

# Foundations for a Realist Ontology of Mental Representation

Fumiaki Toyoshima and Adrien Barton

IRIT, CNRS, Université de Toulouse, Cr Rose Dieng-Kuntz, 31400 Toulouse, France

## Abstract

Mental representation remains nebulous, notwithstanding its importance for the understanding of various cognitive phenomena. In this paper we outline a project to articulate a foundation for an ontology of mental representation from the realist perspective. We propose that the philosopher J. R. G. Williams’s three-layered naturalistic metaphysics of representation can serve as a theoretical basis for a realist ontology of mental representation. To illustrate this proposal, we examine his contention that functions are a non-representational basis for representation, from the viewpoint of the etiological and dispositional theory of functions that is developed in the realist upper ontology Basic Formal Ontology (BFO). We argue that functions that underline representation may not be etiological (and thus not functions in BFO) and that discussion on whether they can be still characterized as dispositions in BFO leads to specifying a challenge from misrepresentation to a function-centered approach to representation.

## Keywords

mental representation, representation, misrepresentation, function, etiological theory of function, disposition, Basic Formal Ontology (BFO)

## 1. Introduction

Mental states in nature have a representational dimension: for example, my belief that Paris is a city is *about* Paris. The representationality (synonyms: “intentionality” [1], “aboutness” [2]) of mental states — or more broadly the representation in general — nonetheless remains largely unexplored in formal ontology, despite the increasingly recognized connection of representation with various topics such as informational entities [3], mental attitudes [4] (e.g. belief [5]), representational objects [6], semiotics [7], and texts [8]. For that matter, many foundational questions about (mental) representation are notoriously difficult to answer. For instance, what is the relationship between the representationality of mental attitudes and that of information entities, such as engineering specifications and clinical records? More fundamentally, what makes it the case that something is representational at all?

In this paper we sketch out a project to specify a foundation for an ontology of mental representation from the perspective of ontological realism [9] which prescribes that ontologies should represent actual entities as described by science. We adopt this realist methodology for ontology development partly because it may be sometimes regarded as unable to provide a satisfactory treatment of cognitive and mental entities.<sup>2</sup> To develop a realist approach to mental representation, we propose to leverage J. R. G. Williams’s [10] three-layered metaphysics of representation and the foundational framework of the upper ontology Basic Formal Ontology (BFO) [11][12] because the former aims for a naturalistic and reductive approach to representation and the latter is theoretically underpinned by the realist methodology.

---

CAOS VII: Cognition and Ontologies, 9th Joint Ontology Workshops (JOWO 2023), co-located with FOIS 2023, 19-20 July, 2023, Sherbrooke, Québec, Canada.

EMAIL: toyo.fumming@gmail.com (A. 1); adrien.barton@irit.fr (A. 2)

ORCID: 0000-0002-4690-1221 (A. 1); 0000-0001-5500-6539 (A. 2)



© 2023 Copyright for this paper by its authors.

Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

CEUR Workshop Proceedings (CEUR-WS.org)

<sup>2</sup> To illustrate this point: In analyzing mental attitudes and intentionality, Biccheri et al. [4] state as follows: “The choice of DOLCE [the Descriptive Ontology for Linguistic and Cognitive Engineering] is motivated by its ontological commitment to its being tailored to common-sense representations of cognitive agents, rather than on the constitution of the ‘reality’ as prescribed by science. This feature brings to the core of DOLCE the importance of modelling the mental and the social realms” (ibid., pp. 130-131).

The paper is structured as follows. In Section 2, we present a general overview of Williams's three-layered metaphysics of representation. Then, we explain Williams's teleoinformational approach to source representation — along with the central idea of Neander's [13] teleoinformational account of perceptual representation, as the former builds upon the latter — and his view of functions as a non-representational basis for representation. In Section 3, we consider the nature of functions that can underpin representation by examining the BFO etiological and dispositional account of functions [14]. In Section 4, we conclude the paper.

