DESIGN AND SENSE: IMPLICATIONS OF DAMASIO'S NEUROLOGICAL FINDINGS FOR DESIGN THEORY

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Abstract: The inclusion of human feelings and emotions presents a serious problem in the design research field. Traditional approaches, focusing on emotions, are problematic for design theory building and do not align with recent findings about human psycho-neuro-physiological functioning. This paper describes research aimed at improving the ways feelings and emotions are represented in theories about design cognition. The paper focuses on recent research findings of Antonio Damasio and colleagues and applies them to theory making about designing and the ways designed artefacts are perceived and used.

Keywords: Design

1. INTRODUCTION

A serious problem in the design research field involves the inclusion of human feelings, affects and emotions (see, for example, Love, 2002, 2001; Sloman, 2001). There is increasing interest in the role of emotion in designing (see, for example, refs). This paper takes the position that focusing solely on emotions is problematic for including human issues in design theory building.

The paper takes the position that emotion-based approaches are problematic because they unhelpfully conflate several important conceptual and functional issues about human internal functioning that are needed to build a satisfactory understanding of the human activities involved in designing. Also they do not take into account, or align with, recent findings about human psycho-neuro-cognitive functioning. A parallel in the world of machines, is that current approaches to understanding design cognition via emotions is like trying to understand how an engine works by focusing on the colour of the car and refusing to have anything to do with engineering theory.

The paper focuses on recent research analyses by Portuguese scientist Antonio Damasio and colleagues in the field of neuro-cognition and applies them to theory making about designing and the ways designed artefacts are perceived and used.

The paper draws on research in which key characteristics of Damasio's analyses and research findings as described in Damasio (1999; 1994) were mapped onto design theories about cognition. Three areas of design theory strongly impacted by human feelings and affect were identified, and Damasio's approach to the same issues was compared and contrasted with the existing design research literature. The findings of this comparative analysis suggested the need for a fundamental review of key areas of design theory, in particular a radical overhaul of the central theory areas of design cognition, user interaction and design collaboration.

The paper has five parts. The second section briefly reviews some background issues. The third part outlines some key concepts from Damasio's analyses focusing particularly on those issues that obviously connect with building more comprehensive design theories. Part four draws out the implications of Damasio's work for design theory and design research. The final section summarises the paper and points to future directions in design research in relation to design, sense and sense making.

2. BACKGROUND

All design theories presume theories about human cognitive processes because designing is an essentially human activity, and the purposes of actualized designed outcomes are tied to human utilization and values. Human feeling, emotional, automatic and non-rational processes have been mainly included in design theories by being subsumed within Cognitive Science models of design cognition (see, for example, Franklin, 1999; ISRE, 2001; Ortony, Clore, & Collins, 1988; Susac, 1998) or nebulously connected to theories about the way designers and users experience, e.g. objects and thoughts (e.g. *Design and Emotion Society*, 2003; Hummels, Djajadiningrat, & Overbeeke, 2001). In essence, these approaches have included human non-rational issues via loosely-conceived and relatively superficial conceptualisations of emotions – even compared to much earlier work by, e.g. Dewey (1895; Dewey, 1895). This paper explores how design theories might take into account the recent work of Damasio and colleagues that builds theories of feeling, affect, thinking and creativity directly on an understanding of the physiological processes involved. Damasio's focus on internal human functioning contrasts with the extensive literature in design research that explains designing in terms of psychological, behavioural, informatic and emotion theories. His analyses of the neurological data suggest that there is significant epistemological benefit from problematising the relationships between feeling, feelings, emotions, consciousness and human homeostatic physiological processes that are precedent to, and underpin, rational thinking.

Damasio's analyses are based on neurological research by himself and colleagues at the Dept of Neurology, University of Iowa. In most cases, theories and their confirmation come from observing pathology of human neurological and physiological systems mainly via brain lesions. He points out (p14) that this type of work has recently seen significant change of pace because new technical research method such as fMRI and PET techniques shorten time to gaining insights relating to brain lesions. Previously the time for correlation between behavioural and neurological data was significant because, in most cases, neurological data could only be gathered via autopsy at the time of a subject's death. Now fMRI techniques enable lesion-based research to progress with living subjects.

