Foundation for a Realist Ontology of Cognitive Processes

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Abstract

*What follows is a first step towards an ontology of conscious mental processes. We provide a theoretical foundation and characterization of conscious mental processes based on a realist theory of intentionality and using BFO as our top-level ontology. We distinguish three components of intentional mental process: character, directedness, and objective referent, and describe several features of the process character and directedness significant to defining and classifying mental processes. We arrive at the definition of representational mental process as a p*rocess that is the bringing into being, sustaining, modifying, or terminating of a mental representation. *We conclude by outlining some benefits and applications of this approach.*

Keywords

Mental Process, Mental Representation, Intentionality.

Introduction

Contemporary cognitive science is a highly interdisciplinary field which draws on a wide variety of heterogenous data, ranging from neurology to the analysis of literary texts. A range of ontologies have been developed with the goal of making these data more easily discoverable and analyzable. Following the principles and methodology of the OBO Foundry can provide a means of integrating these different kinds of data effectively by creating ontologies which are both orthogonal to each other and also interoperable.

Here we describe the foundations of cognitive process ontologies such as the Mental Functioning Ontology (MF) and its extensions (1-3). One unique feature of cognitive process ontologies is that they can be of value also outside of the sciences of cognition in applications in finance, medicine, and intelligence analysis, where cognitive processes such as planning, diagnosing, and problem-solving play an important role (4). Successfully capturing cognitive process data in these fields holds the promise of bringing improvements to the management of data about cognitive practices and thereby providing a new sort of starting point for machine-assisted cognition approaches to artificial intelligence. It may also help us find better ways of understanding evaluative, forensic, diagnostic and other investigative practices (5).

Current cognitive ontologies

Work on cognitive ontologies has thus far focused on the needs of the cognitive sciences and of the mental health domain. The most direct and extensively developed and utilized ontologies for this domain remain the Mental Functioning Ontology (MF) and its modules the Emotion Ontology (MFOEM) and the Mental Disease Ontology (MFODO), as well as the Cognitive Atlas (1) (2) (6). The goal of these ontologies has been to build frameworks for bridging data collected in different sorts of cognitive and neurological studies, focusing on familiar types of mental processes such as remembering, deciding, attending on the one hand (1) (7-9) and on mental disease on the other (3).

The need for ontologies in the cognitive domain is expressed by Poldrack and Yarkoni as follows:

> a search of PubMed reveals more than 1,800 papers whose title or abstract includes the phrase "working memory task." It may not register to most of those authors that in using this term (rather than a more descriptive term such as "Sternberg item recognition task" or "delayed response task"), they are making a theoretical claim, i.e. that the task in question provides a way to isolate a specific mental process called "working memory'' (9).

Hastings, Frishkoff, et al. (7) have noted that recognition tests and other similar tasks are used to operationalize the study of mental processes. That is to say that they are used to study the mental *indirectly*, by defining mental processes in terms of the data by which they are measured. Thus, working memory is studied through research on subjects' responses to recently presented stimuli; intelligence is studied through research on the accuracy of responses to written questions; and volitional decisions are studied through research on physical task completion and recording.

This practice is motivated by an assumption, widespread in the neurological science community, according to which mental phenomena are not readily observable while associated behaviors are. The former are 'subjective'. At the same time we agree with (7) that indirect methods have certain shortcomings. For example, "operational definitions rely on particular measurement methods, and these methods may not be sensitive to all aspects of the phenomenon of interest, or may reflect additional processes, e.g., so-called task demands" (7). To avoid these shortcomings and improve the interpretation of test

results we require a way to characterize the mental domain directly, which means independently of operationalizing techniques and independently of any postulated reductions of mental processes to neurological or physiological behavior.

