Mental Capabilities

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Abstract

We propose capability *as a universal or type intermediate between* function *and* disposition*. A capability is, broadly speaking, a disposition that is of a type whose instances can be evaluated on the basis of how well they are realized. A function, on the view we are proposing, is a capability the possession of which is the rationale for the existence of its bearer. To say for example that a water pump has the function to pump water is to say that the pump exists because something was needed that would pump water. A water pump may have many capabilities, including: to be weatherproof, to run without lubricant, to be transportable, and so forth. But its function is to pump water. We focus here on capabilities possessed by humans – such as piano playing or language using – and we explore the relation between capabilities of these sorts and structures in the brain.*

Keywords*:*
Capability, Ability, Mental Functioning

Introduction

'Disposition' is a class in Basic Formal Ontology (BFO) whose instances are, for example, the fragility of this glass, the irascibility of this old geezer, the solubility of this chunk of salt. Dispositions are potentials for this or that to happen, and they are realized when the right trigger or circumstance arises (sometimes, as in the case of a beating heart, always). Dispositions specifically depend for their existence on their bearers and – unlike roles, such as the student role or the lawyer role – they are dependent *only* on their bearers. Hence, they are, according to BFO, internally grounded, specifically dependent, realizable entities.

BFO 2.0 elucidates disposition as follows:

> *d* is a disposition means:
> *d* is a *realizable entity*,
> & *d*'s bearer is some *material entity*,
> & *d* is such that, if it ceases to exist, then its bearer is physically changed,
> & *d*'s realization occurs when and because this bearer is in some special physical circumstances,
> & this realization occurs in virtue of the bearer's physical make-up (1).

One subclass of 'disposition' is formed by those dispositions which provide the rationale for the existence of their bearers. A disposition of this sort is called a 'function'. Here 'rationale' covers both cases where functions exist in reflection of evolutionarily development (as in the case of lungs or hearts) and cases where functions exist in reflection of intentional design (as in the case of the water pump and other material artifacts). In BFO:

> *f* is a function means:
> *f* is a disposition,
> & *f* exists in virtue of its bearer's physical make-up,
> & this make-up is something that this bearer possesses because it came into being, either through evolution (in the case of natural biological entities) or through intentional design (in the case of artifacts), in order to realize processes of a certain sort (1).

Examples include: the function of amylase to break down starch into sugar, reflecting the fact that the disposition *to break down starch into sugar* was evolutionarily selected for; and the function of a hammer to drive nails, which exists because the hammer was designed to bear a disposition *to drive in nails* (1).

Spear et al. (2) note that,

> The notion of function is indispensable to our understanding of distinctions such as that between *being broken* and *being in working order* (for artifacts) and between *being diseased* and *being healthy* (for organisms).

Functions go hand in hand with the gradeability of their realizations. (Compare the treatment of 'normativity' in (2).) Your heart may pump well, or it may pump less well, and the latter is sometimes associated with the presence of disease (3–6).

However, there appears to be a further class of dispositions whose instances are also evaluated based on how well they are realized but whose bearers were not created specifically to realize that disposition as a matter of evolutionary selection or intentional design. This class of disposition is broader than that of function. More recently the term 'capability' has been mooted as an appropriate term to describe entities in this

intermediate class (7). A capability is (roughly) a disposition whose realization brings benefits to some organism or group of organisms. Those capabilities which constitute the primary reason for the existence of the bearer (either as a matter of evolutionary biology or as a matter of intentional design) we call functions.

Both organisms and artifacts can have capabilities. For example, my hands are capable of opening cans of sparkling water and my car is capable of keeping me warm. In both of these examples the disposition is not a *mere* disposition. Rather, it is a disposition that in typical circumstances brings benefits to an organism interacting with the bearer of this disposition or to an organism that itself bears this disposition. Such benefits can be graded on a scale (in some cases on multiple scales). Thus, capabilities are not mere dispositions. But they are also not functions. They are a class of realizable entities intermediate between the two.

