



# Frogs recognize prey: a causal-behavioral teleosemantics

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## Abstract

I propose a version of teleosemantics for simple animal representations that combines Millikan's suggestion that they represent the most crucial "normal conditions" required for them to bring about their beneficial behavioral effects with Neander's suggestion that they represent their "normal causes". The content of a simple representation is the most crucial among the normal conditions responsible for its tokens having beneficial behavioral effects that also causes such tokens. I argue that this version delivers more plausible contents than other versions of teleosemantics. Frogs' prey detectors represent the animals they prey on rather than nutritious or small moving things.

**Keywords** Teleosemantics · Indeterminacy · Function · Mental content · Naturalism

## Introduction

Teleosemantics is one of the most promising candidates for naturalizing semantics. It suggests that the contents of representations are determined by certain links to the world involved in the performance of the functions of the mechanisms that produce or use them—where the function of a mechanism is what it has been selected for doing by natural selection or some analogous process. In this paper, I only address the simplest mental representations of animals, those produced and used by innate sensory and motor mechanisms that have been selected for doing their jobs by phylogenetic natural selection. Teleosemantics seems *prima facie* well suited to explain their contents. However, there are worries about whether it delivers the right results even in these simple cases, since the relevant mechanisms have functions that involve various links to the world. To avoid indeterminacy, teleosemantics must establish which links are relevant for content determination.

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There are two main alternatives to avoid indeterminacy. Ruth Millikan suggests that the contents of representations are certain “normal conditions”: the most crucial conditions in the world that tokens of the representations are supposed to covary with in order for the motor mechanisms that use them to bring about their beneficial behavioral effects. However, her account delivers contents that seem implausible given the recognitional capacities of the sensory mechanisms that produce simple representations. Karen Neander proposes that the contents of representations are their “normal causes”: the events in the world that the sensory mechanisms that produce them causally respond to when they are not malfunctioning. Yet, her account is problematic because it does not make room for misrepresentation due to deceptive external circumstances. I argue that both alternatives fail to account for what biologists regard animals as recognizing. While biologists characterize certain inner states of frogs as responsible for prey recognition, neither Millikan’s nor Neander’s theories treat them as representing the *animals* that constitute frogs’ prey.

I propose a version of teleosemantics that takes into account both the causes and effects of representations. I suggest that the content of a simple representation is the most crucial among the normal conditions required for its tokens to bring about beneficial behavioral effects that is also causally responsible for such tokens. This version allows for misrepresentation due to deceptive external circumstances and delivers contents that are plausible given the recognitional capacities identified by biologists: frogs represent the *animals* they prey on. In the following sections, I introduce teleosemantics and its problem of indeterminacy (“[Teleosemantics, misrepresentation and indeterminacy](#)” section), lay out Millikan’s and Neander’s versions (“[Millikan’s teleosemantics](#)” and “[Neander’s teleosemantics](#)” sections), and argue that both fail to deliver the contents identified by biologists (“[Frogs recognize prey](#)” section). Afterwards, I present my hybrid approach (“[Causal-behavioral teleosemantics](#)” section) and discuss its handling of causal sensitivity (“[Causal sensitivity](#)” section). Lastly, I address further issues with Neander’s and Millikan’s theories (“[More on Neander](#)” and “[More on Neander](#)” sections), and briefly examine recent suggestions by David Papineau, Manolo Martínez, and Marc Artiga, which share similar aims with my hybrid approach (“[Recent approaches](#)” section).

## Teleosemantics, misrepresentation and indeterminacy

Drawing on the classical example of frogs’ prey detectors, I illustrate how teleosemantics provides a framework to account for misrepresentation, which favors it over purely causal or informational semantics. But I point out that it faces a challenge regarding the determinacy of function and content.

Frogs are visual hunters that eat insects, worms and any small animal that fits into their mouths. A hungry frog innately responds to prey-sized animals moving in front of it with prey-catching behavior: it snaps its sticky tongue to catch and eat them. The philosophical discussion of this case was inspired by Jerome Lettvin et al. (1959), which colloquially characterized certain retinal ganglion cells of frogs as *bug detectors*. Subsequent studies showed that prey-recognition takes place in the visual regions of frogs’ brains (Ewert et al. 1983: 414–415). Let us assume that the

neural state,  $R$ , which is activated by a moving prey animal and triggers prey-catching behavior, represents the presence of a *prey animal*. How can this state have such a representational content?

