10 RESPONSES TO PRODUCT FEATURES: AN AFFECTIVE NEUROSCIENCE PERSPECTIVE

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Design aesthetics concerns the study of the way the features of a product are perceived by an observer. This paper shows that the moment of perception can be advantageously described with the help of results from affective neuroscience. It also shows, among other things, that the affective state of an individual is always prior to a later, slower, conscious cognition, and that it influences judgment during purchase and use. This can also be observed in great detail through the measurement techniques used in affective neuroscience. A comparison with current models of affect in design research is also presented. Finally, results from affective neuroscience allow the designer to play with emotions, knowing which stimuli will have an impact on the individual and when.

Keywords: Affective neuroscience, Theories of affect.

1. INTRODUCTION

The part of design that addresses aesthetics is "the study of the way in which a product's design affects the observer's perception".[1] This is an important topic, because it has a strong impact both on the time people need to decide whether to purchase an artefact or not and during the product experience. There are several techniques to study the impact of the form of an object to the user (interviews, observations, etc.) and they are based on several theories: gestalt theory, Kansei, even semiotics, though the later is often associated with ergonomics and human factors engineering (studying the signs that the product carry that will prevent the user from making oversights or mistakes); see Ref. 2 for a thorough review. In the area of design aesthetics, it is also important to understand in depth the user's reaction to the product gestalt. In this paper we will focus on the affective response to the perception of an object as modelled in affective neuroscience. It has been convincingly proved that affect comes prior to reason or cognition and thus has a large impact on product perception. A better understanding of human responses to product features will facilitate the development of guidelines for design aesthetics. In the first sections, the theory behind affect (emotion and pleasure) is presented. Next, the models from affective neuroscience will be discussed in relation to existing models described in the design research literature. Finally, the fact that affective neuroscience introduces novel methods so as to measure the customer's or user's reactions towards a product will be discussed in Section 3.2.

2. THE NEURAL MECHANISMS OF AFFECT

2.1. Preliminaries

2.1.1. An Evolutionary Approach

Affective neuroscience is the branch of neuroscience interested in the study of the neural circuitry of emotion and pleasure, i.e. the pathways of information from a stimulus to an affective response. The

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terms 'affect' and 'emotion' have been found to be interchangeable in the literature. The dominant convention, however, seems to be the use of 'affect', as it can encompass both emotion and pleasure. The very idea of studying neural pathways gives a nuance to the definition of 'affect': it is the result of a reaction to a stimulus. This implies that affects are part of, and subordinated to, behavioural mechanisms. Affective neuroscience takes an evolutionary stand: every mechanism has naturally been developed for specific purposes. The brain is thus globally divided into specialized functional areas (a rough simplification). Consequently, it is generally assumed that: 1) different affects are produced by different brain regions (even if there are redundancies and overlaps), and 2) affects have been developed naturally for particular purposes: reacting to danger, searching for a partner, etc. This notion had already been suggested by Darwin:[3] When facing a snake through a window, he could not help but jump "a yard or two backwards with astonishing rapidity" (p. 38; see also Ref. 4 p. 112) when the snake attacked. The defence system,[4] or fear systemm,[5] had taken over.

2.1.2. Different Models of Affect

One affective system often referred to is Panksepp's,[5] consisting of SEEKING, FEAR, RAGE, PANIC, LUST, CARE and PLAY (Table 1). There is no real consensus about these systems (see LeDoux Ref. 4 pp. 104-137 for a more complete review). LeDoux[4] regards PANIC as merely a disorder of the FEAR system, and hunger and thirst are also considered as affects, as they are not "neutral" neural states. SEEKING could be considered a part of other systems, e.g. lust and hunger. The debate about what an affect is at the semantic level is as open in neuroscience as in other fields, balancing between a broad definition (all is affect except for neutral states) and a narrower one, based on what an affect has been considered to be historically.

The next section will describe the mechanisms behind the arousal of an emotion on a general level. Furthermore, the pleasure system is described in more detail, as it is generally the place triggered at the moment of a purchase. Although the systems are described in a simplified manner, it is sufficient to provide an account of the mechanisms behind affective states.