Some capabilities are distinguished in that they can be realized by their bearers' deliberately and in such a way as to bring concordant benefit to the bearer. For example, the capability to play the guitar is something the guitarist realizes on purpose and something that brings benefit to the guitarist (as also, potentially, to other organisms). A car's capability to warm its passenger, in contrast, is never intentionally realized by its bearer, nor does the production of heat benefit the car itself; rather, it is the passengers who are benefited by being kept warm. To capture these cases, where a capability can be intentionally realized by and for the benefit of its bearer we introduce the further term *ability*.

A still narrower class is that of *mental ability* – for example the ability to perform mental arithmetic. These are abilities that, in contrast to the case of playing tennis, or playing the guitar, can be realized purely mentally.

Methods

We shall use 'ability' to refer to a realizable entity that (i) has an organism as its bearer and (ii) is such that its possession and/or realization brings benefit to this bearer and (iii) is realizable deliberately (thus on the basis of an intention of the bearer). Thus, plants, fungi, and unicellular organisms bear no abilities.

This paper assumes that mental properties supervene on the physical properties of the brain and nervous system. Given this assumption, when mental capabilities are acquired, there must be some physical change in the brain. We will present evidence that the acquisition of abilities on the part of a human being is in some cases correlated with the development of novel neuronal structures. The relevance of cases of this sort would turn on the fact that the entities in question would be examples of mental *functions* – since they would be capabilities whose bearers have evolved (or better: developed) to realize dispositions of the given sort.

We here consider three examples: being able to carry out arithmetical operations in one's head, being able to speak a second language, and being able to play a musical instrument. All of these are such that they can be exercised deliberately. We postulate that there are networks formed in the brain in the process of acquiring such abilities, and that these networks are the bearers of the corresponding acquired dispositions. (Note that we here use the term 'bearer' in the narrow sense, following BFO; in common speech we often speak of the whole organism as bearer in such cases.)

Evidence for the Existence of Abilities

Mental Arithmetic

Starting with the case of mental arithmetic, (8) points to evidence to the effect that, first, there are a number of shifts in the neuronal networks in children between second and third grade and that, second, some of these developments, such as greater connectivity in visual-processing areas, are directly related to learning arithmetic:

> [Our] results suggest that the development of numerical skills is characterized not just by a shift to dorsal PPC areas involved in visuo-spatial attention, but also to ventral visual areas that are involved in higher-order visual processing. We suggest that ventral visual areas contribute to arithmetic skill development by building improved perceptual and mnemonic representations for numerical problems (8).

Furthermore, it is clear that damage to certain areas of the brain will impair arithmetic function (9). In addition, (8) found that when a child learns arithmetic there are "significant task-related changes in brain response and connectivity."

The authors found also that performing arithmetical calculations correlates with the coordination of multiple parts of the brain. This is inferred from the significant activation found when children do arithmetic in the pre-supplementary motor Area (preSMA), bilateral anterior insula cortex (AIC), and the visual cortex (VC) (8).

Mental arithmetic is clearly an ability in our sense of the term. Arithmetic is done intentionally, and people can be better or worse at doing mental arithmetic, can improve their skill with practice, and in typical circumstances benefit from the performance of this skill. It is indeed a widely shared ability, and it would seem that everyone (even the uneducated) have the ability to perform very simple calculations, so that it is considered to be abnormal (and in some cases a disability) if one is unable to carry out such calculations to a certain level.

This difference in skill might be explained by pointing to the finding in (8) to the effect that there are task-related changes in connectivity which occur when children engage in tasks that train mental arithmetic. Although the neuronal networks that bear the ability to perform mental arithmetic exist before this ability is exercised, practicing mental arithmetic certainly changes the connectivity of these structures. Arithmetic can thus be considered as an ability that is in part innate and which can be developed through practice. Many human abilities are similar in this regard. Jumping, running, and eating are all abilities that are innate in this sense.