An influential approach suggests that contents are determined by the reliable causal or correlational links in virtue of which representations carry information about reality (Dretske 1981; Fodor 1990). According to this approach,  $R$  can be said to represent the presence of a *prey animal* insofar as its tokens are reliably caused by or reliably covary with the presence of prey animals. Fred Dretske suggested that  $R$  indicates or represents *bugs* because it is caused *only* by moving bugs in frogs' natural habitat (Dretske 1981: 35). Notice that tokens of  $R$  are *not* caused only by moving prey animals: “[The frog] will leap to capture any object the size of an insect or worm, providing it moves like one. He can be fooled easily not only by a bit of dangled meat but by any moving small object.” (Lettvin et al. 1959: 1940). Lettvin and his colleagues fooled frogs in their lab with prey dummies to study them. But  $R$  may be caused even in frogs' natural habitat by small moving objects (SMOs) that are not prey animals, such as leaves carried by the wind. The informational account cannot treat such cases as instances of *error* or *misrepresentation*, since whatever causes or is correlated to  $R$  will be part of what  $R$  represents. As Peter Godfrey-Smith points out: “informational semantics has been hounded by a problem with error” (Godfrey-Smith 1989: 533–534). A proper theory of content must distinguish between certain “normal” causal or correlational links between representations and reality, which determine their content, and “abnormal” ones involved in cases of misrepresentation.

Teleosemantics relies on a teleological or teleonomic notion of function to determine which are the “normal” content-determining links. The teleonomic function of an item is what it has been selected for doing by Darwinian natural selection or some analogous process that explains its current existence. Consider a particular kidney—say, one of  $A$ 's kidneys. It has the function of filtering blood because the explanation of why it exists is that having kidneys benefited  $A$ 's ancestors by filtering blood, thereby aiding their survival and reproduction, which resulted in the inheritance of the trait by their descendants, including  $A$ .  $A$ 's kidney has this function even if it *fails* to perform it. The function of an item is not what it is disposed to do, but what it is *supposed* to do given the selective *history* that explains its existence.<sup>1</sup> Very roughly, teleosemantics proposes that representations, or the mechanisms that produce and/or use them, have functions that involve or that they perform in virtue of certain links to reality that determine their content. These are links that representations are supposed but may fail to have. In the case of the frog,  $R$  is produced by sensory mechanisms presumably selected for prey-recognition and is used by motor mechanisms presumably selected for prey-capture. So  $R$  is *supposed* to be tokened in the presence of prey animals. If this accurately described the unique

<sup>1</sup> This teleonomic account of functions is *etiological*. Its main proponents are Millikan (1984) and Neander (1991). An early precursor is Larry Wright (1973). Paul Griffiths (1993) and Godfrey-Smith (1994) suggest amendments to handle vestigial traits. While alternative accounts exist, I will adopt the etiological approach shared by the versions of teleosemantics I discuss.

functions of the sensory and motor mechanisms, teleosemantics would characterize *R* as representing the presence of *prey animals* and explain why frogs *misrepresent* when *R* is triggered in their absence.

But teleosemantics faces a challenge related to the determinacy of content. Assuming that frogs exclusively eat flies, Jerry Fodor (1990) argued that teleosemantics fails to provide determinate contents because Darwinian natural selection does not dictate whether frogs' detectors should be regarded as *fly* detectors or *SMO* detectors: "Darwin doesn't care how you describe the intentional objects of frog snaps. All that matters for selection is how many flies the frog manages to ingest in consequence of its snapping" (Fodor 1990: 72–73). And there are more possibilities to consider. We could describe frogs as having detectors of proximal *small moving images* (*SIMs*) in their retinas, as snapping in response to *SIMs* aids frogs in catching flies. We could even characterize them as having detectors of *food* or *nutritious objects*, since ingesting flies benefits frogs by providing nutrients.

