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Dispositions and Processes in the Emotion Ontology

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Abstract. Affective science conducts interdisciplinary research into the emotions and other affective phenomena. Currently, such research is hampered by the lack of common definitions of terms used to describe, categorise and report both individual emotional experiences and the results of scientific investigations of such experiences. High quality ontologies provide formal definitions for types of entities in reality and for the relationships between such entities, definitions which can be used to disambiguate and unify data across different disciplines. Heretofore, there has been little effort directed towards such formal representation for affective phenomena, in part because of widespread debates within the affective science community on matters of definition and categorization. We describe our efforts towards developing an Emotion Ontology (EMO) to serve the affective science community. We here focus on conformity to the BFO upper ontology and disambiguation of polysemous terminology. The full ontology is available for download from: https://emotion-ontology.googlecode.com/svn/trunk/ontology/EMO.owl under the Creative Commons CC BY 3.0 Attribution license.

Introduction

High quality ontologies in the biomedical sciences enhance the potential for integration of the exploding quantities of experimental and clinical data that have become available on-line. When appropriately designed, ontologies allow annotations of data to be unified through disambiguation of the terms employed in a way that allows complex statistical and other analyses to be performed which lead to the computational discovery of novel insights [11].

Affective science is the study of emotions and of affective phenomena such as moods, affects and bodily feelings. It combines the perspectives of many disciplines, such as neuroscience, psychology and philosophy [2]. Emotions have a deep and profound influence on all aspects of human functioning, and altered or dysfunctional emotional responses are implicated in both the etiology and the symptomology of many pathological conditions. Depression, for example, which is characterised by abnormally low affect and generally flattened emotional reactions, is one of the fastest-growing public health problems in many countries, corresponding to massive growth in sales of pharmaceuticals (and other substances) which target human affect [9].

Research in affective science faces the need to integrate results obtained on the basis of subjective reports and those obtained by neuroscientific or other methodologies, and to compare results across disciplines. It is therefore essential to have a shared, disambiguated and clear reference terminology for the domain [4, 13]. To address this requirement, we are developing an Emotion Ontology (EMO). Due to space constraints, we focus in this paper on addressing certain ambiguities in the language we use to talk about emotions and on providing definitions for one variety of affective phenomenon, namely occurrent emotions.

1 Background

1.1 Ambiguity in Emotion Language

Emotion terminology in English displays the following two-tiered structure [20]. First of all, there are a handful of fairly high-level terms: *affect*, *feeling*, *emotion*, *mood*, *passion*, *sentiment*.

Secondly, there are a large number of much more concrete terms for particular emotion types such as *anger*, *astonishment*, *awe*, *bliss*, *despair*, *disgust*, *embarrassment*, *fear*, *happiness*, *hate*, *joy*, *love*, *pride*, *regret*, *resentment*, *satisfaction*, *scorn*, *shame*, *sympathy* and *terror*. A similar structure is to be found in many other natural languages [3].

This emotion terminology may be used to describe phenomena of different sorts, as we can see by considering examples for the emotion *anger*.

A statement that John is angry with Mary, in the absence of any further contextual clues, can be interpreted to mean (Scenario 1) that John is experiencing a feeling of anger and displaying anger behaviour which has Mary as its object or target, that is: he is speaking in a raised voice to or about her, clenching his fists, breathing heavily and so on. The outward behaviour which expresses the anger may, to a certain extent, be suppressed, but internally, the anger is strong. In this scenario, the anger that John is experiencing and displaying is an occurrent entity (a process).

On the other hand, the statement that John is angry with Mary may be interpreted to mean (Scenario 2) that John is likely to react angrily, for example due to some past slight, given the right triggers, such as if Mary comes into the room, or her name is mentioned in conversation, causing his anger at Mary to flare up again, *even though* he was quite happy beforehand, while thoughts of Mary were far from his mind. Here, the anger that John has for Mary is dispositional. In such a case John is angry even when he feels no anger [10, 3]. Note that this is a different disposition from the one for John to become angry *in general*: this can be seen by considering that John would not normally become angry with someone just because they walk into the room. Rather, his anger when Mary does so is caused by a specialization of his general disposition to become angry, just as driving this car or that truck are specializations of driving in general [6]. This distinction is of relevance in research involving self-reports, since subjects may self-report being angry in the dispositional sense when the experimenters are attempting to analyse characteristic brain states related to anger processes. Another complication is that John may or may not be *aware* of his anger.