Speaking a Second Language

Mechelli, et al. (10) provide evidence for structural changes to the brain induced through training that results in proficiency in a second language. They found that there were measurable differences in the density of grey matter in those subjects who were proficient in a second language (10). Grey matter consists

mainly of the cell bodies of neurons (11), and the increase in grey matter density implies the genesis of new neurons in those regions.

In this case, too, the increase in brain matter density can be understood as a matter of developments in an existing structure, rather than as the appearance of a new structure. This means that the learning of a second language indirectly causes modifications to neuronal networks in the brain.

The difference in density is more pronounced in those who learned their second language earlier in life, reflecting the fact that this may be the result of a more natural process (informal socialization rather than formal learning). Whether (or the degree to which) the structures developed in language learning are simply extensions of existing networks of neurons or should be understood as separate networks altogether may thus depend in part on when the language was learned.

Playing a Musical Instrument

Acquiring the ability to play a musical instrument has been shown to go hand in hand with the development of associated neuronal networks. Elbert et al. (12) found that string players – specifically, violinists who fret with their left hand – had greater cortical representation in the brain for their left hands than the control group, and that the amount of cortical representation correlated with the age the subject learned to play.

Croom also notes that musical training can cause "significant changes in the function and organization of the brain" (13). Croom asserts further that neuroplasticity – the capability of the brain both to develop existing neuron networks and to create new networks – is greater in musicians than in non-musicians. Additionally, "musicians that practiced the piano since childhood had a more structured pyramidal tract than non-musicians". Moreover, "white-matter bundles pertaining to the motor circuits in the brain are better structured in musicians than non-musicians" (13).

Capability Bearing Structures

We take it that our three examples of ability are different enough to allow for some reasonable generalization to other examples of abilities such as computer programming skill or map reading ability – namely that the acquisition of these abilities, too, involves significant changes in underlying neural networks.

In each case it is shown that the acquisition of the ability correlates with significant changes in the brain. Though these changes are required for one to have an ability, they do not seem to bear abilities themselves. This is in large part because when exercising an ability, like playing the violin, the musician doesn't intentionally realize the dispositions in her brain – these dispositions are realized *involuntarily* – she simply realizes her disposition (her ability) *to play the violin*.

Thus, the structural changes in the brain that correlate to the acquisition of an ability bear capabilities. The specific boundaries of the brain structures are largely unknown, we refer to them nonetheless as 'capability bearing structures', pointing out that these boundaries will be a matter of gradations rather than of physical discontinuities. We will refer in what follows to an ability bearing structure that is a network of neurons found in the brain as a "capability bearing network". The question of interest is whether capability-bearing networks bear evolutionary functions, artifact functions, roles, or some other class of realizable entity.

Do these networks bear biological functions?

It is relatively clear that the ability to perform arithmetic, the ability to speak a second language, and the ability to play a musical instrument are distinguished from a mere disposition in that they intentionally realized. These abilities are trained by the organism, which results in the acquisition or further development of the ability in conjunction with a change in neuron networks in the brain. The networks themselves are not, however, intentionally developed. When a novice pianist learns to play piano, the ability is acquired intentionally through deliberate practice by the pianist. Yet, a pianist need not intend that anything happen to the structures in her brain for those structures to change. Finally, while the processes that are realized by the pianist's piano playing ability are realized intentionally, this is not the case of the processes carried out by the underlying neuron networks.

If the above-mentioned abilities are dispositions, then they are dispositions with a purpose (they are intentionally acquired and intentionally realized). However, it seems that they cannot be biological functions in BFO's sense. This is because entities like contemporary languages and musical instruments were introduced too recently in our history for a disposition (say) to speak Italian or to play the viola to be borne by an ability-bearing structure that would have been evolutionarily selected for. The case is less obvious for arithmetic reasoning. For all we know, there may have been some evolutionarily significant advantage for those who had ability-bearing structures that bore this ability. However, it is at the same time clear that the ability to perform arithmetic using Arabic symbols is again too recent in our evolutionary history for a corresponding, selected-for ability-bearing structure to exist (14).