Damasio's analyses bring together philosophy, psychology and biology (as elements of the new field of cognitive neuroscience) particularly as they relate to the phenomena of mind, consciousness and behaviours. He draws attention to the importance of these links (P13) in terms of triangulating and validating analyses. He notes that humans are aware of the inter-correlatedness of the phenomena of mind, consciousness within mind, and behaviour through self-analysis, and because of human enthusiasm for analysing others. Physiologically, these phenomena are actualised by and therefore closely correlate with functions of living organisms, specifically, in humans with the functions of the brain. This triangulation is useful in terms of theory making and validation.

The rapid advances in these areas of neurology have lead to new professionals such as experimental neuro-anatomists, neuro-physiologists, neuro-pharmacologists and neuro-biologists, which supports and extends research in cognitive neuro-science into the realms of molecular events and the composition and action of specific genes. (P15).

In short, Damasio's analyses and theories about how people think and feel are grounded on substantial understanding of the physiological underpinnings of human functioning to the extent that it is possible to deduce e.g. that a particular theory about a human process could not apply because the physical substrate for that process does not exist.

3. DAMASIO'S THEORIES ABOUT FEELING, FEELINGS, SENSE OF SELF, EMOTIONS, CONSCIOUSNESS, HUMAN HOMEOSTATIC PROCESSES, AND IMAGOGENIC THINKING

The following is distilled mainly from Damasio's 1999 book (Damasio, 1999) as this contains and extends on the ideas of the 1994 text (Damasio, 1994) with the exception of the philosophical issues relating to mind-body duality, reason and Descartes – none of which is a focus of this paper. Page numbers in the text refer to Damasio (1999).

3.1 Separating 'emotion', 'feeling an emotion' and 'sense of oneself feeling an emotion'

Damasio insists (P8) on the importance on biological grounds of distinguishing between:

- An emotion
- The feeling of that emotion
- The sense of self feeling that emotion (i.e. knowing that as an individual it is 'me' that is feeling the emotion.)

Clinical research has shown that these are phenomena with physiologically distinct processes. These issues are conflated and blurred in current design theories

3.2 Emotions

In the above, Damasio uses a technical definition of *emotion.* Emotion consists of the myriad of small changes to an individual's physiology (e.g. blood pressure, muscle tone, facial appearance) that can be triggered and executed without an individual being aware of it. There is nothing particularly unusual or human about emotion – many animals exhibit emotion responses, particularly to changes in their environment – e.g. a cat stands hair on end, arches back and spits when threatened (p 35). Some key characteristics of emotions (P51):

- A pattern of complicated collections of chemical and neural responses
- All emotions have some kind of regulatory role whose role is to assist the organism in maintaining life
- Biologically determined processes depending on innately set brain devices and laid down by long evolutionary history, although expression can be modified by cultural and learning factors
- Located in a very restricted set of sub-cortical brain structures that regulate and represent body states
- Emotion brain devices can be engaged automatically
- Emotions use the body as a theatre (using internal milieu, visceral, vestibular and musculo-skeletal systems) and have effects on numerous brain circuits. The collection of these changes becomes the basis for the neural patterns that in turn become the *feelings* of an emotion

Following convention, Damasio divides emotion into different types: the p*rimary (universal) emotions* consisting of happiness, sadness, fear, anger, surprise, and disgust; *background emotions* such as well-being, malaise, calm, and tension; and s*econdary (social) emotions* such as embarrassment, jealousy, guilt, and pride

3.3 Feelings

The *feeling of an emotion* refers to the generation of a *neurological image* (image refers to a representative neurological pattern) representing within, the human organism that state of emotion. This distinguishes the physicality of the emotion, as a set of bodily changes, and the separate internal representation of that emotion – the feeling. We are not necessarily conscious of either of these phenomena.

3.4 Sense of self feeling and emotion

The conscious feeling of an emotion requires an additional step: the sense of oneself as an individual (the sense of *me*) that has that feeling and that emotion. It is perhaps, one of Damasio's most important insights that the 'feeling of self' is essential to affective processes. This feeling of self, consciousness, and the role both play in feelings and emotions is significantly neglected in the literature on affect and affective cognition. Damasio draws attention to the importance of understanding the complex interdependencies between the mechanisms of consciousness and those of feeling and emotions to understand any of their roles in human functioning.

