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Mapping the brain basis of feelings, emotions and much more: A special issue focused on ‘The Human Affectome’

Howard Casey Cromwell^{a,b,*}, Christos Papadelis^{c,d,e}^a Department of Psychology, Bowling Green State University, Bowling Green, OH, USA^b J.P. Scott Center for Neuroscience, Mind and Behavior, Bowling Green State University, Bowling Green, OH, USA^c Jane and John Justin Neurosciences Center, Cook Children's Health Care System, Fort Worth, TX, USA^d Department of Bioengineering, University of Texas at Arlington, TX, USA^e School of Medicine, Texas Christian University, TX, USA

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ABSTRACT

The Human Affectome Project was launched by the non-profit organization Neuroqualia (www.neuroqualia.org) in 2015 with the seemingly impossible goal: To map a psychological process and form possible definitions and working models for affective states and related emotions. Twelve reviews based on emotions, feelings and motivation were written dedicated to mapping the brain basis of affect. A capstone piece ‘The Human Affectome’ provides a foundation for the special issue by giving detailed up-to-date definitions for key terms including feeling, affect, emotion and mood. Critically, the piece offers an overall model synthesizing three main features of affect: valence, motivation, and arousal. Affect itself is explored as the main umbrella function capturing all feeling states and related processes. Overall, the project and the special issue has been a highly successful interdisciplinary effort producing a novel approach that can be used to understand, guide and revise contemporary research on the brain basis of feeling and how diverse feeling states interact with each other in typical and atypical fashions.

Mapping customarily requires parametric information across one or more physical dimensions with boundaries and benchmarks. Working on the genome sequence presented and still presents unique challenges in mapping. Genetic material as a concrete, physical substrate with ordered units is amenable to mapping. The human genome mapping project was immense and the findings produced lasting influences in diverse scientific fields ranging from biomedical to social sciences and spinoff mapping projects involving diverse species, the environmental effects and disease (e.g., Cancer Genome Anatomy Project; [Strausberg et al., 2000](#)). Mapping remains a popular and productive guiding framework to explore, define and understand complex scientific problems. The proteome, metabolome and neural connectome, each being mapped with large groups collaborating to deliver new insights into anatomy and function. Affect differs from these core biological processes in many ways, but could it be mapped? The Human Affectome Project was launched by the non-profit organization Neuroqualia (www.neuroqualia.org) in the fall of 2015 with the seemingly impossible goal to map a psychological process and form possible definitions and working

models for affective states and related emotions. The goal was obviously immensely important, but the road taken has been rather long and tortuous.

Dr. Leroy Lowe served as the driving force in the overall effort. He had related experience organizing 350 cancer researchers from 31 countries in two large interdisciplinary projects that aimed to solve significant challenging problems in cancer research. That effort was called the Halifax Project and it was a project that was based specific hallmarks of cancer ([Hanahan and Weinberg, 2000, 2011](#)), an emerging model of cancer biology that had already woven together many (previously disparate) areas of cancer research. His team was focused and cohesive, the diverse team merged their ideas and had a concrete goal to tackle and overcome. Looking at the field of affective neuroscience, Dr. Lowe believed the field would benefit from having a possible similar, overarching model of affective experience that could explain the relationships between the many areas of research being undertaken.

* Correspondence to: Department of Psychology J.P. Scott Center for Neuroscience, Mind and Behavior Psychology Building Bowling Green State University Bowling Green 43403 Ohio.

E-mail address: hcc@bgsu.edu (H.C. Cromwell).

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1. Building the team: foundations for the mapping affect

To initiate the project and obtain the necessary leaders, Dr. Lowe coined the term “The Human Affectome”, recruited senior researchers to an advisory board, built a project website and launched Neuroqualia. He then invited a wide range of researchers from many areas within the field of affective neuroscience to express their interest in the project, he recruited team leaders from those who were interested and then he helped them build a series of teams that could be tasked to review the many diverse areas of research within the field. A gathering of affective neuroscience researchers in Halifax, Nova Scotia, Canada in the summer of 2016 was meant to develop cohesion. In that workshop, the concept of the human affectome was discussed and attempts were made to define core principles. Consensus was difficult to achieve in the large, diverse group. Affective scientists and neuroscientists came with different backgrounds and perspectives. Dr. Lowe had recruited human affective scientists, animal model researchers, biomedical engineers, and clinical neuroscientists. His hope was that this diverse group could work together to produce comprehensive views on specific feel states. The initial two-day conference ran into obstacles and division between and within the teams. In the first talk of Day 1, alarms went off when individuals ran up against differing views surrounding the core concepts, how to define them and what research should be included. Dr. Lowe persisted despite these serious problems, and the large research team was convinced to persist in their efforts. A major advance came when a push for a more objective strategy was made toward delineating feeling states and producing a common thread across the different topics and teams.

2. A pathway toward consensus: using computational linguistics

One objective way to produce a common thread among the teams was to implement a big data approach to identify as many articulated feelings as possible. An exploration of the full range of feelings that we express in language might offer something of value to the teams as they tried to gain a holistic understanding of their respective areas of research. An objective approach required a computational linguistic procedure that identified over three-thousand feeling words that are used in the English language (Siddharthan et al., 2018). Although the task force made no attempt to develop a definitive list of human feelings, the individual teams did use these linguistic terms to help them better understand the full range of valenced experiences that we articulate in language. So, in some respects, although the field of affective neuroscience has grown substantially in the past few decades, this was really the first time that so many researchers in so many areas combined their efforts to grapple with the full scope of affective experience.