Of course, this is not to say that there are no language-, music- or arithmetic-related functions of any sort. There may, for example, be brain structures bearing functions (such as: to develop specialized pattern recognition skills or to manipulate abstract systems) that are of relevance to the acquisition of the mentioned abilities.

Do these Structures bear Artifact Functions?

Given that the dispositions borne by the ability-bearing structures described are not biological functions, one might consider whether they are artifact functions. The structures do indeed appear to be artifact-like in the sense that they are brought about, at least in part, by intentional human intervention. One might go so far as to describe the process of learning, or instructing someone, to play the piano as the process of *producing* a piano player. Production of this sort requires also the production of relevant piano-playing ability-bearing structures.

Production in this sense, however, does not involve the creation of a *designed object* and this is what is needed if the produced entity is to count as having a function in the BFO sense. Rather, what is created is, precisely, an ability, something that is similar to an artifact in that it is an entity created as a consequence of intentional actions on the part of one or more agents. In creating

the ability we do indeed bring about changes in a specific parts of the brain of the subject involved. But these changes do not (or at least: do not given our current technology) give rise to entities in the brain that are designed. The development of ability-bearing structures is rather merely a by-product of developing an ability.

For these reasons, ability bearing structures are not artifacts and the dispositions they bear are not artifact functions.

Do these Structures bear Roles?

Roles in BFO are externally grounded realizable entities. Given that acquired abilities are neither mere dispositions nor functions, it is worth discussing why they are also not roles. BFO 2.0 defines role as follows:

> *r* is a role means:
> *r* is a realizable entity
> & *r* exists because there is some single bearer that is in some special physical, social, or institutional set of circumstances in which this bearer does not have to be
> & *r* is not such that, if it ceases to exist, then the physical make-up of the bearer is thereby changed.

Paradigmatic examples of roles are administrative in nature. When someone becomes a student (for example by signing the corresponding forms and receiving an appropriate validating stamp from the salient authorities), then they take on the student role. This role is realized in processes such as: doing homework, paying tuition, attending classes. What enables someone to participate in each of these processes is that some institution has acknowledged the person's status as a student. Importantly, nothing need change physically or psychologically on a person who becomes a student; the required changes are institutional, rather than physical.

Other examples of roles are also social. Consider a key that takes on the role of being the key that opens my front door. Suppose I need to change the locks in my house, so I purchase new set of locks and keys. At the beginning of the day the new keys are effectively useless to me, but then, after installing the new locks, the keys become very important: it now unlocks my door. During the process of the key's going from useless to important, nothing internal changes about the key. All of the relevant changes are external to the key (namely the old locks being replaced by the new locks). In this way the role of *key that opens my front door* is externally, not internally, grounded.

The realizable entities borne by ability-bearing structures are not roles because they are internally grounded. It is impossible, for example, for a person to lose the ability to play the piano unless that person undergoes some physical change. The same is true of the ability to perform arithmetic or the ability to speak a second language.

Results

In order to account for abilities like playing a musical instrument or using language, we introduce the following definitions.

> *c* is a capability means:
> *c* is a *disposition*
> & *c*'s realization in the normal case brings benefits to an organism or group of organisms, where 'in the normal case' means not only: in the normal range on the scale, but also: in a context that is normal for the group to which the bearer or user belongs (7).

a is an ability means:

> *a* is a *capability*
> & *a*'s realization is intended by the bearer

The class of capabilities is meant to capture those dispositions that are evaluable on a scale of how well the processes that realize the dispositions are realized. Some capabilities are realized intentionally, and these we term 'abilities'. As such, abilities are capabilities that can only be borne by things that are capable of intentional action. We might also classify the bearers of capabilities on the basis of what kind of process realizes the capability.

Introducing 'capability' enables us to formulate a new definition of BFO: function to read:

> *f* is a function means:
> *f* is a capability,
> & *f* exists in virtue of its bearer's physical make-up,
> & this make-up is something that this bearer possesses because it came into being, either through evolution (in the case of natural biological entities) or through intentional design (in the case of artifacts), in order to realize processes of a certain sort.