## 2. J. R. G. Williams's Three-Layered Metaphysics of Representation

### 2.1. General Overview

Williams [10] develops a three-layered metaphysics of representation. Its central structure can be displayed as follows:

**Third layer.** Linguistic representation: The representation involved in words and sentences.

**Second layer.** Mental representation: The representation involved in belief and desire.

**First layer.** Source representation: The representation involved in perception and action.

In Williams's view, linguistic representation derives from mental representation, which in turn derives from source representation. Moreover, source representation emerges from some non-representational elements of the world. In this sense, he aims for a naturalistic and reductive account of representation.

Williams's philosophical theory of representation will be useful in providing a foundation for a realist ontology of mental representation or even of representation in general. First and foremost, he explicitly aims for the metaphysics of representation — rather than a so-called conceptual analysis of representation, as illustrated by the analysis of the meaning of such terms as “perceives” and “believes” (ibid., pp. xvii-xx). In addition, his method of deriving representation from the non-representational natural world can mesh well with the realist methodology for ontology development, as ontological realism (as explained above) in formal ontology arguably implies a form of naturalism and Williams states that “[g]rounding representational facts in a non-representational and naturalistic world is compatible with [his aim] to offer a metaphysics that grounds representational facts in the non-representational world” (ibid., pp. xvi-xvii).

Moreover, his proposal to specify three kinds of representation and their relationship will cohere well with the “adequatist principle” of ontology construction, according to which “the entities in any given domain should be taken seriously on their own terms” [11](p. 46), so that ontologies can jointly represent all the different sorts of entities at all different granular levels of reality. It will thereby have the potential to characterize other kinds of representation. As Williams ([10], p. xxii) suggests, it will be natural to extend his framework to analysis of many other kinds of representations such as non-verbal signals and paintings.

### 2.2. The Teleoinformational Approach to Source Representation

Williams argues that functions are a non-representational basis for representation on the grounds of his teleoinformational account of source representation, namely the representation of perception and action. Attributed traditionally to Dretske [15][16] and Millikan [17][18], the teleoinformational theory of representation says that: “roughly, [...] a state represents that  $p$  iff that state has the function to be caused by the fact that  $p$ ” [10](p. vi). For instance, my perceptual state represents this apple being red in virtue of this perceptual state having the function to be caused by the fact that the apple is red.

Williams takes two steps to develop a teleoinformational approach to source representation. First, he adopts Neander's [13] teleoinformational account of the representation of perception, as he finds it more defensible than the traditional teleoinformational approach to a broader range of representations (for example, of source and mental representations, using his terms). Second, he extends her teleoinformational theory of perceptual representation to the representation of actions, or to the representation of “action-guiding states” in his terms.

We will briefly present the core idea of Neander's teleoinformational account of perception without entering into the details of Williams's theory of source representation. This is because we are, in this paper, primarily interested in Williams's view of functions as a non-representational ground for representation. Neander [13](p. 151) articulates a simple version of her teleoinformational theory of perceptual representation. For the sake of clarity, we will provide a slightly reformulated version thereof as follows (note that Williams [10](p. 185) formulates a more sophisticated version of her teleoinformational approach, which is outside the scope of our paper):

### **Teleoinformational account of Perceptual Representation (TPR)**

(Let R and C be particular events.) A sensory-perceptual representation R, in a sensory-perceptual system S, has the content *there is C* if and only if S has the function to produce R-type events in response to C-type events.

We make brief remarks on the expressions "event", "*there is C*", and "in response to" appearing in TPR. Firstly, the term "event" can be intuitively and broadly understood as entities occurring in time, including so-called states. Suppose that, when I see a red apple, I perceive this apple as red. We can say that my perception is causally related to the event (say  $E_1$ ) of this apple being red.<sup>3</sup>

Secondly, the term "*there is C*" does not mean that sensory-perceptual representations have such a sentential structure. It is simply one way of describing the content of sensory-perceptual representations. Moreover, the term "there is" should be understood with: "'there' [being] used as a placeholder for the localization content of the representation" [13](p. 152), where localization is a notion that is associated with the locational indexical such as "over there". For instance, the content *there is this apple being red* roughly means that this apple is red over there (e.g. in my vision), rather than the existence of  $E_1$ .