Finally, emotion language can be used to describe stable or enduring personality traits (Scenario 3), such as in the statement that John is an angry person. This distinction may again be important for annotation of neuroscientific research data, because researchers may well wish to differentiate persons who generally have low anger thresholds from those who have more calm temperaments.

We will use the following terminology for the above scenarios:

- Scenario 1: *Emotion occurrent*. An emotion occurrent is a processual emotion which in which a person participates over a specific time period. A person undergoes or is the subject of the emotion; he – we might say – *emotes*. This terminology leaves open what the person feels or is aware of.
- Scenario 2: *Emotion disposition*. An emotion disposition is a disposition to undergo emotion occurrents if the right circumstances obtain.
- Scenario 3: *Emotional personality trait* (*predisposition*): An emotional personality trait is a stable enduring characteristic of a person which involves a predisposition (i.e. a disposition which gives rise to an increased risk) to undergo emotions of a particular sort, both occurrents and dispositions.

Both the emotion disposition and the emotion personality trait are dispositions which are *realized* in emotion occurrents.

1.2 Basic Formal Ontology

EMO is being developed beneath the Basic Formal Ontology (BFO) [17, 5]. BFO distinguishes between *occurrents* and continuants. *Occurrents* are those entities that unfold over time and have temporal parts; continuants are those entities that endure through time and are wholly present at all times that they exist. For example, John is a continuant, but his angry behaviour is an occurrent.

The continuant branch is then further sub-divided between those entities which exist independently, such as John, and those which are ontologically dependent on some other entity for their existence, such as John's personality (which depends on John). Dependent entities may be *qualities*, such as colour, or they may be

realizable entities, such as dispositions, which are entities that inhere in other entities and which have the nature of propensities or potentials by virtue of which occurrents of certain sorts will be realised if the underlying bearer entity comes into the right *circumstances*. In BFO, dispositions are the most general class of such propensities, with subtypes for tendencies and "surefire" dispositions. An example of a disposition is John's disposition to become angry, for instance when Mary's name is mentioned.

1.3 Emotions as Componential Processes Caused by Appraisals

The question 'What is an emotion?' has been widely debated in both philosophy and science, with different accounts focusing on the centrality and essentiality of different aspects of emotional experiences [4, 8, 10, 13].

Appraisal theories are a modern variant of cognitive theories of emotion [14]. A central claim of cognitive theories is that representations are constitutive of emotions – that is, that emotions are identified by, and caused by, cognitive representations [8]. The main alternative to cognitive theories are feeling theories, which embrace a type of view which goes back to William James and which identifies episodic emotions with bodily feelings and sensations or with the awareness of these [10]. Although a great deal of ink has been spilt in discussions of theories on the continuum between cognitive and feeling theories, there is extensive agreement about the nature of many of the phenomena which figure in these theories – cognitive theories admit that emotions are often accompanied by subjective feelings, and feeling theories admit that emotions are often accompanied by cognitive representations – and disagreements revolve mainly around the underlying mechanisms and causal pathways [4]. It is this common ground which will serve as a starting point for the development of EMO, with future work elaborating the areas of disagreement. A representative definition of 'emotion' is [12, 13]:

> *An episode of interrelated, synchronized changes in the states of all or most of the five organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism.*

The 'episode of interrelated changes' here corresponds to what we have called an 'occurrent emotion' in the above discussion. Scherer goes on to distinguish five different components essential to emotion occurrents, related to the five organismic subsystems as listed in Table 1 and illustrated in Figure 1 [12, 13].

2 Foundational Entities in the Emotion Ontology

EMO describes and places emotion occurrents together with their five component parts. To align with BFO, we will draw on terminology already defined in the Ontology of Mental Disease (OMD) [1]. OMD starts out from the view that all mental disease rests on some physical disorder in the patient, such as a portion of the brain that is affected by some chemical imbalance or that has become damaged due to injury, and then aims to describe what it is for something to be a mental disease. Relevant entities from OMD which will be used in EMO are illustrated in Figure 2.

We can now begin to place the emotion entities beneath this framework via subtyping. We will divide the entities between those that are processual, those that are representations, and those that are dispositions.