2.2. Arousal of an Emotion

This section has mainly been compiled from the following sources: LeDoux[4,7] and McGovern.[6]

2.2.1. First Reaction

The emotional pathway is best illustrated with an example, in this case the sight of an artefact. Visual signals go from the eyes via the optic nerve to the thalamus, where the signal is pre-processed in order to become readable by the cortex (gray matter). The thalamus sends the signals to the visual cortex for further processing (refined analysis of the static and dynamic aspects of the scene), as well as to emotional centres, for example the amygdala, a small brain area central to the detection of frightening

Table 1. Basic affective systems.

Basic emotional system	Description	Associated emotions
SEEKING	Appetitive system, promotes goal-directed behaviour	Interest, curiosity
FEAR	Responds to pain and threat of destruction	Fear, anxiety
RAGE	Aroused by frustration, bodily irritation, or restraint of free movement	Anger, contempt
PANIC	Responds to separation of young animals from their caregiver	Sadness, shyness, guilt/shame
LUST	Coordinates social behaviour and feelings	Erotic feeling, jealousy
CARE	Promotes social bonding and caregiving behaviour	Love
PLAY	Promotes learning. Occurs spontaneously in mammalian young.	Joy, happiness

Source: from Panksepp[5] and McGovern.[6]

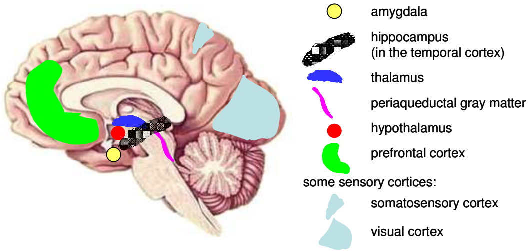

Figure 1. Brain regions involved in fear. Source: adapted from Refs. 4,6,7

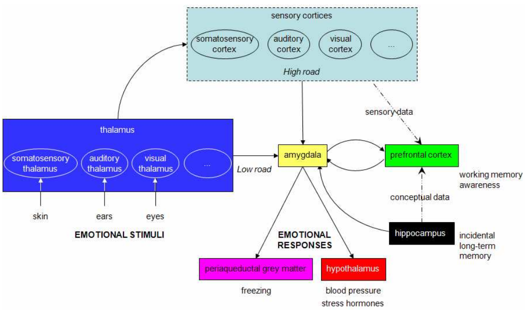

Figure 2. The fear pathway. Source: adapted from Resf. 4 pp. 83,160,164, 170.

stimuli. The emotional centres are directly linked to brain regions responsible for different responses, e.g. the hypothalamus for controlling blood pressure and beginning the production of stress hormones (adrenaline, among others), etc. This implies that the emotional centres take priority over cognition in controlling physiological and motor reactions.

2.2.2. Generating a Feeling

All that has been described so far regarding emotion happens unconsciously, i.e. the information has not yet reached the parts of the brain that are concerned with awareness and attention. This is the next phase. The information processed by the visual cortex is matched with the conceptual memory (in the hippocampus and related association cortices) of what the object represents in the prefrontal cortex or PFC (the location of working memory). The emotional centres also send signals to the PFC and the subject becomes aware (conscious) of the object and of what he or she feels while perceiving the object. This is the definition of a *feeling*. The person can now plan an action and modulate his or her instinctive response (having jumped “a yard or two backwards”, for example).

The artefact and its features are now coupled with all the associated past memories. But what is important to understand is that the emotional centres have their own memory centres, which are less developed than the hippocampus but are made use of first. The brain is made to respond to affect prior to reason. The memory centres have great plasticity: they are influenced by each new experience and experience of the product slightly changes with exposure to new phenomena.

In order to provide an example, the main brain regions involved in fear processing are represented in Figure 5 and the fear pathway in Figure 6 (the fear system is the emotional system for which neurobiological studies have accumulated most evidence).

2.2.3. Mood

Mood (sometimes called ‘affective state’) also alters the perception of an object. It is a long-lasting state of mind and thus differs from emotion, which is a sudden, time-limited occurrence. While reading the neuroscience literature, it is important to bear in mind that “long-lasting” often means weeks or months and is used to describe affective disorders such as depression. In research related to marketing, however, the term is used to cover an affective state of mind that spans from a few hours to an entire day (see e.g. Ref. 8).