Thirdly and finally, the term "in response to" should be construed as causal: "To say that one event is a *response* to another is [...] to say that the first event is caused by the second. To say that a system produced an R-type event in response to a C-type event is (here) to say that the C-type event [...] caused the R-type event" (ibid., pp. 152-153). It is important to notice that that TPR appeals to causation as well as functions.

For illustration, suppose that I perceive this apple as red. According to TPR, a sensory-perceptual representation in my sensory-perceptual system has the content *there is this apple being red*, in virtue of the fact that my sensory-perceptual system has the function to produce an event that is of the same type as this representation in response to an event that is of the same type as  $E_1$ . Note that "being of the same type as" is certainly a vague term (as every entity is of the same type as every other entity, namely an instance of *Entity*), but we do not enter into such details in this paper.

## **2.3. Functions as a Non-Representational Basis for Representation**

Williams ([10], Section 10.4) investigates which theory of functions can serve to underpin his teleoinformational approach to source representation which builds upon Neander's teleoinformational account of perceptual representation. He examines two traditional theories of functions: the Cummins-style account and the etiological account. As for the former, while Cummins [19] may focus on functional explanation rather than functions (cf. [20]), he is typically construed as saying that a function of an entity is the associated actual causal role with respect to the system that has the function bearer as component.<sup>4</sup> For instance, the function of the heart to pump blood is the role of the heart that actually causally contributes to the circulatory system having the heart as component.

Williams says that, when used in the teleoinformational account, Cummins's notion of function fails to explain "misrepresentations that are induced by malfunctions" ([10], p. 196). The term "malfunction" used here roughly refers to a phenomenon in which the function in question is not performed: for instance, the malfunctioning heart is unable to pump blood throughout the body properly. Note that we

---

<sup>3</sup> We will not enter here into the investigation of the possible distinction between 1) the perception of the apple being red, 2) the perception of the redness of the apple — where this redness is a property particular — and 3) the perception of the event of the redness of the apple being there.

<sup>4</sup> Note that Williams sometimes seems to focus on Cummins's original and somewhat epistemic theory of functional explanation.

will discuss the term “malfunction” in more detail later. For Williams, the Cummins-style theory of functions may fail to account for malfunctions and hence for misrepresentations.

To illustrate it, let us borrow one of Williams’s examples: consider a synesthetic person (say Mary) who, all external conditions being perfectly normal, has red experiences when she sees a squared object. Suppose that Mary sees a white squared box and that, at the same time, damage to Mary’s retina produces color-blindness, so that colored surfaces no longer prompt red experiences. In this scenario, it is reasonable to think that Mary perceives this box as red. Following Neander’s teleoinformational account of perceptual representation, we can analyze Mary’s perception as follows: a sensory-perceptual representation in Mary’s sensory-perceptual system has the content *there is this box being red*. By TPR, this amounts to saying that Mary’s sensory-perceptual system has the function to produce an event that is of the same type as this representation in response to an event that is of the same type as the event of this box being red. Given the Cummins-style theory of functions, Mary’s sensory-perceptual system actually plays a causal role with respect to the causal link between the event of this box being red and the representation in question — the former event nonetheless does not occur, since this box is actually white. Thus, the Cummins-style theory of functions fails to account for misrepresentations induced by malfunctions.

As compared to the Cummins-style theory, the etiological theory of biological functions links a function of an entity with historical facts about evolutionary selection. For example, Bob’s heart has the function to pump blood in virtue of the fact that the blood-pumping of human hearts in the past has been responsible for the natural selection of human beings (e.g. in the sense of enhancing the inclusive fitness of human ancestors) and hence for the existence of present human beings, including Bob. Neander [21][22] herself favors the etiological account of functions, although her teleoinformational account of perceptual representation is supposed to remain neutral on theories of functions.