Emotion component	Function	Organismic subsystem	Major substrata
Appraisal	Evaluation of objects and events	Information processing	CNS
Neurophysiological component	Bodily symptoms, system regulation	Support	CNS, ANS, NES
Action tendencies	Preparation for action	Executive	CNS
Motor expression behaviour	Communication of reaction and intention	Action	SNS
Subjective feeling	Monitoring of internal state	Monitor	CNS

Table 1. Component parts of emotion occurrents.
CNS – Central Nervous System. ANS – Autonomic Nervous System. SES – Somatic Nervous System. NES – Neuro-Endocrine System.

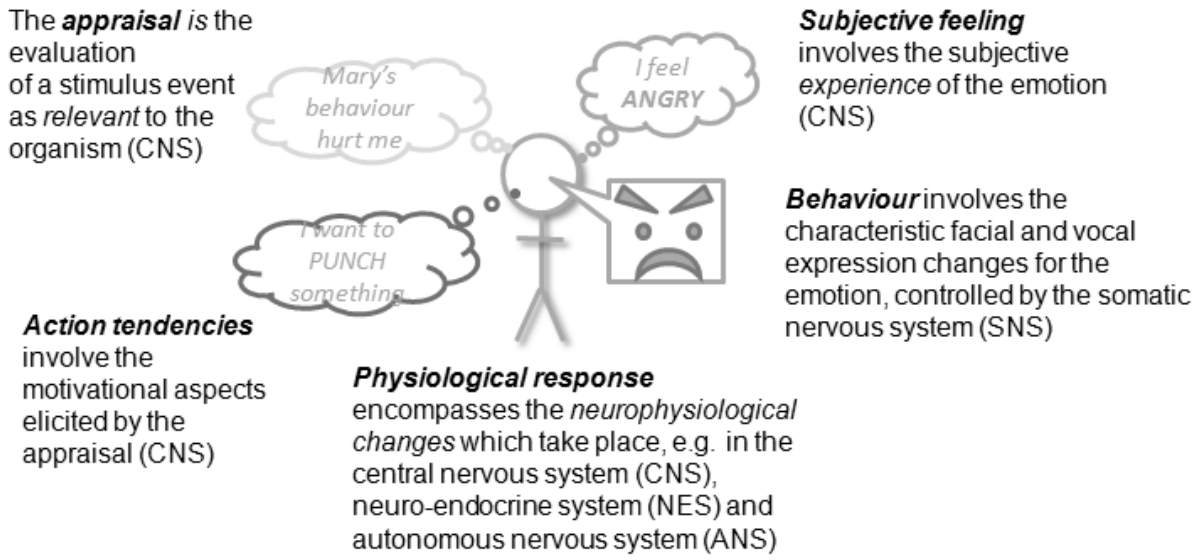

Figure 1. Components of John's anger occurrent

2.1 Mental and Physical Processes

An emotion occurrent is a synchronized complex of mental and physical processes. More specifically:

> An *emotion occurrent* is a mental process that is a synchronized complex of constituent mental and physical processes including an *appraisal process* as part, and which gives rise to an *action tendency*. At least one appraisal precedes the other components of the emotion, while it or others continue throughout the emotion occurrent and guide the process.

The constituent mental and physical processes that usually form a part of the emotion occurrent include the appraisal process, bodily changes (such as increased heart rate), experience of subjective feelings, and behavioural processes (such as altered facial expressions). Different emotions are characterised by differing patterns of behaviour and action tendencies.

> An *appraisal process* is a mental process that gives rise to an *appraisal*, which will be defined below.

> A *physiological response to emotion process* is a bodily process which encompasses all the neurophysiological changes caused by the emotion, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).

> An *emotional behavioural* process is the behaviour of the organism in response to the emotion, which includes the characteristic facial expressions for particular emotion types.

Expressive behaviour is an actual part of an emotion, and actual actions seem to be part of some emotions, such as *anger* and *fight* or *flight*. But not of all:

> *For pride and humility are pure emotions in the soul, unattended with any desire, and not immediately exciting us to action. But love and hatred are not completed within themselves, nor rest in that emotion, which they produce, but carry the mind to something further.* (Hume Treatise Book II Section VI p. 115)