The above sets the first conceptual distinctions. These are in the realm of conceptual tools and distinctions. Of more interest in terms of building coherent theories about design cognition and the ways that users interact with designed artefacts is Damasio's description of why and how these processes come about.

3.5 Emotions, feelings and Relationship with life-regulating processes and reason

Damasio views human evolution ethologically regarding the human as a very sophisticated form of organism that has got to its present state by adding to previous biological systems and/or reusing them for alternative processes often whilst they are simultaneously used for their original functions. A simple organism has emotions (changes of physiological state) in response to changes in its environment. How an organism responds to their environment is very strongly determined by homeostatic processes that maintain the organism's physiological states within a narrow window of variability in which the organism is viable (P137). Emotions can be seen as higher-level components of homeostatic life regulation processes (regulating metabolism, simple reflexes, motivation, biology of pleasure and pain etc) that produce stereotypically suitable behaviours appropriate to survival (P54). The relative relationships are shown in Table 1. Consciousness occurs just above the boundary between feelings and high reason.

High reason	Complex customized plans of response are formulated in conscious reason and may be executed as behaviour
Feelings	Sensory patterns signaling pain, pleasure and emotions may become 'images'
Emotions	Complex stereotyped patterns of response (secondary, primary, and background emotions (
Basic life regulation	Simple stereotyped patterns of response including metabolic regulation, reflexes, the machinery for pain and pleasure, drives and motivations

Table 1: Damasio's Levels of Life Regulation (Damasio, 1999, p. 55)

Emotions result from either direct observation of an object or situation external to an individual, or from observation of an internally held representation of an object or situation via the thought process. Whilst the biological basis of emotions is preset, the means of inducing emotions is open to change from an organism's experiences of its environment in a learning process that is strongly skewed by the underlying primitive processes. Thus emotion responses become 'attached' to perceptions of particular objects and situations either observed directly or thought about.

3.6 Core and Extended Consciousness

Damasio differentiates between *core consciousness* as the basic *sense of the existence of oneself*, and *extended autobiographical consciousness*, the memory that it is a particular person with a particular history and memories that is existing and doing things. The differentiation is because there is at least one significant biological difference in the ways that these two forms of consciousness are actualized. Further, clinical research shows that brain compromised individuals can lose the facility of extended consciousness without losing core consciousness but not vice versa. They are based on physiologically different processes with the core consciousness using a short-term memory and in fact being renewed moment to moment. This contrasts with extended autobiographical consciousness, which uses long-term memory to give an internal image of an individual with a life history.

Extended consciousness is built on and depends on core consciousness and emotion. Lack of emotion always means lack of consciousness.

3.7 Core consciousness

Core consciousness is easier described in terms of what it is not (p. 122). It does not depend on working memory, remembering or recalling an image, learning, nor does it depend at all on language. In terms of building design theory, Damasio states very explicitly that core consciousness 'is not equal to manipulating an image intelligently in processes of planning, problem-solving or creativity.' It is a transient phenomenon rebuilt moment to moment. Emotion and core consciousness are interrelated. The entire range of emotional expression (secondary, primary and background) is not functional in individuals who have faulty core consciousness. (This contrasts with those with impaired extended consciousness but with unimpaired core consciousness. In this case, only secondary (social) emotions are missing which is what might be expected as the autobiographical self that underpins these social emoting is absent.

Core consciousness also has other roles (p125) it 'focuses and enhances attention and working memory'; 'favours establishment of memories'; 'is indispensable for the normal operations of language', and 'enlarges the scope of the intelligent manipulations we call planning, problem-solving and creativity'.

3.8 Proto-self and homeostatic mechanisms

Damasio proposes core consciousness depends on an inner sense based on images of a feeling. This he suggests is an image of the human internal milieu - the internal state of the organism: This *proto-self* he suggests (p. 154) is ' a coherent collection of neural patterns which map, moment by moment, the state of the physical structure of the organism in its many dimensions' – over many interconnected brain levels and locations intimately connected with regulating the body's state.

An important issue is that it is not possible to be conscious of the proto-self. It has no ability to perceive, contains no knowledge, and language is not part of its structure. It emerges continuously and dynamically from the complex states of the body as a

distributed 'reference' – an image of the body state like the feeling in section 3.3.