All functions are capabilities because all functions can be assessed on how well they are realized. This requires a normative standard for evaluation, and we believe that it is possible to have such standard only in the case that there is some benefit that is being brought to an organism or group of organisms. (In the case of evolved capabilities this may be: survival.) Mere dispositions can be described in terms of how they are realized, but they cannot be evaluated (graded on a scale) in the way that is possible for capabilities and thus also for functions. For example, a car has a disposition to make engine noise. The different dispositions to make engine noise possessed by various cars will be realized differently in a measurable way: some cars will have louder engines than others. However, this disposition becomes a capability only when a normative standard is in play. Suppose that someone uses the noise of their car to scare away racoons. In this case, we can identify the car as having the capability to scare away racoons, and as such an evaluative standard is introduced; the better the car can scare away racoons, the more desirable the car. In this case, louder cars are evaluated more positively in terms of their racoon scaring power.

The standard that appears common to all functions is whether or not the realized process is the process, which the bearer was designed to realize. For example, cars were designed to transport one or more persons. If a car does not enable such transport, it is not realizing its function. The same goes for biological structures; a heart realizes its function of pumping blood, if it successfully pumps blood.

A process that an artifact or biological structure was designed

to perform is necessarily a capability, since it serves the interest of at least one organism. The function of any organ, for example, benefits the organism in that it allows the organism to survive more easily than it otherwise would. Vestigial organs, like the appendix, still have a function, since its realization could benefit the organism it is a part of. However, since the environment does not require that this function be realized, the appendix never realize their function.

Similarly, artifacts that possess functions are designed to bring benefit to some organism, otherwise they would not be designed. Even destructive artifacts like nuclear weapons bring some benefit to the ones dropping the bomb, despite the horrific destruction that they cause.

One might object that someone might design an artifact to realize a process that is not beneficial to any organism. If the realization of this process is not beneficial to any organism, then it cannot be a capability. Would this not be an example of a function that is not a capability?

The natural response to this is to maintain that this artifact has no function. It was designed with a disposition, but since there is no benefit that it brings to any organism, there is no evaluative standard by which we can judge how well this process is carried out. As such, there is no way to judge how well the process realized by the designed disposition is carried out, meaning that it cannot be a function.

Moreover, suppose that two of these artifacts are created. As soon the question is asked, "which artifact function better", we need an evaluative standard. Notice "functioning better" requires a normative evaluation. This is different than asking "which artifact makes the louder noise", or "which artifact can withstand greater heat?" These are descriptive questions, which can be descriptively evaluated in order to learn more about the dispositions of each artifact. Asking which artifact is better, necessarily implies a normative standard against which the function is compared, and in order to have such a standard, there much be some good that is trying to be reached. This good is the benefit that it brings to organisms.

Reed and Dumontier [16] use the term 'capability' in the Semanticscience Integrated Ontology (SIO) to mean roughly what is meant in BFO by 'disposition'. They then distinguish 'capability' and 'disposition' in the following way: "[t]herefore, a 'capability' in SIO is about the mere possibility while a 'disposition' focuses on the likelihood" [16]. We take this to mean that a SIO disposition is a SIO capability that is likely to occur. The distinction between a BFO disposition and a BFO capability is a more substantial and useful distinction than that of SIO. Likelihoods and probabilities are able to be ascribed to dispositions numerically. Moreover, a set of SIO capabilities that are likely and therefore SIO dispositions will vary with context and domain. As a result, this distinction does not seem to belong in a top-level ontology.

By contrast, the difference between BFO disposition and a BFO capability introduces a basic class distinction. Capabilities are a particular kind of disposition – ones that can benefit some organism when realized. Since it is still possible within BFO to describe the likelihood that a particular disposition or capability will be realized, BFO's distinction both more accurately describes reality than SIO and has additional descriptive depth.