The first step to solve the indeterminacy problem is to notice that the relevant mechanisms have an array of different functions that are captured by the alternative descriptions. As Neander (1995) points out, frogs' prey detectors contributed to frogs' survival *by*:

being activated in the presence of food or nutritious things  
*by*  
 being activated in the presence of prey animals  
*by*  
 being activated in the presence of SMOs or SIMs.

These are *all* functions of the detectors. The full explanation of why the detectors exist must include all of them. So frogs' detectors do not have indeterminate functions, but various hierarchically-nested functions.<sup>2</sup> Content determinacy can be achieved by choosing which functions are involved in the determination of content. The main teleosemantic theories have forked into two directions. One of the alternatives, suggested by Millikan, delivers contents related to the higher-level functions, which I shall call "high-level" contents, while the other, proposed by Neander, delivers contents related to the lower-level functions, or "low-level" contents. I will discuss these alternatives before suggesting a proposal that combines features of both to deliver "mid-level" contents.

<sup>2</sup> I take "food" to be the same as "nutritious things". The lower level may be decomposed into two levels: the detectors are activated in response SMOs *by* being activated in response to SIMs (Neander 2013 & 2017). Alternatively, we may skip SMOs altogether, characterizing the lower level as involving SIMs (Millikan 1990b).

## Millikan's teleosemantics

Millikan's solution to the indeterminacy problem relies on the functions of the "consumer" mechanisms that *use* representations and the "normal conditions" required for such mechanisms to perform their functions (Millikan 1989, 1990a, b). The consumer has the function of bringing about certain *beneficial behavioral effects*. Crucially, the successful performance of this function explains the existence of both the producer and the consumer of a representation, which have been selected for collaborating to achieve such goal. Millikan argues that the main function of the producer is to provide what the consumer needs to perform its function (Millikan 1989: 286). And what the consumer needs is the representation to be tokened when certain *condition* in the world obtains—it needs "a certain correspondence relation... between sign and world" (*Ibid.*: 287). This is a *normal condition*, which tokens of the representation are supposed to covary with, for the consumer to perform its function: "a condition, the presence of which must be mentioned in giving a full normal explanation for performance of that function" (*Ibid.*: 285), where a *normal explanation* tells how the function was "historically performed on those (perhaps rare) occasions when it was properly performed" (*Ibid.*: 284). Such explanation covers only successful performances that benefited animals, aided in their survival and reproduction, and contributed to the inheritance of the trait by their descendants. Millikan identifies the content of a representation with the *normal condition* involved in the normal explanation of the performance of its consumer's function (*Ibid.*: 287), or more precisely, in the *most proximate* or *least detailed* normal explanation (Millikan 1984: 33–34), since the *full* one also involves normal background conditions that are not part of the representation's content.

Millikan argues that her approach solves the indeterminacy problem (Millikan 1990a: 153). Her initial suggestion is that the firing of the frog's detector is supposed to coincide with "the presence of an edible bug" (*Ibid.*: 154). Even if frogs' detectors have an array of functions, the only one that matters for content determination is that they token *R* when an edible bug is present, since this is the normal condition for the consumers to properly perform *their* function of catching edible bugs. Millikan emphasizes that whether the detectors perform this function by *causally* responding to bugs or not is irrelevant to the content of *R* (Millikan 1989: 290). As I argue below, this feature of her teleosemantics is responsible for its drawbacks, but I set that aside for the moment. While Millikan (1989, 1990a) assumes that consumers have the single function of catching edible bugs, in reality, they have an array of functions. The motor mechanisms activated by *R* contributed to frogs' survival by:

making frogs snap their tongues towards and catch food or nutritious things

*by*

making frogs snap their tongues towards and catch prey animals

*by*

making frogs snap their tongues towards and catch SMOs or the sources of SMIs.