3.9 Perceptions of objects

The perception of an object (either external to the body or internal via thought image) results in ' a collection of minor adjustments [to the body] required to continue gathering signals about the object as well as emotional responses to several aspects of the object'. That is, observing an object, or thinking about it, results in changes to the proto-self.

3.10 Consciousness

Damasio suggests that consciousness is the process by which our organisms construct a (wordless) message about how our organism (represented by our proto-self) has been changed by perception of an object. He suggests core consciousness is a moment-by-moment narrative each short phase of which has beginning, middle and end. 'The beginning corresponds to the initial state of the organism. The middle is the arrival of the object. The end is made up of the reactions that result in the modified state of the organism'. Here the focusing and emphasizing aspect of the prototype has an important role. Damasio proposes the formal hypothesis that 'core consciousness occurs when the brains' representation devices generate an imaged nonverbal account of how the organisms own state is affected by the organism's processing of an object, and when this process enhances the image of the causative object, thus placing it saliently in a spatial and temporal context'.

In short:

1. Core consciousness depends on interaction between body and object
2. The body's states are mapped onto the brain as first order neural images (proto-self)
3. The images relating to the object cause changes to the images relating to the organism
4. These changes are re-represented in a second order map of the relationship between object and body. This is a map of the transitional multidimensional dynamic of change rather than a map of a stationary situation.
5. These second order maps become mental images in same way as first order maps
6. The body-related nature of organism maps (proto-self) and 2nd order maps means that the mental images are *feelings*.

3.11 The Autobiographical Self

Te moment by moment representation of core consciousness are *facts* and as such can be committed to memory, be classified and related to other memories of past and potential futures. These processes of converting core consciousness to the memories that give rise to a sense of autobiographical self and extended consciousness are strongly dependent on the focusing and emphasizing aspects of the proto-self mechanisms forming a bridge between the transient and relatively stable processes (p. 173).

The relationship between the moment-to-moment neural maps of core consciousness and the relatively stable memories that underpin autobiographical self and extended consciousness are reflexive but not symmetrical. Bringing to mind the stored items from long term or working memories results – obviously – in further core consciousness processes that in turn result in further focusing and emphasizing. Together these also point to explanations of a broad range of human processes such as learning, acculturation, habituation, conditioning, cognitive fixation and group dynamic effects.

3.12 Feeling feelings

To recap, emotions are the changes in body states, caused by interaction with objects (which include objects represented imagogenically. Feelings are the 1st order neural representations of these states. It is only when feelings are associated consciously with a sense of self that feelings are *felt* and perceived. The sequence is (p283):

1. Engagement with an inducer of emotion, e.g. sight of an object, thought about an object. It is not necessary that this is conscious.
2. Signals from perception processes trigger emotional-induction neural sites associated with that type of object
3. These in turn trigger brain and body sites that result in the whole physiological response that is the emotion
4. First order neural maps (proto-self) are made of changes to body states. Feelings emerge.
5. Neural patterns from emotion-induction sites mapped onto second order neural maps along with changes in proto-self that result from emotions. This results in an account of the events.

4. IMPLICATIONS OF DAMASIO'S THEORIES FOR DESIGN THEORY AND DESIGN RESEARCH

Damasio's work confirms the importance of recent trends towards emphasizing the human aspects of design such as emotions, feelings, identity, sense of self, and values (see, for example, *Design and Emotion Society*, 2003; Davis, 2001; Massachusetts Institute of Technology -Affective Computing Research Area, 1999; Sloman, 2001, 1999; Wilson, 1999). Damasio relates his processes, particularly when discussing the broader roles of the processes of extended consciousness and autobiographical self, to higher-level human activities such as planning and reflection (see, for example, p. 58). His theories apply directly to designing, which is essentially a planning process (Simon, 1981, p. 129) Damasio's model offers a rich conceptual and theoretical backdrop on which to locate models of designing and object use. It

offers many insights into understanding the internal processes of designing and the ways people interact with designed artefacts.