Williams argues that the coupling of etiological functions with the teleoinformational account of source representation is problematic because it would undesirably imply that some creatures who appear to have perceptual representations do not have them, much less mental representations because the latter representations derive from the former. Consider “Swamp Sally”: a duplicate of the person Sally that is formed miraculously (as by a lightning strike), the original idea being attributed to Davidson’s [23] “Swampman” thought experiment. Williams critically states:

Lacking an evolutionary history, Swamp Sally’s brain states will have no proper functions, if those are understood in the etiological theorist’s sense. In the current context, this implies that she perceives nothing and intends nothing, and because of the way that belief and desire are grounded in such states, she has no mental life. [10](p. 197)

Williams concedes that leading teleoinformational theorists such as Neander and Millikan adopt the etiological account of functions and “do accept the Swamp Sally verdicts” (ibid.). He still maintains that: “I can’t myself shake the feeling that this is simply a counterexample to the combination of teleoinformational and etiological accounts. [...] it’s really hard to see how any purely etiological theory will avoid counterexamples of this sort” (ibid.).<sup>5</sup>

---

<sup>5</sup> Williams [10] outlines “an overall shape of theory that will avoid both counterexamples from swamp people [to the etiological theory] and from malfunction [to the Cummins-style theory]” (ibid., p. 199) and that is compatible with his teleoinformational account of source representation, with the following statement:

An item *s* has uber-function to F (within a system S which has the capacity to C) iff either *s* has a Cummins-function to F (relative to S/C) or *s* has the etiological-function to have that Cummins-function to F (relative to S/C). [10](p. 198)

This basic idea is that the first and second disjuncts in the right-side of the formula, respectively, can avoid “counterexamples from swamp people” such as Swamp Sally and “counterexamples from malfunction” such as the case of the synesthetic person Mary.

He argues that a possible counterexample to his proposal is Swamp Sally when Sally is a synesthetic person, but that this does not constitute a counterexample because one could see Swamp Sally as: “a deviation from some other merely possible creatures [than humans] for whom chromatic quale are systematically produced by shapes [such as being squared], where it would be not natural at all to think that experiences represent certain properties of the textures of the surfaces” (ibid., p. 198). We will leave Williams’s preliminary account of functions out of scope, as he does not elaborate upon the details of the term “uber-function”.

### 3. What are Functions that Underlie Representation?

We presented Williams's view of functions as a non-representational basis for representation with reference to his teleoinformational approach to source representation, which builds upon Neander's teleoinformational account of perceptual representation. We will examine the nature of such functions from the viewpoint of the etiological and dispositional account of functions that is developed in the realist BFO framework, as an ontologically realist construal of mental representations consists in analyzing which part of reality as described by science they are, and functions are arguably part of such a natural world.

#### 3.1. Functions in BFO

Let us begin by presenting an overview of BFO [11][12] and functions in BFO [14]. BFO includes a top-level distinction between continuants and occurrents, the former being further classified into independent continuants and dependent continuants. Among dependent continuants are specifically dependent continuants, which depend (existentially) on at least one independent continuant. On the occurrent side, we can find processes: occurrents that exist in time by occurring, have temporal parts and depend on at least one independent continuant as participant. Note that the BFO term "process" can be taken as synonymous with Neander's and Williams's term "event".

One subtype of *Specifically dependent continuant* is *Realizable entity*, defined as a specifically dependent continuant that inheres in some independent continuant and is of a type some instances of which are realized in processes of a correlated type. Among realizable entities, a disposition is a "A realizable entity (...) that exists because of certain features of the physical makeup of the independent continuant that is its bearer" [11](p. 178). To use a canonical example, the fragility of this glass is the disposition of the glass to be realized in a process (realization) of breaking when it is pressed with sufficient force and this disposition exists in virtue of some structured molecules of the glass.

*Function* in BFO is a subtype of *Disposition*: a function is a disposition of a bearer with a specific kind of historical development. In more detail, a function is a disposition that its bearer possesses in virtue of its having a certain physical makeup because of how it came into being, either through evolution (when the bearer is a natural biological entity) or intentional design (when the bearer is an artifact). For instance, the function of the human heart is a disposition to pump blood such that the heart comes to have such a four-chambered structure because it has contributed to the survival and reproductive success of the human ancestors.

#### 3.2. The Etiological Aspect of Functions in BFO

Firstly, BFO embraces an etiological approach to functions, as Spear et al. [14] explicitly acknowledge. Therefore, the BFO etiological account of functions can be subject to Williams's objection from Swamp Sally: it would imply that Swamp Sally has no mental representations, although Swamp Sally behaves exactly in the same way the biological person Sally does.