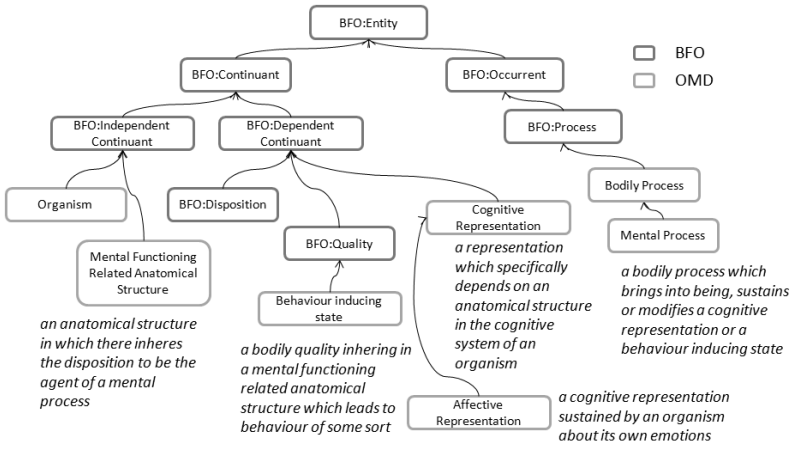

Figure 2. Overview of the top level of the Ontology of Mental Disease. Arrows represent 'is a' relations.

2.2 Mental Representations

Core to appraisal theories is the centrality of the appraisal as a mental representation.

> An *appraisal* is a cognitive representation which represents an evaluation of the *relevance* of some triggering object or event to the organism.

Appraisals represent value relations (good, bad, better...) which are judged as holding between the appraising organism and the triggering object or event. If Sam is afraid of the dog one object of his fear is the dog (the triggering object), the other is its dangerousness for him (a kind of 'bad' value relation). If John is angry with Mary, one object of his appraisal is Mary, the other is his judgment of Mary's behavior as unjust or insulting towards him.

Appraisals are normally taken to be judgments which use *concepts*, which implies that non-concept-forming organisms (such as small babies and dogs) cannot have emotions. Some researchers therefore assign a different type of emotion in this case, called a *proto-emotion* [8], which lacks a full appraisal component. In EMO, in line with multi-level appraisal theorists [14], we presuppose only that occurrent emotions are experiences *of a type that can be* associated with complex concepts in those organisms which can form concepts. The complexity of emotions which can be experienced by organisms increases with the conceptual complexity of the organism – we do not ascribe complex emotions such as *schadenfreude* (taking pleasure in the misfortune of others) to babies or animals.

Just as one may be aware of one's visual perceptions, memories or judgings so too one may be aware of one's anger. The subjective feeling of the emotion is also a representation, but of a different sort. Awareness of one's emotion is a type of inner perception. Just as one can be aware of one's sadness, one can be aware of seeing someone. Such awareness and inner perception are intentional acts or states, directed towards objects. It is often assumed that feeling is a awareness or inner perception, but in fact the most common locution in this area is *X feels sad/unhappy/angry*. If ordinary language is a reliable guide, therefore, feeling sad is a *way* of feeling ("sad"), not *what* one feels ("sadness"). In what follows we leave open the exact relation between these two types of feeling.

> The *subjective emotional feeling* is an *affective representation*, that is, a representation that the organism has about its own affect.

An affective representation differs from a cognitive representation, since the latter can be divided between a form of judging or belief and a form of inner perception, while affective representations are a fusion of these: to be aware of one's anger is to feel anger. Furthermore, they differ in their objects: the affective representation is about the *internal state* of the organism, while the appraisal is about the relevance of the triggering object or event to the organism.

Examples of subjective emotional feelings are the characteristic angry feeling accompanying anger, or the highly painful feeling that accompanies grief.