2.3. The pleasure system

Although pleasure is considered to be an affective state (see Panksepp's[5] SEEKING, Table 1), there are good reasons to differentiate it from other systems. Emotion and pleasure have been differentiated intuitively and historically; moreover, pleasure or pain is almost always involved during emotion Ref. 9, p. 82 while the different emotions themselves can occur quite independently of each other. This section is mainly based on McGovern.[6]

Pleasure is quite difficult to interpret in terms of neural networks. First of all, the term 'pleasure' is a subjective notion to which 'reward' or 'hedonic sensation' is preferred. Ref. 10, p. 1109 Secondly, a distinction is made between pleasure as the satisfaction of obtaining an object (reward/punishment), which is triggered by a *desire*, and the sensation of pleasure in "consuming" the object (hedonic sensation or liking/disliking, including pain). The first case would primarily correspond to the moment of purchase and the second to the user's experience.

The hedonic sensation is thought to be mediated mainly by the nucleus accumbens (NAcc). The NAcc is linked to the PFC, which, just as in the case of emotions, is the place where the sensation is made conscious. While the NAcc is assessing the hedonic aspect of what is "consumed", the system responsible for the desire is activated and "learns" that the object gives pleasure and remembers its different features.

The desire system (usually called 'appetitive system'), activated when cues eliciting a reward are present (e.g. the poster of a known brand logotype in a store advertising a new pair of shoes that will make friends jealous or substantiate one's status in the group), is known as the medial forebrain bundle, or MFB. Once a cue is detected, the MFB system assesses the cost/benefit of performing an action on the basis of what was learnt by earlier experiences of pleasure. It also reaches the PFC, so that the person becomes aware of a potential reward; he or she experiences desire and can modulate the MFB excitement state by means of a more reasoned judgment. Once the action (the purchase, for example) has been performed, the person feels satisfied.

Primitive needs like hunger and thirst are innate, while other more subtle needs are learnt. Incidentally, these secondary needs are better learnt if coupled to the primary needs: that is why sports cars are often represented with sensual women, as this is quickly linked to the need for reproduction. Ref. 11, p. 241 Figure 3 presents the main brain regions involved in the pleasure system.

3. IMPLICATIONS FOR RESEARCH AND PRACTICE IN DESIGN

3.1. Implications for Design Aesthetics

Affective neuroscience sheds new light upon some of the models used in design aesthetics and emotional design.

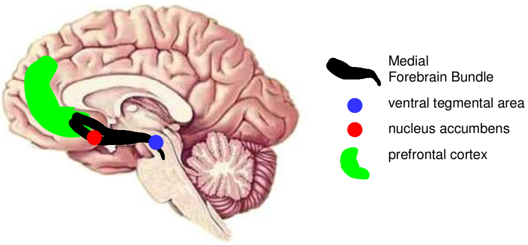

Figure 3. The main brain regions associated with pleasure.

First, it suggests an elaboration on Norman's three-level cognitive processing model[12]—the *visceral* (affective) level, the *behavioural* level (habits, automatisms) and the *reflective* level (consciousness). In this model, there is no interplay between the visceral and reflective levels; the results from affective neuroscience imply that there is a need for including this interplay and reflecting on it.

Desmet and Hekkert[13] also propose a three-level product experience. The aesthetic level is very similar to the pleasure system. Both Norman[12] and Desmet and Hekkert[13] mainly speak of emotion as a conscious experience, which in neuroscience corresponds to feeling. The emotional level is based on the appraisal theory derived from cognitive psychology and assumes that emotion is the result of cognition. This is contradictory to the results presented above (for a criticism of the appraisal theory from the neuroscience stance, see Ref. 4, pp. 42–72): The appraisal can be non-cognitive. This is still, however, a bone of contention in psychology beyond the scope of this paper. Nevertheless, results from neuroscience confirm that pleasure and emotions are irredeemably linked to the product experience.