The normal conditions for the performance of each of these functions are, respectively, the presence of (1) food or nutritious things, (2) prey animals and (3) SMOs or SMIs. To truly solve the indeterminacy problem, Millikan needs a criterion for identifying which of the consumer's functions is involved in content determination. Millikan (1990b) accepts that consumers have more than one function and offers such a criterion. She argues that they have lower-level functions of producing certain behaviors given certain *proximal* stimuli—e.g., snapping the tongue in a certain direction given the location of an SMI in the retina—since this partly explains the historical proliferation of the mechanisms (*Ibid.*: 331–332). She emphasizes that performing these functions plays a role in the normal explanation of how the consumers perform their higher-level functions involving *distal* affairs—and that performing the former is a *means* to performing the latter (*Ibid.*: 335). However, she maintains that success in performing the latter is what truly matters, as it brings about the beneficial effects that are most crucial for selection for the trait (*Ibid.*: 336). Consequently, the content of a representation is the normal condition involved in the performance of the higher-level function, which I will call the “*most crucial normal condition*”.<sup>3</sup>

In the frog case, Millikan's criterion may be applied to argue that *R* represents *edible bugs* rather than *SMIs*, since the trait only benefited frogs when the higher-level function of snapping towards and catching edible bugs was performed, contributing to their survival and the inheritance the producers and consumers of *R* by their descendants. However, following the same line of reasoning, frogs represent *food* or *nutritious objects* rather than *edible bugs*, as it was only because the objects caught were nutritious that the trait was truly beneficial. Millikan (1991) seems to accept this result, claiming that “the firing [of *R*] means frog food” (*Ibid.*: 163).<sup>4</sup> Likewise, Carolyn Price (2001) proposes a version of teleosemantics that aligns with Millikan's in key aspects, and she argues that *R* represents *nutritious objects*, since what “makes flies relevant to frogs is their biochemical properties—the properties that make them nutritious to frogs” (Price 2001: 80). Teleosemantic theories that focus on the *benefits* of the behaviors guided by representations tend to deliver high-level contents.

A reasonable concern is that frogs are unable to perceptually recognize their prey as nutritious, as I argue below. Neander proposes a different kind of teleosemantics aimed at delivering contents aligned with the capabilities of sensory systems.

<sup>3</sup> In fact, Millikan argues that *only* the higher-level function and the normal condition for its performance must be mentioned in the most proximate or least detailed normal explanation (Millikan 1990b: 336–337n). Lower-level functions and normal conditions for their performance are needed only for the *full* normal explanation.

<sup>4</sup> Millikan (1991) alleges that “the systems that use... the frog's fly detector signals, don't care at all whether these correspond to anything black or ambient or specklike, but only whether they correspond to frog food” (*Ibid.*: 163). Is she reverting to her earlier assumption that the consumers have a *single* function, now identified as getting food? Clearly not, since she explicitly argues that both the producers and the consumers have multiple functions (*Ibid.*: 161).

## Neander's teleosemantics

Neander's solution to the indeterminacy problem relies on the low-level functions of the sensory mechanisms that produce perceptual representations; more precisely, on what they are supposed to causally respond to or detect (Neander 1995, 2013, 2017). Her initial suggestion is that the content of a perceptual representation is determined by the *most specific function* of the mechanism that produces it, which is the one it performs on its own when it does not malfunction and which is the lowest in its array of hierarchically-nested functions (Neander 1995: 118). She argues that *R* represents the presence of *SMOs*, since detecting *SMOs* is the lowest-level and most specific function of the perceptual mechanism involved: "it is *by* detecting small dark moving things that the frog detects frog-food and flies" (*Ibid.*: 130). While the detectors have higher-level functions involving prey animals and food, they are not malfunctioning when they causally respond to *SMOs* that are neither animals nor nutritious, so "the frog doesn't misrepresent as long as its representation *R* is caused by something appropriately small, dark and moving" (*Ibid.*: 129).

