggested to ground the most primitive forms of perception (Riffert, 2003; Falkner et al., 2006). On the other end of the scale, the purely anthropocentric and cognition based interpretation of the self abstracts away from its contents, and following the arguments of Gallagher and Marcel (1999), ... 'these abstractions are losing the connection to normal experience'. What remains is the vast range of experience based on perception and interoception, a range that has previously

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