Jordan[14] focuses on the notion of '*pleasure*'. Product pleasure is "the emotional, hedonic and practical benefits associated with products". Based on Tiger,[15] Jordan has developed a four-pleasure framework: physio-, socio-, psycho- and ideo-pleasures. Obviously the term 'pleasure' here includes more than does neurophysiologic pleasure. However, the goal of Jordan[14] is to set up a typology of the *causes* of a positive affect. This also shows one of the limitations of neuroscience for design. As shown in Section 0, pleasure is reduced to a like-dislike model and does not have the power of analysis and interpretation of the existing models.

The main contribution of affective neuroscience is to provide a new framework and to emphasize the role of emotions and pleasure over cognition. The affective neuroscience perspective can also serve as a basis for discussing other models (for an extended review of the latter, see Hiort Ref. 2). Results from neuroscience can be combined with those other models, as in Lenart and Pasztor.[16] However, this short review also shows that most of the knowledge about how a product is perceived by a subject is already largely available (although in a less articulated way) in cognitive psychology, sociology and philosophy, which is where the above models are derived from. Affective neuroscience gives a view of the perception of an object at the millisecond level. At the same time, it reveals the limitations of such a detailed description.

First, an emotion appears in a matter of milliseconds (less than 100 ms) and can disappear just as fast. A person can experience many different emotions in a short period of time, and it can be difficult to understand what they relate to. Second, apart from a limited number of unconditioned stimuli that are genetically encoded and present in every human being, the remainder have been learnt and are highly dependent on the culture and the group(s) the person is embedded in and on the person's history. Moreover, emotion and pleasure are coupled to past memories; they are essential to tagging a specific stimulus and making it part of our "self-narratives",[17] but they do not provide any information about them. Finally, in the case of purchase, for example, the cognitive mind rapidly takes over and considers other factors, e.g. price or what the product represents in terms of value: when it comes to clothing or furniture, trends and group pressure are as important as affect.[18]

3.2. Implications for Experimental Research in Emotional Design

Beyond providing solid grounds for the development of research in design aesthetics, affective neuroscience also offers novel methods to measure perception by measuring changes in the brain*directly*, which also concerns the three domains presented in the introduction, namely purchase, use and design for emotions. The most spectacular technology is functional magnetic resonance imaging (fMRI), which provides high quality brain images of affect. It involves scanning the brain and measuring the blood oxygenation (an active region requires more oxygen). McClure *et al.*[19] and Erk *et al.*[20] are the two seminal works that explored user perception of the artefact by fMRI . McClure et al. showed that favourite brands are present in the pleasure centres, obliterating other sensations: a person whose favourite brand is Coca-Cola® might prefer the taste of Pepsi® in a blind test, that is, experience more pleasure, but the same person actually *experiences* more pleasure drinking his favourite soda when the brand is shown. The same neural centres are activated. Nor are any social factors, e.g. group pressure,

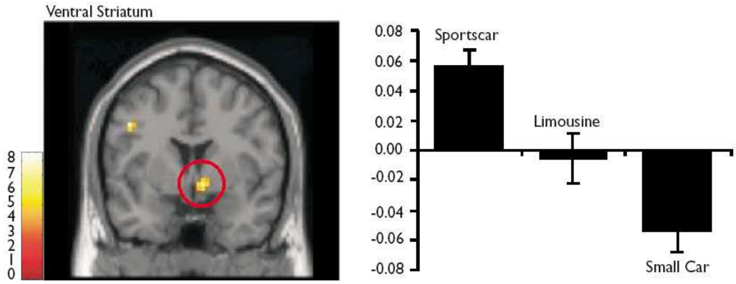

Figure 4. NAcc response to different types of cars. Source: Erk *et al*. Ref. 20

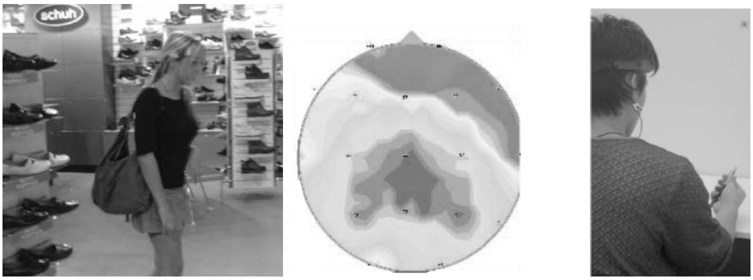

Figure 5. a. Subject carrying an ambulatory EEG. Source: Lewis and Bridger Ref. 21, p. 36. b. EEG brain map showing the emotional response to a happy face. Source: [22] c. 2-point EEG system. Source: Tomico *et al*. Ref. 23, p. 532.

involved. Erk *et al*.[20] showed that sports cars trigger more pleasure than other types of car (Figure 4). The fMRI results are highly accurate, but the equipment required limits its applications.