The computational linguistics effort involved an automated search of over 4.5 million English books containing close to half a trillion words (Siddharthan et al., 2018). The taskforce was then asked to review and categorize 11,386 word “senses” (a word sense is one of the meanings of a word), which resulted in a new affective dataset comprised of 3664 word senses (feelings). An initial list of 14 categories was created based on consultation with the literature. A group of 107 scientists received a subset of words each, and assigned each word sense to a category. When disagreement between at least two annotators emerged, the disagreement was resolved by merging or renaming categories. The process continued until each word sense is reliably assigned to a single category without overlap.

The categories that annotators could reliably categorize were as follows: (1) Physiological or Bodily states; (2) Self; (3) Social; (4) Actions and Prospects; (5) Attention; (6) Hedonics; (7) Attraction and Repulsion; (8) Anger; and (9) General Wellbeing. Additional detail on the definitions for each of these categories—and the process of assignment, reliability assessment and arbitration—can be found in the archived preprint of this work (Siddharthan et al., 2018). Using the resulting definition for feelings and drawing on the literature that supported the

creation of this definition, initial categories of relevance were created and then those categories were refined using an analysis of linguistic data.

3. Review papers of the special issue: diverse views on key topics related to emotion and affective states

The subsequent reviews that were then produced by the taskforce teams were focused on sadness (Arias et al., 2020), positive emotions (Alexander et al., 2021), fear (Raber et al., 2019), anger (Alia-Klein et al., 2020), physiological feelings (Pace-Schott et al., 2019), actions (Williams et al., 2020), anticipatory feelings (Stefanova et al., 2020), the self (Frewen et al., 2020) social feelings (Eslinger et al., 2021), hedonics (Becker et al., 2019), motivation (Cromwell et al., 2020), and attention (Dolcos et al., 2020). Each team is comprised of a diverse group that includes basic and clinical work. In some cases, the teams include both human and animal model neuroscience research and, in most cases, they include work using a variety of techniques from behavioral observation to neuroimaging. The goal was to develop expertise and communication across a variety of neuroscience and affective points of view. The researchers comprised international groups with expertise in basic research using animal models, preclinical research and human affective neuroscience. The reviews describe and merge information from diverse methods including lesion work in animals (Cromwell, 2021), comparative neurophysiology, electroencephalography and all forms of modern neuroimaging. In addition, work across the lifespan is included, for example, the review on motivation (Cromwell et al., 2020) included a specific section on development of motivation and its intersection with emotional processing and regulation.

The series of reviews produced by the project aimed to cover each of the identified categories. For the purpose of reviewing, some broad categories were divided into two separate reviews, due to the sheer number of linguistic feeling terms they include, resulting in 12 reviews as follows:

Reviews	Linguistics categories
1) Physiological	1) Physiological
2) Self	2) Self
3) Social	3) Social
4) Actions	4) Actions/Prospects
5) Anticipatory	
6) Fear	
7) Attention	5) Attention
8) Hedonics	6) Hedonics
9) Motivation	7) Attraction/Repulsion
10) Anger	8) Anger
11) Happiness	9) General Wellbeing
12) Sadness	

Taskforce teams were tasked with providing a broadly scoped review that offered a succinct summary of the progress that had been made in the understanding of the neuroscience in their respective topic categories. These included areas of broad agreement and any major areas of contention within the field. The teams were also asked to review and discuss the nature of the feeling word senses allocated to their team, with the goal of offering commentary on whether these word senses informed our current understanding of the neuroscience in their area of research. Finally, teams were asked to describe any fundamental interactions or relationships that are known to exist between the topic area being studied and the other topic areas being reviewed in the overall effort. This last task was intended to help the taskforce develop a more holistic perspective on how these domains of research relate to one another, with a goal of developing a functional model of affect that could serve as a focal point for future research.

4. The capstone synthesis

Attempts to produce a synthesis of this work proved extremely challenging. Initially the teams submitted sections that explained how the area of the research in their respective reviews related to the reviews being produced by the other teams. Then the teams all submitted answers to common questions and several iterations of a synthesis were attempted. The challenge in bringing together many researchers working in different areas is that the resulting complexity can be challenging. But slowly, and surely, a model emerged that appears now encompass the field of affective experience as we currently understand it.

This synthesis piece is included in the special issue. A capstone entitled 'The Human Affectome' provides a foundation for the special issue by giving detailed up-to-date definitions for key terms including feeling, affect, emotion and mood (Schiller et al., 2022). The piece emphasizes three main features of affect: valence, motivation, and arousal. Affect itself is the main umbrella term capturing all the others. There are diverse varieties of affective states that range from emotion/feelings to sensory experiences and basic motivational states. This wide-ranging view gives new meaning to the term and provides a basis for which we could search for a common core mechanism of affect, one that involves these diverse processes inside or outside of the emotional realm. A theoretical framework for affect is presented revolving around allostatic concerns and with the key aim of value assignment. These concerns weigh both local and global levels of sensitivity to be inclusive and comprehensive—makes the computation of value optimal and adaptive. A useful model is proposed for how the concerns utilize information on valence, motivation and arousal in a variety of workspaces. Overall, the synthesis presents a lush, active forest and the reviews gives heightened levels of details for the trees. The special issue and all the work into developing the novel approach expand previous notions of affect and feeling into new directions. At the same time, the overall team, the reviews and the model of the capstone acknowledge and attempt to merge these new views and the synthesis into the well-grounded foundation of affective neuroscience views laid down by pioneers in the field (Damasio, 1999; Panksepp, 1998; Buck, 1984).

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