A concern about Neander's proposal is that teleonomic functions are standardly characterized as *selected effects*—including Neander (1991) herself—so a mechanism allegedly cannot have the function of causally responding to something. Millikan contends that "it cannot be the function of a state to have been produced in response to something" (Millikan 1989: 283). David Papineau objects that Neander's teleosemantics starts "at the wrong end" by focusing on "what is supposed to *cause* the frog's state... what it is supposed to detect..." (Papineau 1998: 7). Addressing this issue, Neander (2013 & 2017) argues that the function of a mechanism—what it has been selected for *doing*—is a *selected causal role* or *selected disposition* that must include its *effects* but may also involve its input *causes*; so sensory mechanisms can and do have *response functions*: functions to produce representational states in response to certain input causes (Neander 2013: 23–26 & 2017: 127–130). The content of a perceptual representation, she suggests, is its "normal cause" (Neander 2017: 136). More precisely, a representation *R* produced by a perceptual system *S* represents the presence of *C* if and only if "S has the function to produce R-type events in response to C-type events (in virtue of their C-ness)" (*Ibid.*: 151). The parenthetical qualifier highlights that causation is property-sensitive (*Ibid.*: 159). Neander argues that frogs' detectors, when functioning properly, produce *R* in response to *SMOs qua SMOs* and not *qua* prey animals or nutritious objects: they are "*not* causally sensitive to the presence or absence of frog food or flies as such" (*Ibid.*). While she is right about frog food, I argue below that the detectors *are* causally sensitive to small moving animals.

Millikan (2013) is skeptical about response functions. Consider *S*'s alleged function of tokening *R* in *response* to *C*. According to Millikan, *S*'s function is instead to token *R* in the presence of *C*, which is a selected effect, while *C* causing *R* is part of the normal explanation of how this function is performed and not itself a function (Millikan 2013: 39–40). She points out that *S* may perform this

function *abnormally*: it may token *R* in the presence of *C* by accident, without *C* causing *R* (*Ibid.*: 40). Neander cannot account for this, since the response function was *not* performed, which shows that we need a function of the sort Millikan prefers. But this is compatible with such function being performed by means of performing a response function. In any case, *S* tokens *R* in the presence of *C* *normally* by causally responding to *C*. So even Millikan's account supports characterizing some events as the *normal causes* of representations. It is a mistake to think that the account of functions as selected effects rules out normal causes from teleosemantics. Relying on normal causes is as legitimate as relying on normal conditions—even if neither of them are parts of functions.<sup>5</sup>

Another concern is whether Neander's teleosemantics can account for *distal* contents. As Neander (1995) acknowledges: "It is, after all, *by* responding to a retinal pattern of a particular kind that the frog responds to small dark moving things." (Neander 1995: 136). Her original criterion based on the lowest and most specific function actually delivers *proximal* contents. Neander (2013 & 2017) deals with this problem by supplementing her teleosemantics with a *distality principle*. According to this principle, a perceptual representation *R* refers to its distal normal cause *D* rather than its proximal normal cause *P* if and only if the sensory system has the function of tokening *R* in response to *D* (*qua D*) by tokening *R* in response to *P* (*qua P*) (Neander 2013: 34 and 2017: 221–222). This principle picks out the *higher* response function as the one that determines content. So it is incompatible with Neander's original criterion, which she abandons (Neander 2017: 271n).

Frogs allegedly represent *SMOs* because the detectors' response to *SMOs* is performed *by* their response to *SMIs*, rather than the other way around. Considering that responding to prey animals or food would constitute higher functions, why not regard the detectors as representing them instead? Neander offers two considerations against these candidates. First, the detectors are *not* causally sensitive to such stimuli, she contends, so their functions related to prey animals and food are not *response* functions (*Ibid.*: 223). Second, they lack the discriminative capacity to distinguish between *SMOs* that are prey animals or food and those that are not. She claims that "an attenuated form of verificationism" is justified for simple perceptual representations: they cannot refer to *X* rather than *Y* if their producer in a normal system has "no ability... to distinguish between the two" (*Ibid.*: 120). A *normal* system is one with no internal *abnormalities*, such as brain lesions (*Ibid.*: 107). A lesioned frog may fail to distinguish *SMOs* from large moving objects. According to Neander, the frog *misrepresents* when *R* is triggered by the latter, as they do not cause *R* in normal frogs (*Ibid.*: 116). Neander (2017) still identifies the content of a perceptual representation with what causes it when its producer is not malfunctioning.

<sup>5</sup> Millikan (2013: 37–39) also argues that there cannot be selection *for*, but only selection *of*, a mechanism responding to certain inputs. But this is a misuse of Elliot Sober's (1984) distinction between selection *for* beneficial traits that are causally efficacious in the selection process and mere selection *of* free-riders that come along with the beneficial traits. A perceptual mechanism's disposition to respond to certain inputs is clearly beneficial and causally efficacious—not a mere free-rider—in the mechanisms' selection (Neander 2017: 132–133).