This is arguably one of the strongest objections to the combination of functions in BFO with the teleoinformational approach to source representation. To be sure, the BFO etiological account of functions can allow for the mental representation of some non-biological entities. For instance, when combined with the teleoinformational approach to source representation, it can deal with the representational dimension of robots because it can imply that parts of robots have functions, as they are intentionally designed to have them. It would nonetheless have problems with accommodating such examples as Swamp Sally because parts of her biological body do not come into being through natural selection or through intentional design. Because of their etiological character, functions in BFO may not serve perfectly well as a non-representational basis for representation.

### 3.3. The Dispositional Aspect of Functions in BFO

Secondly, BFO adopts a dispositional analysis of functions. Generally speaking, the dispositional theory of functions emphasizes the causal import of functions in common with the Cummins-style theory, as a disposition has in nature the causal import to bring about a process (for more thoughts, see Toyoshima et al.'s [24] analysis of the causal import of realizable entities in BFO). For that matter, Röhl & Jansen [20] group the dispositional and Cummins-style accounts of functions under the same heading of "causal contribution theories of functions" and Artiga [25](p. 98) refers to Cummins's [19] work in touching on the dispositional account of functions. The commonality in this respect between the Cummins-style and dispositional theories may tempt the reader to think that the BFO dispositional analysis of functions is susceptible to Williams's criticism of the combination of the teleinformational approach to source representation and the Cummins-style account of functions: this combination fails to capture misrepresentations that are induced by malfunctions because the Cummins-style account has difficulty in explaining malfunctions.

There is however an important difference between the Cummins-style and dispositional theories of functions. The Cummins-style theory says that functions are identical with the actual causal contributions of the function bearers. Therefore, it may have difficulty in distinguishing between the absence of functions and malfunctions. In contrast, the disposition theory says that function is a subtype of realizable entity and it can exist without its actual performances. Thus, it can distinguish clearly between the absence of functions (which are dispositions) and malfunctions (in which cases functions exist but they are not realized). Briefly, the dispositional theory of functions is better at dealing with malfunctions than the Cummins-style theory thereof.<sup>6</sup>

It is nonetheless unclear whether, even if we adopt the dispositional theory of functions, we can provide a satisfactory teleinformational account of "misrepresentations that are induced by malfunctions" in Williams's terms. According to TPR, a sensory-perceptual representation is produced by a function of the relevant sensory-perceptual system. Thus, a misrepresentation is also produced by a function of the relevant sensory-perceptual system. However, no representation (including misrepresentation) would come into existence without any functionings involved. Therefore, it seems that TPR cannot account for misrepresentations as being induced by malfunctions; rather, it should account for misrepresentations on the condition that they are produced by functions.

This discussion will lead to several questions. Williams seems to assume that misrepresentation is a kind of representation and perceptual misrepresentation can be accounted for by TPR. But do we have good reason to treat misrepresentation as a kind of representation? If so, does TPR need an auxiliary assumption to explain perceptual misrepresentations? For instance, we might consider extending TPR by saying "... if and only if S has the function *or malfunction* to produce ..." by postulating that malfunctions are dispositions that have some historical relations with functions, but are not functions, so as to hold Williams's idea that misrepresentations are induced by malfunctions. Alternatively, we might want to account for perceptual misrepresentations without recourse to a principle similar to TPR. Considering such options will constitute a next step towards a full-fledged function-centered approach to representation.

## 4. Conclusion

The objective of this paper was to outline a project for articulating a foundation for an ontology of mental representation from the perspective of ontological realism. We put forward the idea that J. R. G. Williams's three-layered metaphysics of representation can serve as a theoretical basis for a realist ontology of mental representation. To illustrate this proposal, we examined his contention that functions are a non-representation basis for representation, from the viewpoint of the etiological and dispositional theory of functions that is developed in the realist upper ontology Basic Formal Ontology (BFO). We argued that functions that undergird representation may not be etiological (and thus may not be BFO:functions) and that discussion on whether they can be still characterized as dispositions in

---

<sup>6</sup> It is a long-standing controversy whether the BFO dispositional theory of functions can deal well with all kinds of malfunctions and malfunctionings, though [14][20][26].