Applying Damasio's analyses indicates the activity of designing depends totally on the consciousness processes and feeling activities that connect the emotion responses from experiencing objects and situations to our homeostatic regulation; systems of reward and punishment, pain and pleasure, approach and withdrawal etc. Damasio shows how, together, consciousness, feeling, and reason enable us to go beyond the automatism of emotion responses to be able to undertake these higher order human activities of designing, planning, creating and undertaking reflection – in each case also with conscience, thus bringing in an ethical dimension (pp. 230-233)

The analyses of Damasio (1999) offer causal physical explanation of relationships between individuals' conscious and unconscious processes and their bodies' responses to real and cognitively held objects. These issues are central to design research, design theory and to developing heuristics to improve designing and design management. Whilst confirming the importance of the current trend in design research to place greater attention on human issues, Damasio's work goes beyond and contradicts existing literature in design fields on these issues. Traditionally, theory making about human aspects of designing has been grounded in philosophically based conceptual speculations about internal human processes relating to feelings and emotions without reference to the physicality of the actualisation of these processes. Empirically based causal physical explanations such as the analyses of Damasio's provide the basis for validating or refuting the earlier speculative correlation-based theories. The change in research approach means eventual replacement of correlation-based theories with theories that contain empirically identified causally based explanations. This is true also of Damasio's earlier (1994) work which challenges the mind-body duality and rationalist program of Descartes and others, and again proposes a causally-based explanation of the embodied functioning of reason in feeling human organisms.

Damasio offers causally based explanations of the functioning of three phenomena occurring in humans that are central to design practice, design theory making and design research:

- Non-rational activity (emotion, feeling consciousness etc)
- Rational activity (logic etc)
- Humans interactions with externally an internally perceived objects

The three most obvious areas affected by Damasio's work are design cognition, user interaction, and design collaboration. The implications for design collaboration processes come about because this collaboration requires communication between constituents and these communications themselves are objects as defined by Damasio, and processed by human organisms via the same mechanisms and physiological substrates as other objects. Taking the above issues together, this suggests Damasio's analyses offer a new and causally based foundation for several key areas of design theory-making across a wide range of sub-fields, such as:

- Design cognition
- Perception and interaction of users, customers, designers, and other constituents with designed objects, systems, services and organisations.
- User-centred design activities
- Useability testing
- Models of design process
- The establishment of design brief
- Design management
- Design collaboration and participation processes
- Comparative critique of designed outcomes

Damasio's work also offers the basis for significant advancement of practical, computer emulations of human functioning that replicate the human emotion, feeling and consciousness processes in, for example, robotic devices. Reports of approaches indicate design research in this area mainly draws on emotion-based theories drawn form cognitive science (see, for example, *Design and Emotion Society,* 2003; *The Experience of Everyday Things,* 2002; Sloman, 2001).

Acceptance of Damasio's analyses into the design research fields would lead quickly to radical changes in theories and their foundations, and to new generations of research instruments and methods. For example, one of Damasio's research methods for identifying the essential observable metrics of core consciousness used an ongoing behavioural music-like 'score' comprising parallel 'performances' in the dimensions of verbal report, specific actions, specific emotions, focused attention, low-level attention, background emotion and wakefulness. Reworked, this approach suggests potential improvements to the protocol methods that have been recently fashionable in developing correlation-based models of design activity (see, for example, Cross, 2000; Galle & Kovács, 1996; Gero & Tang, 2001)

5. CONCLUSIONS

This paper has outlined some of the key points from Damasio's (1999; 1994) analyses about the roles and underlying mechanisms that connect emotion, feeling, consciousness and human activity. In doing this the main foci have been how these findings relate to planning processes such as designing, the ways people interact with designed outcomes, and

communication between those involved in design processes.

The above sketch of Damasio's model of the interrelated emotion, feeling, self-creating, consciousness processes of necessity provides an overview rather than a detailed exposition. In the original, Damasio's analyses, explanations and empiical investigations are unusually well validated by the standards of design research. In epistemological terms this presents a situation in which a new set of theories challenge the foundations of the existing theory base and are simultaneously better justified and offer causal rather than correlatory explanation.

The implication is that it is necessary to review in depth and breadth the foundations of design theory as they relate to, or are dependent on, theories of human functioning that involve emotion, feelings, reason, cognition, agency, perception, human interaction, interaction with objects, consciousness, identity, values and sense of self. This would appear to include almost all of theory relating to human design activity.

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