As in the practice of biological science generally, studies of underlying mechanisms always begin with observations of organisms and behaviors. This is because the latter are more well understood. The same, we hold, is true of mental entities. Operationalization and other modeling techniques may be useful and informative in some cases, but they both depend on and are improved by an understanding of the initial phenomena of interest. Part of the solution to both the bridging and operationalization challenges is to provide a way to characterize the mental as it is understood pre-theoretically in the sorts of subjective experiences that give rise to inquiry into the mind in the first place. What is needed for this sort of understanding is a characterization of the sorts of mental processes one cites when asked questions like "What were you thinking?", "How did you arrive at that diagnosis?", or simply "How are you feeling?" In so far as there are meaningful answers to these questions, there are also cognitive processes which we are describing when we give such answers. The reason there are mental process data is because such processes *are* observable – both directly through introspection (conscious self-awareness) and also indirectly, through reports others provide of what they observe through introspection. Such reports are readily available and can, we believe, serve as a basis for an ontology of mental processes.

Methods

The theory of intentionality as the starting point for an ontology of mental processes

In the following we provide a theoretical foundation for a characterization of mental processes based on a realist theory of intentionality. This realist theory was employed already in building the Mental Functioning Ontology (MF) as well as providing a starting point for the current development of the Cognitive Process Ontology (CPO) (5), but in the MF related literature the theory itself remained implicit.

We draw here specifically on the literature of what is called realist phenomenology (10–16), which takes as its starting point the two-part thesis that 1. the mental phenomenon we are most evidently familiar with is our own conscious awareness and that 2. this conscious awareness bears the defining characteristic that it is always *consciousness-of* one thing or another. If I look through the window and become conscious of squirrels on the lawn, then my consciousness is successfully directed toward those very squirrels. A thought you might have just now of a meeting you attended yesterday *is about* a meeting that happened yesterday. As a picture is a picture of something and a statement is a statement about something, so thinking is in every case a thinking about something. (See Figure 1.)

This quality of consciousness has traditionally been called 'intentionality', though it is also sometimes referred to using the terminology of 'representations', as when we say that an act of consciousness has a certain 'representational quality' (17). In more general parlance, intentionality is just what is conveyed by the term 'aboutness'. Aboutness, as we will show, is complex and comes in different types.
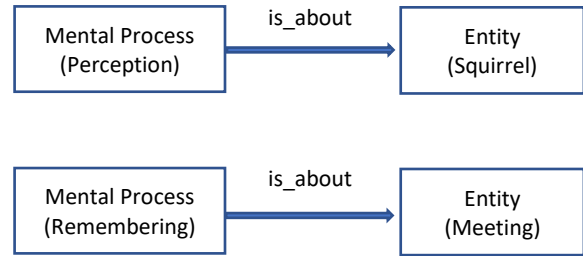

Figure 1: Relation of Aboutness

Direct realism

Realism is a view about what entities exists and what our knowledge of them consists in. Our approach to the mental is called 'direct realism' and sometimes referred to as 'common sense realism', which we characterize by the following principles:

a. The types of entities and features of the real world are much as we take them to be in common sense ordinary life and our knowledge of those entities is augmented by advances in scientific discovery.

b. Mental processes are the means by which we acquire knowledge of, think about, feel towards, and act in meaningful ways in relation to the real world.

c. We can and often do enjoy direct cognitive access to the entities and features of the real world and these direct cognitive relations are central to our ability to know reality.

d. The aboutness of mental processes is unrestricted in the sense that it can relate to portions of reality of any type, including any type of real entity or feature, including types themselves and also including instances of these types and combinations of types and instances.

e. Mental processes are natural processes and as such are also parts of the natural world.

These principles entail that our minds have access to a real world of which we are a part. We can directly think *about* real-world entities and features, as well as acquire knowledge of portions of reality *out there* in the world. Direct realism rejects views according to which we can access in our thoughts and perceptions at best only inner mental entities such as sense data or subjective appearances. It also rejects views according to which the real world is made or constructed by the mental processes that apprehend it.

Direct realism does not entail that all intentional conscious mental processes involve direct aboutness relations, nor that all intentional conscious processes are always about some real entity. However, following (18) we maintain that all such non-veridical and non-relational mental aboutness is ultimately dependent and derived in various ways from direct relational aboutness to some portion of reality. The ways in which intentional conscious mental processes can fail to relate to that which they purport to be about is multifarious and is outside the scope of this paper. For our analysis it is sufficient to point out

that mental processes have intentional qualities whether they are direct, indirect, veridical, or non-veridical. Furthermore, we note that intentional conscious mental processes can and often do directly relate, that we are aware of and can locate these cases, and that we can describe the features of mental processes that make this possible when it does occur.