Electroencephalography (EEG) measures the electric impulses generated by brain activity. Although this method is less accurate, it utilizes much lighter gear and therefore allows in *situ* observations (Figures 5a and 5b). For example, Tomico et al. used EEG to measure the “Kansei” (pleasure or comfort) sensation of the participants’ dissimilar manipulation of different pens (Figure 5c).

Increasing excitement about these new methods has led to the term *neuromarketing*, first coined by Professor Ale Smidts in 2002,[21] which is a fast-growing industry in branding and marketing.[24] All these measurement methods require the knowledge of experts, and consequently such studies are very expensive (see e.g. Ref. 25). For a criticism of the use of these technologies in the emotional design field, see Singleton and Hilton.[26] Alternatives that involve indirectly measuring brain response to affective stimuli exist, e.g. measuring physiological responses to emotional stimuli (Figure 6), or the face expression analysis,[27] which is one of the starting points in Desmet’s[28] PrEmo tool.

3.3. Implications for design practice

First, for the field of design aesthetics, affective neuroscience shows the importance of considering affect in any type of design: the first perception of a product always occurs at the affective level. Consciousness always has the “gut feeling” that serves as input for the subsequent thinking process, and this greatly affects decision-making and product experience. Affective neuroscience also shows the importance of mood during purchase and experience, mood being a “long-lasting emotion”. Importantly, the reason-emotion dichotomy becomes obsolete; the first impression is triggered by past memories, themselves previously elaborated by integrating both rational and non-rational thinking and perceptions.

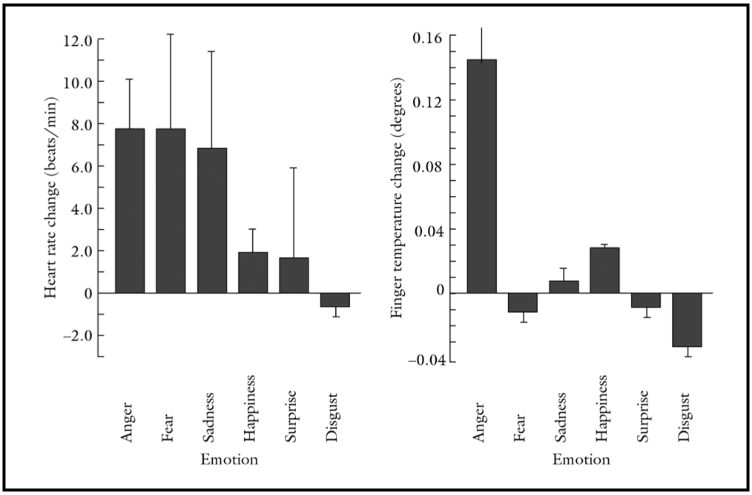

Figure 6. Examples of the unique physiological signatures of different emotions. Source. Ref. 29

The results from affective neuroscience also allow the designer to play with emotions, knowing which stimuli, conditioned or unconditioned, will have an impact on the individual. Such an implication has been explored in Lenart and Pasztor.[16]

4. CONCLUSION

Affective neuroscience permits the clarification of the way the design of a product affects the observer's perception, which is essential for design aesthetics. The main contribution of affective neuroscience to design research lies in a detailed description of these phenomena and an emphasis on emotion and pleasure over cognition. These results, incorporated in the current models utilized in design research, can help refine the description of the perception and experience of a product. At an epistemological level, it is, however, important to remember that the models in design research are not intended to be "true" to reality (realism), but to be useful (instrumentalism). Affective neuroscience presents quantitatively valid results by means of stringent experimental methods; it embodies emotion into neural networks and thus comes closest to the "world out there". Nevertheless, although they are somewhat remote from the conventions of neuroscience, affective theories in design, e.g. Jordan's[14] four-pleasure model, are powerful tools to bear in mind when designing.

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