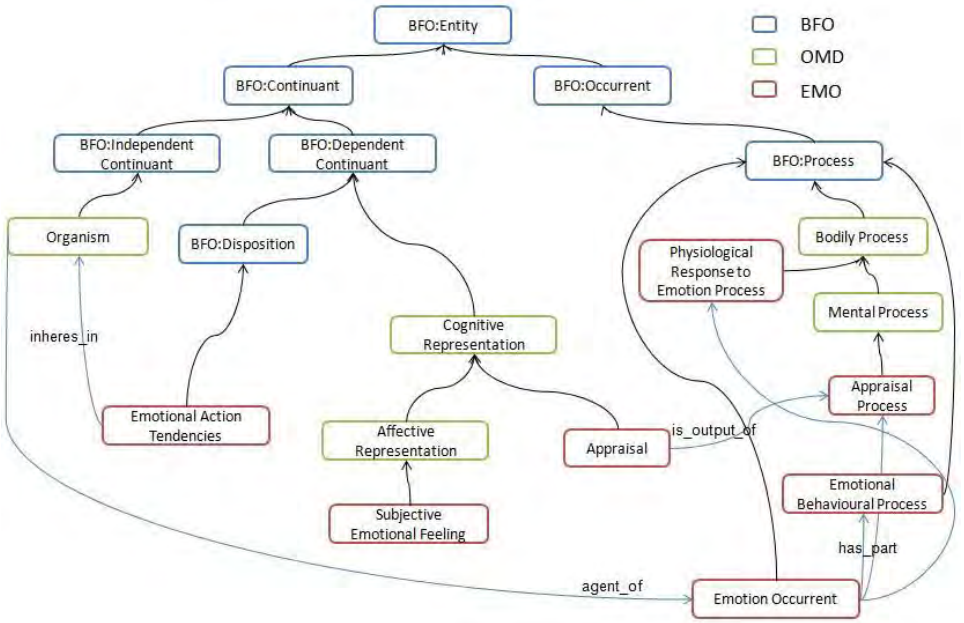

Figure 3. Processes, representations and dispositions in the Emotion Ontology. Unlabelled arrows represent 'is a' relations.

2.3 Dispositions

The final entity in our list of emotion components is the action tendencies which are elicited by the emotion. Action tendencies differ from behaviour in that they may not be realized; indeed, action tendencies, if they are realized, are realized as behaviour. For this reason, we say they are *dispositions*. Dispositions and tendencies are not parts of emotions since they are not occurrents, but they are parts of the definitions of many emotions.

> *Emotional action tendencies* are dispositions to behaviour which inhere in an organism by virtue of the physical changes brought about by an emotion process.

The resulting ontology is illustrated in Figure 3.

3 Discussion

Recognising the need for clear categorical distinctions in support of research design, the accumulation of research findings, and linking affective science to the biomedical science of affective disorders, emotion researchers have long been proposing typologies and lists of emotions and affective phenomena [4, 10, 8, 13]. Thus far, a broad shared agreement on definitions for emotion terms has not been achieved, although there is agreement on many of the relevant constituent elements [4].

Requirements in computing and artificial intelligence have led to the development of ontology-like resources for emotions. *Affective computing* aims to integrate emotional responses into computer interfaces in order to produce more realistic systems which are able to respond to the emotional communication of their users. To facilitate affective computing, Lopez *et al*. propose a slim ontology schema for describing emotions in *human-computer interfaces* [7]. Also motivated by affective computing requirements, the W3C's emotion markup language (EML, http://www.w3.org/TR/emotionml/) is an XML-based standard for markup of emotions in text or databases. Another computing application which has led to developments in this domain is natural language processing, for which Valitutti and Stock developed an emotion lexicon [19], Triezenberg has developed an emotion terminology which categorises emotion types and related behaviour [18], and Yan *et al*. have developed an extensive terminology for the domain of emotions as expressed in Chinese [21]. Effectively marking up references to emotions in text, databases, and human-computer interfaces relies on an unambiguous shared understanding of what emotion terms denote. All of the ontology-like resources that have thus far been developed make use of

emotion terms assumed to be defined elsewhere. The formal and unambiguous scientific definition for terms in this domain is therefore still an open requirement, and it is to fill this gap that the power of shared community-wide ontologies is required.

Our approach, following best practices promoted by the OBO Foundry [15] and the principles of Ontological Realism [16] will be to engage each of the different sub-communities, both scientific and computational, at every stage in the development of EMO in order to address and reconcile, rather than ignore, fundamental terminological and definitional disagreements. This will allow the application of the developed ontology to multiple application scenarios both in support of scientific research and in support of intelligent computing.

4 Conclusion

We have presented the first steps in the development of an emotion ontology based on BFO and OMD, focusing on the definition of occurrent emotions and their component parts. Researchers continue to disagree on the essential nature of emotions. For example, behaviourists give central importance to expressive behaviour in defining emotions, while some cognitive theories take actual behaviour to be essential only to some emotions, such as anger. To address this, our ontology will provide definitions for the different terms used to denote *components* of emotions, which can then be used separately if needed in annotations of the relevant scientific literature.

Much future work remains in the project, first in terms of enhancing the ontology through delineating the different types of emotions and defining appropriate terms for them, and also addressing the different types of affective phenomena of other sorts, such as moods, and secondly in terms of applying the ontology in the practical annotation of scientific research data and in the development of novel applications that draw on emotion semantics.

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