BFO leads to specifying a challenge from misrepresentation to a function-centered approach to representation.

In the future we will first provide an ontological formalization of source representation (the representation involved in perception and action) with a central focus on misrepresentation. We will then move onto an ontological analysis of mental representation: the representation involved in belief and desire. This project will have practically fruitful results: for instance, further development of a BFO-compatible ontological analysis of belief and desire [27] and a more careful treatment of aboutness in the BFO-compliant Information Artifact Ontology (IAO), as Smith & Ceusters [28] suggest that the IAO should be embedded in a broader framework of ontologies, e.g. the Mental Functioning Ontology (MF) [29]. It is also worth considering the application of our realist ontology of mental representation to the development of so-called “mental models” because mental models can be defined as a kind of representations, e.g. as “internal representations containing meaningful declarative and procedural knowledge that people use to understand specific phenomena” [30](p. 2200). Our long-term goal is to elaborate a full-fledged realist ontology of mental representation as well as of representation in general, including linguistic representation (the representation involved in words and sentences).

## 5. Acknowledgements

FT is financially supported by the Japan Society for the Promotion of Science (JSPS).

## References

- [1] Jacob, Pierre, “Intentionality”, *The Stanford Encyclopedia of Philosophy* (Spring 2023 Edition), Edward N. Zalta & Uri Nodelman (Eds.),  
URL = <<https://plato.stanford.edu/archives/spr2023/entries/intentionality/>>
- [2] S. Yablo. *Aboutness*. Princeton: Princeton University Press, 2014.
- [3] Sanfilippo, E. M. Ontologies for information entities: State of the art and open challenges. *Applied ontology*, 16(2), 111-135, 2021. doi:10.3233/AO-210246.
- [4] Biccheri, L., Ferrario, R. & Porello, D. Needs and intentionality – an ontological analysis and an application to public services. In B. Brodaric and F. Neuhaus (Eds.), *Proceedings of the 11th International Conference on Formal Ontology in Information Systems (FOIS 2020)* (pp. 125-139). Amsterdam: IOS Press, 2020.
- [5] A. Barton, W. Duncan, F. Toyoshima and J.-F. Ethier. First steps towards an ontology of belief. In L. Jansen, D. P. Radicioni and D. Gromann (Eds.), *Proceedings of the 4th Joint Ontology Workshops (JOWO 2018)*, Cape Town, South Africa, September 17-18, 2018. CEUR Workshop Proceedings, vol. 2205, pp. 1-5.
- [6] Mizoguchi, R. & Borgo, S. Towards an ontology of representation. In F. Neuhaus and B. Brodaric (Eds.), *Proceedings of the 12th International Conference on Formal Ontology in Information Systems (FOIS 2021)*, Bozen-Bolzano, Italy, September 13–17, 2021 (pp. 48–63). Amsterdam: IOS Press, 2021.
- [7] Bateman, J. A. Ontology, language, meaning: Semiotic steps beyond the information artifact. In S. Borgo, R. Ferrario, C. Masolo and L. Vieu (Eds.), *Ontology Makes Sense: Essays in Honor of Nicola Guarino* (pp. 119–135). Amsterdam: IOS Press, 2019.
- [8] Garbacz, P. A formal ontology of texts. In R. Ferrario and W. Kuhn (Eds.), *Proceedings of the 9th International Conference on Formal Ontology in Information Systems (FOIS 2016)*, Annecy, France, July 6–9, 2016, (pp. 345–358). Amsterdam: IOS Press, 2016.
- [9] Smith, B. & Ceusters, W. Ontological realism: A methodology for coordinated evolution of scientific ontologies. *Applied Ontology*, 5(3–4), 139–188, 2010. doi:10.3233/AO-2010-0079.
- [10] Williams, J. Robert G. *The Metaphysics of Representation*. Oxford: Oxford University Press, 2019.
- [11] Arp, R., Smith, B. & Spear, A. D. *Building Ontologies with Basic Formal Ontology*. Cambridge, MA: MIT Press, 2015.
- [12] Otte, J. N., Beverley, J. & Ruttenberg, A. BFO: Basic Formal Ontology. *Applied Ontology*, 17(1), 17–43, 2022. doi:10.3233/AO-220262.