While Millikan's theory treats frogs as representing things they have no capacity to recognize, Neander's treats normal frogs as unable to misrepresent under deceptive external circumstances. Both fail to account for what biologists regard frogs as recognizing, as I argue in the next section.

## Frogs recognize prey

In the philosophical discussion about how to explain the contents of simple representations, the initial assumption was that frogs represent *prey animals*—such as *bugs* or *flies*. When Dretske (1981) introduced the case, he attempted to show that his informational theory was able to show why frogs represent *edible bugs*. In his discussion of teleosemantics, Fodor (1990: Ch. 3) assumed that it should explain that frogs represent *flies*. Even Millikan (1990a) initially maintained that her teleosemantics shows that frogs represent *edible bugs*. But the assumption was discarded when it became clear that the proposed theories did not deliver mid-level contents. Millikan (1991) and Price (2001) endorsed high-level contents like *food* or *nutritious things*, while Neander (1995) proposed low-level contents, aligning herself with Fodor (1990: Ch. 4) and Dretske (1990), who ended up suggesting contents such as *little black dots*. However, I will argue that the original assumption was on the right track: an adequate theory should provide mid-level contents for simple mental representations.

The high-level contents delivered by Millikan's theory seem implausible in the case of simple representations. These representations are the outputs of perceptual systems and directly control motor systems. They are not influenced by, and do not participate in, inferential processes of the sort involved in the use of complex conceptual representations. So, it is reasonable to doubt that they represent things or events that the sensory systems themselves have *no* capacity to *recognize*. The case of the frog clearly illustrates the problem. There is no evidence that frogs visually recognize what they catch as *nutritious*. As Lettvin et al. (1959: 1940) point out, the frog “will starve to death surrounded by food if it is not moving.” Recall that they even regard the frog as being “fooled” in the lab by a nutritious “bit of dangled meat” that is “the size of an insect or worm” and “moves like one” (*Ibid.*). What they suggest is that the frog mistakes the piece of meat for a small moving animal, since it does not respond to it as a nutritious object. Biologists determine an animal's recognitional capacities based on the events or objects in its environment to which it *responds* with goal-directed behavior. Consequently, anurans—frogs and toads—are characterized as *recognizing prey* (Ewert et al. 1983), not nutritious objects, even when getting nutrients explains *why* recognizing and catching prey animals is adaptive and evolved. Millikan's theory delivers contents that are not supported by our best scientific theories about what animals recognize. I consider this a serious drawback.

Similarly, the low-level contents favored by Neander do not align with what biologists say about recognitional capacities and recognitional failures under deceptive external circumstances. Lettvin et al.'s (1959: 1940) characterization of the frog as being “fooled” by “any moving small object” and of certain neurons as *bug detectors*

is inconsistent with her account. However, Neander (2017: Ch. 5) argues that mid-level contents are ruled out by mainstream neuroethological studies, by Ewert and his colleagues, according to which toads' "prey" recognition involves detecting small elongated objects moving in the direction of their longer axis: "worm-like objects" (WLOs). She interprets these studies as demonstrating that toads merely recognize *WLOs*, since they show that toads cannot distinguish WLOs that are prey animals from those that are not. Yet the authors explicitly state that the activation of certain toad neurons *means* "Object recognized as prey" (Ewert et al. 1983: 459). Neander (2017: 116) contends that their talk of *prey* recognition is "simply shorthand" for *WLO* recognition. But experiments with prey dummies are described as follows: "The toad may interpret such a small object as a prey animal and try to catch it" (Ewert 1980: 72). Toads are regarded as representing *prey animals* and as fooled by prey dummies. Other neuroethologists say similar things: toads "are readily deceived by small cardboard models moving in front of them" (Simmons & Young 2003: 9).