Basic structure of intentional mental processes

We restrict our discussion to intentional (henceforth *representational*) mental processes of the sort we consciously experience. We focus exclusively on non-pathological cases of mental processes. We believe that, as in the case of anatomy so also in the case of the ontology of the mental, disorders and anomalies are best defined in terms of standard (or 'canonical') cases (19).

We begin with three general observations about representational mental processes.

1. They have a representational structure.

2. This representational structure is complex.

3. This representational structure is tied to the portions of reality the corresponding mental processes are about in non-arbitrary ways.

We discuss each of these in turn.

Structure of a mental process

Three dimensions have traditionally been distinguished in the relational structure of representational mental processes, namely: *character, representational directedness,* and *objective referent* (11) (20) (21).

The *character* (or 'mode') of a representational mental process is that feature by which process types such as judging, doubting, supposing, inferring, hoping, desiring, and fearing are distinguished from each other. Differences in character are differences in the *way* an entity is consciously represented. Representational mental processes are not mere cases of aboutness; there is always some characteristic *way* each is about something. Wondering whether Jim is ill, doubting that Jim is ill, discovering that Jim is ill, and affirming that Jim is ill are each about Jim in some specific way. In each case a distinct characteristic manner of relating (wondering, doubting, discovering, affirming) relates the experiencing subject to the same portion of reality, namely, Jim and his illness.

The *representational directedness* (or 'content') of a mental process is the qualitative way an entity is represented to be in an experience. This quality is what gives a mental process its aboutness to a particular entity as qualified in this or that way. For example, it gives rise to the difference between thinking about an airplane ticket as yours, or as lost, or as cancelled. Mental processes of a single character type can involve a different representational directedness. Thus, one might wonder about the weather, wonder about your flight times, or wonder about that parking spot at the airport. In each case the same process character (wondering), is paired to a different representational directedness: being "about the weather", "about your flight" or "about that parking spot", respectively. The difference between the character and representational

directedness is the difference between the manner in which you bring something to mind, and the way that thing brought to mind is represented to be.

Character and directedness are mutually dependent parts of a representational whole. A pairing of this sort is common to many sorts of processes. For example, walking has both a manner of walking (for example a certain gait or a limp) and a direction of walking. An instance of one type can only exist with an instance of the other as parts of a complex whole. This relationship is illustrated in Figure 2.
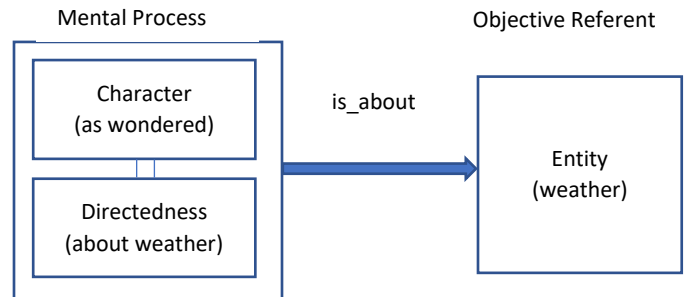
Figure 2. Representational Structure
"| |" indicates a relation of mutual dependence

The *objective referent* of a mental process is the entity or portion of reality that a given thought is or is intended to be about – for example the people, meetings, buildings, cars, trucks, and so on that we consider in our thoughts or perceive in our everyday experience of the world. The object of Jim's doubting, discovering, and affirming in the example above is the actual person *Jim* and his actual *illness*. It is thus not what some might call a concept of Jim or any other theoretical mental entity; it is not a bundle of sense data; and it is not any sort of image or representation of Jim.

Representational structure is complex

The representational qualities involved in mental processes are both internally complex, which means that they have multiple parts standing in relations to each other, and externally complex, which means that they are embedded in larger complex wholes consisting inter alia of the representational qualities of other distinct mental processes.