Discussion

Capabilities

What is distinctive about capabilities is that they bring a gradable benefit to some organism. Note that 'benefit', here, is not to be understood as having any moral implications. For example, a professional assassin might possess the capability to kill someone and make it look like an accident. This is a capability of the assassin, because it brings benefits to himself and to his employer.

Although all dispositions (including capabilities and abilities) can be potentially beneficial in their realizations, capabilities are set apart from mere dispositions in that their realization *normally* bring benefits. For example, a beer glass has the *disposition* to shatter. However, it does not have the *capability* to shatter, since in the normal case its shattering brings no benefit to any organism. In the normal case means: reliable, regularly, expectedly, as a result of the nature of the capability itself and of its bearer (potentially also of its owner, employer, and so forth).

The examples of abilities we addressed above, for example playing music, show that some capabilities are such that they bring benefits to others. There are also capabilities – for example cars or other artifacts – which bring benefits to their owners or to some other entities distinct from the bearer of the capability. This can be true also of natural entities.

Niagara Falls, for example, has the disposition to increase the relative humidity in the area around the base of the falls, but we would not say this is a *capability* of the Falls because it is not bringing a benefit to any organism in the normal case. On the other hand, Niagara Falls also has the disposition to attract tourists – and in this case we may indeed be talking about a capability of the Falls, a thesis that is supported by the fact that engineers are regularly commissioned to manage its flow. Niagara Falls as currently managed is comparable to a car, or to any other artifact created by design to bring benefits to its owner or user. Here the benefits are brought to the tourists who use Niagara Falls as a tourist destination.

The benefits that capabilities bring are characterized by aiding the interests of the organisms. An organism's interests can range from mere animalistic survival to a human being living a fulfilling life. Some dispositions possessed by both organisms and non-organisms aide in the interest of one organism or another. As long as the realizations of these dispositions can be used to serve the interests of an organism, that disposition is a capability. Understood in this way, one can see how the car's disposition to provide heat is a capability – it aids in the physical well-being of any organism being kept warm within the car. Moreover, a human's capability to make autonomous decisions improves their well-being insofar as being able to act autonomously contributes toward their flourishing as a human.

They can lead a more fulfilling life as an autonomous, free agent, than as a slave for example.

Fiat Capabilities

A fiat object is an object that does not have physical or bona fide boundaries (15). For example, Hawaii is a fiat object because there is no physical discontinuity that separates it from its surroundings. The archipelago is a single entity because a political fiat boundary has been drawn around it, a boundary that exists not physically but rather institutionally.

Similarly, some capabilities are really groups of more basic capabilities, functions, or dispositions. When we pick out these fiat capabilities, we are picking out a group of more basic capabilities that we often use singular terms to refer to. For example, the assassin's capability to make his hit look like an accident might require the capability to plan a hit, to undiscoverably manipulate a car brake system, to track his target's movements, and so forth. These all contribute to the fiat capability of being able to make his target's death look like an accident, and the realization of the assassin's capability *consists* in realizing these other capabilities.

Similarly, a Tae Kwon Do Master's capability to practice Tae Kwon Do consists in a group of other capabilities. The Tae Kwon Do master has capabilities to perform a myriad of different techniques including blocks, kicks, and punches. Each individual technique is a capability on its own.

Fiat capabilities also allow us to distinguish differences between instances of a capability. Both a Tae Kwon Do master and a Tae Kwon Do student possess the capability to practice Tae Kwon Do, but the student is less capable than the master. One reason for this is that the master possesses a greater number of capabilities, which we include within the fiat capability involved in Tae Kwon Do. Since the latter is a fiat capability, we can account for different ability levels among bearers of this capability based on how many specific capabilities that contribute to the fiat capability are possessed.