Biologists also interpret toads as being deceived when they fall victim to aggressive mimicry. For instance, the puff adder moves its tongue in a worm-like fashion to attract and eat toads, which are "fooled into mistaking the mimic for the model" (Glaudas and Alexander 2017: 2). Aggressive mimicry is standardly regarded as deceiving its victims (Jamie 2017). Even Ewert (1980: 45) indicates that mimicry involves "signal falsification", which does not match Neander's interpretation of his studies as ruling out mid-level contents. Our best scientific theories about what animals can recognize support mid-level contents and make room for recognitional errors or misidentifications. Regarding anurans as representing *prey animals* plays a crucial role in biologists' explanations of their *prey-catching* behavior, its success, and their deception by mimics. Neander's theory cannot account for toads being deceived, since prey dummies and puff adders' tongues are WLOs and toads' detectors are activated by them without malfunctioning. I consider this a major flaw. Interestingly, Millikan's theory may also be unable to account for toads being deceived by puff adder lures, insofar as snakes' tongues are nutritious objects.

Both Millikan's and Neander's teleosemantics provide valuable insights, yet they fail to account for what biologists take animals to (fallibly) recognize. If my assessment is correct, we need a different kind of teleosemantics.

A troubling aspect of the philosophical debate about how to explain the contents of simple animal representations is that it seems to rely heavily on *intuitions* about what animals represent that are not shared by all authors engaged in the debate, making it difficult to adjudicate among different proposals.<sup>6</sup> To overcome this situation, I suggest relying on *identifications* of the contents to be explained (the *explananda*) that are firmly established independently of mere intuitions and the philosophical theories of content (the *explanantia*) under evaluation. The considerations I just offered in favor of mid-level contents are based on characterizations of perceptual recognition that biologists employ to explain animal behavior. These characterizations are neutral with respect to philosophical theories of content and intuitions, they

<sup>6</sup> I thank an anonymous reviewer for urging me to address this issue.

are empirically well-supported, and play important explanatory roles. As far as I can tell, they constitute the best identifications of contents available for the simple animal representations at stake in the philosophical debate and offer robust *explananda* for theories of content. The original assumption that frogs represent *bugs* was on the right track precisely because philosophers initially deferred to Lettvin et al. (1959). To her credit, Neander (2017) considers neuroethologists' views on perceptual recognition to find independent identifications of the contents she favors. Nonetheless, I argued that she misinterprets neuroethologists, who do not rule out mid-level contents. While more work needs to be done on this issue, I will assume that my reading is roughly correct and that the biology of behavior supports mid-level contents.

## Causal-behavioral teleosemantics

Can teleosemantics deliver mid-level contents? I suggest that a hybrid approach that combines key features of Millikan's and Neander's proposals can deliver such contents. Teleosemantics *can* account for why frogs represent the *small animals* that constitute their prey.

I propose a version of teleosemantics, which I shall call "Causal-Behavioral Teleosemantics" (CBTS), that relies on both the causes and beneficial behavioral effects of simple mental representations to explain their contents. CBTS embraces Millikan's idea that the content of a representation is a *normal condition* that its tokens are supposed to covary with for its consumer to perform one of its functions—bringing about certain beneficial behavioral effect. But CBTS does not follow Millikan in identifying content with the normal condition for the performance of the highest-level function of the consumer regardless of whether such condition is causally involved in the tokening of the representation. On the contrary, CBTS incorporates Neander's proposal that the content of a simple representation is an event that its producer is supposed to respond to in order to perform one of its functions: a *normal cause* of tokens of the representation.

As pointed out above, a normal cause may be either part of a response function, characterized as a selected causal role, or part of the normal explanation of how the producer performs one of its functions, characterized as a selected effect. CBTS is compatible with both options. But, unlike Neander, CBTS does not equate a normal cause with the stimuli that producers respond to whenever they are functioning properly or not malfunctioning. Instead, CBTS identifies a normal cause *only* with what the producers respond to in function-conferring occasions. These are occasions where *all* the functions of the producers and consumers were successfully performed, which effectively contributed to selection for the sensory-motor trait. In Millikan's terms, function-conferring occasions are those covered by a normal explanation of successful performances of the sensory-motor trait. If events *X* and *Y* both trigger a representation when the perceptual mechanism is functioning properly, but only *X* does so in the situations that contribute to the trait's selection, then only *X* is a normal cause of the representation—even if the properly functioning perceptual mechanism cannot distinguish *X* from *Y*.