Consider the experience E of wondering whether you turned the stove off this morning. This experience is not simply about the stove and its being on or off. Rather, your concern is complex and includes representing (thinking about) the stove as *your* stove, as an appliance, as persisting across time, as occupying a certain physical location, as previously having been used by you, as a valued object, as capable of being on and off, as having a color, a size, a function, an associated fire risk, and so on. Some of these will be in the front your attention and concern (the on switch, the fire risk), others at the periphery (its cooking function).

Such qualities and relations belonging to (or associated by you with) the stove are co-represented in the experience E, not just concurrently, but in such a way as to form a unified whole of which each co-representational quality is a part. Some of these aboutness relations are illustrated in Figure 3. Each small arrow signifies a relation of aboutness towards a part or feature of the

stove. Each is what we might call a 'partial representation' involved in the whole representational complex that is about whether the stove is on. The large arrow signifies the aboutness of the total representational structure of which the other representational qualities are parts.
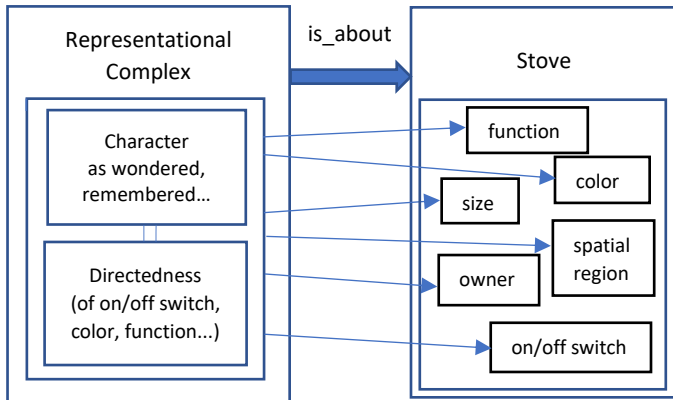

Figure 3: Complex of Representational Qualities in Experience E

The representational complex with which you wonder about your stove in E is not static and will vary across time. It is also not the case that every person that wonders about your stove represents it in the same way and with the same set of qualities. However, some parts of this representational complex are essential to any mental process of any person that would relate to that very stove. For instance, your stove (and any stove) is represented as a physical object; and were it not so represented, the stove would fail entirely to be related to your thinking. You would not in fact be thinking about the stove at all. A representational quality directed to the material nature of something like a stove is so fundamental to our thoughts about physical objects that it normally goes unnoticed. Other parts are accidental. For instance, if you sell your stove and no longer represent it as one of your possessions, your thought can nonetheless be related to, and be about, the same stove.

Additionally, mental processes do not occur in isolation. Every representational complex arises in the context of other representational qualities about not only the immediate object of concern but of the representing subject and the environment of this subject. Thus, your initial wondering takes place in combination with processes of representing your current environment, your bodily position and location, the obligations and tasks you are currently fulfilling, the present passage of time, the occurrences you just witnessed and the anticipated occurrences just beginning, and much more.

Horizon

This last-mentioned example points to another structural feature of mental processes. The structure of every representational mental process involves what phenomenologists have called its 'horizon', which extends outward both spatially and temporally from the object or process in the foreground of the experience (22). Our representational complexes are directed not only to their target and its various parts and features as described above, but also to the expected and anticipated parts, features, relations, and actions of the target beyond what is currently presented. There are many sorts of horizons corresponding to

the different contexts within which our mental processes represent.

For example, your stove, when you stand before it and perceive it, is represented also as having parts and features that are not wholly present to you (its inside, its backside, its weight, the cable connecting it to the power supply, its dispositions, for instance to cause a fire). They are co-represented as waiting, in the background so to speak, for you to perceive should you turn your attention to them. The directedness corresponding to the parts and properties of an object that are co-represented but not immediately present in the experience make up what can be called the object's 'internal horizon'. There is also an 'external horizon' of directedness towards the relations and anticipated actions of an object of concern. This anticipatory structure can be illustrated by our experience of processes unfolding in time. The experience of witnessing the beginning of an action you are familiar with, say the leap of a cat, co-represents the anticipated path of flight and landing. The expected unfolding of the cat's action makes the experience to be *about* a leap from the very start.