- [13] Neander, K. *A Mark of the Mental: A Defence of Informational Teleosemantics*. Cambridge, USA: MIT Press, 2017.
- [14] Spear, A.D., Ceusters, W. & Smith, B. Functions in Basic Formal Ontology. *Applied Ontology*, 11(2), 103–128, 2016. doi:10.3233/AO-160164.
- [15] Dretske, F. *Knowledge and the Flow of Information*. MIT Press, 1981.
- [16] Dretske, F. *Explaining Behavior: Reasons in a World of Causes*. MIT Press, 1988.
- [17] Millikan, R. G. *Language, Thought and Other Biological Categories*. MIT Press, 1984.
- [18] Millikan, R. G. Biosemantics. *Journal of Philosophy*, 86(6), 281–297, 1989.
- [19] Cummins, R. C. Functional analysis. *Journal of Philosophy*, 72(November), 741–764, 1975.
- [20] Röhl, J. & Jansen, L. Why functions are not special dispositions: An improved classification of realizables for top-level ontologies. *Journal of Biomedical Semantics*, 5, 27, 2014. doi:10.1186/2041-1480-5-27.
- [21] Neander, K. Functions as selected effects: The Conceptual Analyst’s Defense. *Philosophy of Science*, 58(2), 168–184, 1991.
- [22] Neander, K. The teleological notion of ‘function’. *Australasian Journal of Philosophy*, 69(4), 454–468, 1991.
- [23] Davidson, D. Knowing one’s own mind. *Proceedings and Addresses of the American Philosophical Association*, 61, 441–458, 1987.
- [24] Toyoshima, F., Barton, A., Jansen, L. & Ethier, J.-F. Towards a unified dispositional framework for realizable entities. In F. Neuhaus and B. Brodaric (Eds.), *Proceedings of the 12th International Conference on Formal Ontology in Information Systems (FOIS 2021)*, Bozen-Bolzano, Italy, September 13–17, 2021 (pp. 64–78). Amsterdam: IOS Press, 2021.
- [25] Artiga, M. New perspectives on artifactual and biological functions. *Applied Ontology*, 11(2), 89–102, 2016. doi:10.3233/AO-160166
- [26] Jansen, L. Functions, malfunctioning, and negative causation. In A. Christian, D. Hommen, N. Retzlaff and G. Schurz (Eds.), *Philosophy of Science. European Studies in Philosophy of Science*, vol. 9, Cham: Springer, 117-135, 2018.
- [27] Toyoshima, F., Barton, A. & Grenier, O. Foundations for an ontology of belief, desire and intention. In B. Brodaric and F. Neuhaus (Eds.), *Proceedings of the 11th International Conference on Formal Ontology in Information Systems (FOIS 2020)* (pp. 140–154). Amsterdam: IOS Press, 2020.
- [28] Ceusters, W. & Smith, B. Aboutness: Towards foundations for the information artifact ontology. In F. M. Couto and J. Hastings (Eds.), *Proceedings of the 6th International Conference on Biomedical Ontology (ICBO 2015)*, Lisbon, Portugal, July 27–30, 2015. CEUR Workshop Proceedings (Vol. 1515, pp. 1–5), 2015.
- [29] Hastings, J., Ceusters, W., Jensen, M., Mulligan, K. & Smith, B. Representing Mental Functioning: Ontologies for Mental Health and Disease. In Towards an Ontology of Mental Functioning (ICBO Workshop), *Proceedings of the Third International Conference on Biomedical Ontology (ICBO 2012)*, 2012.
- [30] Al-Diban S. Mental models. In N. M. Seel et al. (Eds.), *Encyclopedia of the Sciences of Learning*. Springer, Boston, MA, 2200-2204, 2012. [https://doi.org/10.1007/978-1-4419-1428-6\\_586](https://doi.org/10.1007/978-1-4419-1428-6_586)