Barton et al. have proposed a variety of ways that more basic dispositions are able to compose a greater disposition [17]. More specific but strictly speaking different dispositions (Barton et al. uses the example of a domino's disposition to fall to left and its disposition to fall to the right as composing a greater disposition to fall) can compose a disposition that encompasses both. This is part of the idea behind fiat dispositions. The guitarist's capability to play guitar could very well be composed of her capability to fret the neck and her capability to strum. This way of combining dispositions as well as the other axioms that Barton et al. have proposed are consistent with our view of fiat capabilities. Their axioms for combining dispositions when applied to fiat capabilities such as the capability to play guitar or to speak German.

Abilities whose bearers are both mental and physiological

Acquiring an ability involves in many cases undergoing physiological changes beyond the neurological. To acquire the ability to play the piano, for example, requires that the joints in your fingers becoming gradually more flexible in order that you can play progressively more complex pieces. An ability to speak German, similarly, involves both physical components (involved in creating sounds) and mental components (corresponding for example to the speaker's knowledge of German grammar). There are then physiological structures outside the brain which are partial bearers, along with neuronal networks, of acquired abilities.

BFO and cognitive representation

Cognitive representations are relevant to mental capabilities insofar as cognitive representations are involved in the processes that realize the capability. A guitarist playing a song might visualize the chord shapes of her fretting hand, a technique which helps her fret the chords accurately. Similarly, visualization occurs while reading [16], meaning that visual as well as linguistic cognitive representations are present when the capability to use language is realized.

Reed and Dumontier [16] contend that BFO is not as well suited as other ontologies due to its realist orientation. They contend this is one reason why a cognitive representation is defined in BFO as a specifically dependent continuant which depends on "an anatomical structure in the cognitive system of an organism" [16]. Their contention is that these representations may exist independently of any anatomical structure, but BFO is not able to capture this, since the entities it captures must correspond to reality.

The realist orientation of BFO does not, however, prevent it from capturing cognitive representations. A cognitive representation needs to inhere in some kind of cognitive structure. Otherwise it could not exist. A cognitive representation is only a *cognitive* representation if it exists in a mind. So unless one is willing to argue that minds can exist independently of brains (or perhaps some other physical structure like a computer if technology brings us so far), one must accept that cognitive representations inhere in a cognitive system. BFO's realist orientation gives it the aim of describing reality. To the extent that cognitive representations are a part of reality, BFO's framework will be able to describe them.

Conclusion

In this paper, we propose *capability* as a new subclass of *disposition*, defined in such a way that all functions are capabilities and all capabilities are dispositions. In addition, we propose *ability* as those capabilities which are intentionally realizable by the bearer, and we have demarcated the kinds of bearer that a capability or ability has, focusing especially on mental abilities.

We remain neutral as to whether the term 'capability' should be added to BFO, or whether it should form part of a new Capability Ontology descending directly from BFO by analogy with the Information Artifact Ontology.

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Response to Reviewers

We would like to thank the anonymous reviewers for their thorough feedback and criticisms. The comments provided were extremely helpful in improving the paper. The biggest changes that were made was a revision of our definition of capability, and the addition of a lengthier discussion defending our idea that all functions are capabilities.

Our change to the definition of 'capability' was minor but useful in avoiding a primary worry raised by one of the reviewers. The definition of 'capability' now requires that the realization of this disposition bring a benefit to some organism rather than the bearer. This allows non-living things (and organisms, but it is particularly relevant for non-living objects) to bear dispositions that are capabilities as they benefit some organism and need not benefit themselves. Partially to address what counts as a 'benefit', which is crucial to our definition of 'capability', more time was spent explaining what we mean by benefit and showing that all functions must benefit some organism. By being more thorough in our argumentation to this, we hope to have better addressed both reviewers' worry that there are some functions, which are not capabilities.

We also heeded one reviewer's advice to incorporate an article discussing the mereology of dispositions. This change improved our paper by having it interact with further relevant literature, and specifically improved our section of fiat capabilities by drawing on some of the work already done on the mereology of dispositions. We believe that our account of fiat capabilities (and dispositions) is consistent with work already being done on the topic. Finally, care was taken to thoroughly address the comments on specific areas of the text, either to fix errors or provide additional clarification or argumentation where necessary.