There are also elements of the horizon that pertain to the context of the occurrence of the mental process itself. Since mental processes occur in the context of other concurrent mental processes, what we might call a 'subjective' horizon extends out to the anticipated further experiences of the conscious subject herself. The horizon of a single representational mental process involves representational qualities directed to other potential experiences of other objective referents and other mental processes. In the above example, the perception of the leap of a cat includes the anticipation of its landing, but the perceptual process also represents something about itself and its own potential. It co-represents its own expected continuation, and specifically a continuation that leads to the presentation of the completion of the cat's landing. The subjective horizon of a perceptual experience also relates to the potential for further perspectives. The directedness to the cat's leap includes the co-representation of your perspective and its potential to change with respect to that leap. For example, should the cat leap behind a tree and just out of view, co-represented is a horizon of potential adjustments to your perspective needed to get a better view of the landing.

The horizon of mental process can also include representations of the mental processes of other persons (22). We see the world not merely as we see it but also, potentially, as Jim, over there on the other side of the room, would see it. Should we see Jim looking with interest around a corner that occludes our view, our perception has as a part of its horizonal content a representation of Jim's perspective. His action is seen as including a perspective we ourselves could have should we go over next to him and look for ourselves. This is part of what we might call the 'inter-subjective horizon', consisting of those familiar and expected mental features, processes, and behaviors of other persons and other thinking organisms. For example, Jim's action is, in the normal case, perceived as motivated and rational. His behavior of looking around a corner is an objective referent whose horizon points to a motive, purpose, and perspective that Jim bears, and that purpose, motive, and perspective represented as something that we could, in principle, possess.

Fulfillment

A further central structural dimension of our experience is the dimension of *fulfillment*. When we witness the completion of the cat's leap we experience a fulfillment of our initial expectation. What had initially been mere anticipations of leap and landing become filled by perceptual experiences of those very leap and landing processes themselves.

Should you go home and check on the stove you were wondering about, the representational qualities of your consciousness mental processes will continue to change. Yet when you arrive home the stove will (in non-pathological cases) be represented as the same stove as you wondered about earlier in the day. Although new representations of the stove are produced, they are not only about the same objective referent as earlier wondered about, but they are specifically about the stove "as" earlier wondered about, your new mental processes being about your stove in its relation to your previous concern.

Finding that the stove is switched off may offer a sense of relief – something it would not do if you had not been concerned to check on it in the first place. For you to check on and verify that the stove is in fact off (in the canonical case) involves you yourself perceiving that the stove is off. This amounts to perceptually representing the stove and finding it to be as it was previously thought to be. In this process of verifying, representational qualities belonging to the process of wondering are brought into relation with the representational qualities and objective referent of a process of perception. This bringing into relation is a distinct higher-order process that is directed to both the stove as wondered about and to the stove as perceived, and through them represents a new situation: the stove's being as it was thought to be. The fulfillment of the wondering about the stove by way of the perception of the stove is more than a sequence or even a co-representation, but a unity, what has been termed a 'fusion' of parts that represents a new object based on these parts (10). This sense might be expressed with the exclamation "Whew! The stove *is* off".

Through this new process the stove is represented not just as being off, but also as related to another higher-level distinct representation with its own distinct character; what might call the apprehension of truth. A representation of this sort is remarkable because it describes a case of knowledge acquisition and belief formation not just about the stove (the objective referent) but of a representational structure itself. The process of wondering whether the stove was on or off is represented as settled and the *representational directedness* towards the stove's being off is represented as correct or true. This is something that neither mere wondering nor perception nor the sequence of the two could ever result in on their own. Simple perceptual validation and its twin, the process of perceptual frustration form the basis also of scientific observation and hence of all scientific evidence gathering (10).

Consider another example. When a dermatologist examines a skin lesion for indications of a melanoma, she often intends to make a determination whether a biopsy is warranted. But, before this determination can be made an initial examination directed toward the question of whether the patient's lesion bears the clinical phenotype of a melanoma will need to be established. Her examination will typically be directed to ascertaining the presence of those phenotypical features.

The examination process is a perceptual process that represents the lesion along with a context of horizons. Her perceptual examination will include, among other things, representations making up

> a. the intersubjective horizon of the patient (what to ask them, how to communicate with them),
>
> b. the internal horizon of the lesion (coloration, structural features of the epidermis and dermoepidermal junction),
>
> c. the subjective horizon of her potential to get a better view (using a dermascope, moving a lighting source to fix color and shadowing effects), and
>
> d. the external horizon of relations (the age of the lesion, the behavior of the patient, family history).

As the examination proceeds the perceptual processes involved will fulfill to various degrees these horizons, and while doing so will also directly represent various features relevant to the clinical phenotype of a melanoma. Should the features perceptually represented fulfill the doctor's initial representation affirmatively, she will find the lesion to in fact bear that phenotype. The initial question will represented as settled and the representation questioned, that the lesion has the phenotype of a melanoma, will be represented to be true.

The examination of these familiar cases of wondering and examining illustrate both the structure and complexity of the *aboutness* that is part of our everyday conscious experience. Such complexity points to the difficulty of describing mental processes. Whether for the sake of scientific research, therapy, diagnosis, or even personal communication about drinks at party next week, there is a potential for misidentification and misinterpretation. Despite these difficulties, it is worth pointing out that we know perfectly well what is intended when someone tells us that they are wondering whether or not they left the stove on. We know what they mean, and we know to some degree what they are thinking about and how they are thinking about it. We also know what sort of actions and experiences (and what further representations) would settle their concern. This is true in general. When we know what someone is thinking about and how they are thinking about it, we know also what portions of reality and what sorts of representations directed to them would fulfill their intentions, satisfy their desires, help to prove their statements true or false, motivate their actions, or explain the meaning of their words. All of this is due in large part to the sharing of a common real world to which our thoughts are directed and to the shareable repertoire of representational qualities that direct us to it.

Representational qualities are tied to their respective objects in non-arbitrary ways

Each mental process, in virtue of the representational qualities instantiated within it, represents its target in regular and distinctive ways according to its process type. Perceptual processes represent the thing perceived to be both sensorially

present and to be causally responsible for the perceptual process itself. A judgment represents some state of affairs as obtaining or not obtaining (for example, that the stove is off, that the dinner was cold). An emotion represents a thing or an event as differentially valued, as dangerous (in fear) or sudden (in surprise). An expectation represents something as not occurring but as at the same time impending. These representational quality types cannot be arbitrarily exchanged as they are tied to the qualitative character that participates in each mental process according to its type.

The Emotion Ontology (MFOEM) makes use of this relationship between the representational quality types and mental process types. Consider the MFOEM definition of the emotion process of fear.

> Fear =def. An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms. Characterized by feelings of threat and impending doom, and by an urge to get out of the situation.

The representational qualities associated with specific types of emotion processes are captured in MFOEM under 'appraisal'. The emotion process of fear has as a part the 'appraisal of dangerousness' defined as follows.

> Appraisal of Dangerousness =def. An appraisal that represents an evaluation that an object or situation is dangerous to the person (MFOEM).

The emotion process of fearing thus essentially involves the quality of representing an object or situation as being dangerous to the fearing agent. If someone were to appraise an object or event to be safe and secure they could not be said to be afraid of it. Similar principles apply also to the behavioral and physiological dimensions of emotion. Thus, the representational qualities of fear go hand in hand, for example with an increase in heart and breathing rate, increased muscle tension, and piloerection (goose bumps), to name a few.

In cases where the behavioral, affective, and other physiological experiences that are normal for the fearing experience are present without the representational qualities characteristic of fear, we would regard the person to be suffering a disorder.

We can enhance the MFOEM definition of 'fear' by noting that there are representational qualities expressed in the definition but currently couched in terms of feelings. MFOEM adds to the definition of 'fear' the comment that it is "characterized by feelings of threat and impending doom …". Here the term 'feelings', is best understood to imply that the agent is representing something to be threatening, impending, and dooming. MFOEM does not have a term for 'feeling of threat' or 'feeling of impending doom' and 'feeling' itself is defined as follows:

> Feeling =def. The subjective emotional feeling is that (fiat) part of the emotion process by which the organism experiences its own emotion.

While the subjective emotional feelings involved in fear would conform to the above definition and would include at least the

feeling of fear and quite possibly other related feelings of dread or terror, there are also associated representations of dangerousness that include as a part not the *feelings* but the *representational directedness* to threat and impending doom.

The description of these representational qualities can be extended along the lines discussed above. We add to this description that fear, in the normal case, includes co-representations of the presence of a potential and expected harm, such that there is an anticipation of the imminent realization of that harm, and also that the feared thing itself is represented as something that adversely affects conditions and possibilities that the organism deems valuable and important. Being struck with the fear that your laptop containing important work may be irrevocably broken has as a part the conscious representational directedness to the threatening condition of the damaged laptop as well as the impending doom that a permanent loss would entail. Of course, if nothing in the laptop is of sufficiently serious value, then these representations would normally not arise and neither would the emotion of fear.

Objective Referent

We have thus far addressed the role of the objective referent in this discussion, only briefly, with respect to its place in the representational relation and its role in the processes of fulfillment. Representational qualities, however, are themselves to a great deal dependent on and determined by the nature of the entities they are about. An aboutness directed to a color could not be directed to sound, and an aboutness directed to a person could not also be directed to the number five. Each entity type determines the ways its instances can be both represented and known (for example, sounds are heard, colors seen, equations calculated). Each entity type also limits the ways its instances can be represented and known. These are not accidental relationships and there is a remarkable isomorphism between what sorts of things exists and how those things are related to conscious mental processes. Were it not the case, then any sort of entity with any set of features, could be represented by any sort of mental process with any set of features. To the contrary, sounds cannot be premises in deductions, colors cannot be known through a process of counting, and equations cannot be found as spatially extended objects orbiting the earth.

Towards a foundation for the Cognitive Process Ontology (CPO)

With this account in hand, we now turn to the ontological representation of mental processes using Basic Formal Ontology (BFO) as our top-level ontology.

We limit ourselves to representational mental processes of a sort that are experienced consciously and are basic to our shared mental lives and to our shared mental vocabulary. Trivially, mental processes are a type of BFO: process. Process in BFO is a very broad term, but comprehends *inter alia* the coming into being, sustaining, modifying, or passing away of a quality or qualities.

A quality in BFO is a Specifically Dependent Continuant (SDC) that inheres in some independent continuant (IC). In the case of representational mental qualities, the relevant independent continuant is the cognitive system or relevant parts thereof of a

conscious organism. When I am thinking about something, representational qualities *inhere* in the relevant parts of my cognitive system, and correspondingly, those parts of my cognitive system *bear* the representational qualities. In this way my thinking processes relate me, by way of my cognitive system, to the entities I think about. (See Figure 4.) Consequently, mental processes are changes in qualities borne by an organism's cognitive system. Following (18) we define 'mental quality' as follows:

> Mental Quality =def. Quality which specifically depends on an anatomical structure in the cognitive system of an organism.

Throughout the occurrence of a mental process, the cognitive system of an organism *participates* in the process by bearing the mental qualities that come into being, endure, change, or pass away. The qualities themselves participate in the process as those entities that are formed, sustained, modified, or destroyed by the process. We term the whole qualitative structure of representational mental qualities a 'mental representation' and define 'representation' and 'mental representation', as follows:

> Representation =def. Quality which is about or is intended to be about a portion of reality.

> Mental Representation =def. Representation which is a mental quality.

We can now clarify talk of mental processes and their aboutness. Mental processes have aboutness only derivatively; their aboutness is due to the representational qualities that are involved as participants in those processes. Aboutness does not inhere in a process but in the thinker as she is related to the target (some entity or portion of reality) that is being thought about. The conscious processes of a cognitive system, as we experience and communicate about them, are changes in the vast qualitative structures of aboutness we consciously live through. Following our definitions, representational mental processes thus consist in the coming into being, sustaining, modifying, or passing away of mental representations of various complexity and duration.

> Representational Mental Process =def. process that is the bringing into being, sustaining, modifying, or terminating a mental representation. (5)

The basic structural components of a mental representation are its representational character and representational directedness defined as follows:

> Representational Character =def. a quality that is part of a mental representation and determines the way in which that representation is about its objective referent.

> Representational Directedness =def. a quality that is part of a mental representation and determines the way its objective referent is represented as being.
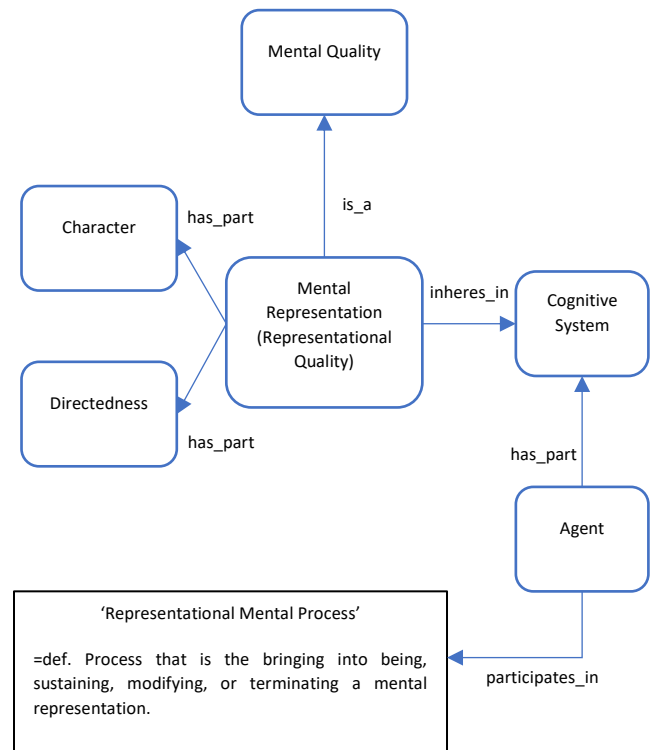

Figure 4. Representational Mental Process

Discussion

Consider now the difference between the characters of processes of fearing, questioning, imagining, and regretting. An adult under suitable conditions is able to distinguish between these on the basis of the representational relation each has to its object. A question process represents its object as yet to be determined, an imaginative process as unreal, a regret as past. An ordinary adult, similarly, cannot fear what she represents as past or regret what she represents as unreal. These examples are not intended to provide necessary and sufficient conditions for each process type but rather to point to the sorts of ties that hold between character, representational content, and objective referent. As a matter of principle descriptions of such ties, when made explicit, often appear as more than obvious to anyone that has feared, questioned, imagined, or regretted.

When mental process data are collected whether for cognitive research experiments, cognitive and behavioral therapies, psychiatric evaluation, correlations in neuro imaging studies, or for review and evaluation of diagnostic and other analytical practices, then, one important organizational dimension of these data relates to the coming into being, changing, and passing away of complexes of mental representations.

Potential difficulties and further research.

Although cognitive processes have been discussed in the above as if they were discrete events, our conscious lived experience is much more like a continuous flow. Divisions into wondering, doubting, perceiving, and so forth, although not arbitrary, delineate events that of their own character do not exist in isolation but are rather fused together in much larger complexes of intentional representational structures. This fact does not,

however, remove the significance of the distinctions we have drawn, but it makes isolating and studying individual processes all the more challenging. Nevertheless, the types instantiated by such processes are important for at least three reasons: 1. They are real. Neither the dependence nor the continuous nature of an entity makes the entity any less real (compare colors, sounds, lexical typography, state borders). 2. Essential distinguishing characteristics and law-like axioms pertain to these entities, as the many examples introduced above demonstrate. 3. We speak easily and naturally of hoping, desiring, reasoning, evaluating, knowing, and these terms are essential ingredients in any ontology or cognitive science that hopes to communicate about the portions of reality that form its own subject matter.

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