CBTS claims that the content of a simple representation is an event that is both a normal condition for its use or consumption and a normal cause of its production. This already rules out certain candidates for content: normal conditions for the performance of the consumers' functions to which the producers are not causally sensitive cannot constitute the content of a simple representation. However, CBTS requires a criterion for choosing among different normal conditions that are also normal causes, given that there may and typically will be more than one candidate—given the array of functions of the consumers and producers of a representation. Otherwise, it will not deliver determinate contents. CBTS adopts the criterion that the content of a simple representation is the *most crucial* among the *normal conditions* for its consumption that also plays a role as a *normal cause* of its production—where a normal condition is more crucial than another if it is involved in the performance of a higher-level function. The proposal can be summarized as follows:

CBTS: The content of a simple representation  $R$ , produced by a perceptual mechanism  $S$  and used by a motor mechanism  $M$ , represents  $C$  if and only if:

- (1)  $C$  is a *normal condition* that tokens of  $R$  are supposed to covary with for  $M$  to perform one of its functions,
- (2)  $C$  is a *normal cause* of  $S$  tokening  $R$  and
- (3) there is *no* higher-level function of  $M$  such that the normal condition for its performance is also a normal cause of  $S$  tokening  $R$ .

To put it plainly, the suggestion is that the content of a simple representation is the most crucial among the normal conditions required for its tokens to bring about beneficial behavioral effects that is also causally responsible for such tokens. Normal conditions that are even more crucial for the benefit of the behavior but are not among the normal causes are not represented.

In the simplest Fodorian case of the fly-eating frog, the activated neural state  $R$  does not represent *food* or *nutritious things*, since the nutritious properties of flies are not causally involved in  $R$ 's activation.  $R$  does not represent *SMIs* either, even though the presence of an SMI is both a normal condition for  $R$ 's use and a normal cause of  $R$ . This is because there is a normal condition for the performance of a higher-level function of  $R$ 's consumer that is also a normal cause of  $R$ : the presence of an SMO. However, I suggest that  $R$  does not represent *SMOs* either, as there is a normal condition for the performance of an even higher function that is also a normal cause of  $R$ : the presence of a fly. This is the most crucial among the normal conditions for  $R$ 's consumption that is also a normal cause of tokens of  $R$ . So,  $R$  represents the presence of a *fly*.

## Causal sensitivity

An obvious objection to my account hinges on Neander's argument that the producer of  $R$  is not causally sensitive to the presence of flies *qua* flies. If she were correct, CBTS would fail to deliver the intended contents. I defend CBTS from this objection and further elaborate on how it delivers mid-level contents.

CBTS embraces the principle that Neander's argument is based on: the property-sensitive nature of causation. It relies on it to deny that  $R$  represents *nutritious*

*objects*. The point is that being nutritious is a property that is *not* causally efficacious in the triggering of *R*. Nutritious objects do not cause *R qua* nutritious. In contrast, SMOs do cause *R qua* SMOs, since the frog's detector causally responds to their size and movement. Now consider a bit of dangled meat. It is both a SMO and nutritious. But it can only cause *R qua* SMO, not *qua* nutritious. I am in agreement with Neander about this. However, I will argue that she misapplies the principle when she uses it to deny that *R* represents *flies*. The property of being a fly, I suggest, *is* causally efficacious in the triggering of *R*.

It will be helpful to consider a different case first. Moths detect bats, which prey on them, *by* detecting the ultrasounds they emit for echolocation, and respond with bat-avoidance behavior (Roeder & Treat 1961). Neander would suggest that the activated detectors represent *ultrasound emitting objects* (UEOs), as their activation is caused *by* the rapid vibrations of moths' tympanal ears *qua* rapid tympanal vibrations, which in turn are caused *by* UEOs *qua* UEOs. But the causal chain does not stop there, as the ultrasound emissions are caused *by* bats *qua* bats in function-conferring occasions.<sup>7</sup> Bats *produce* ultrasounds due to their behavior and physiology, including brain circuitry, vocal cords, etc. The system causally responsible for the emissions is a living bat.<sup>8</sup> Thus, the moth *is* causally sensitive to bats. According to CBTS, the activated detectors represent the presence of *bats*, as their consumers have the function of helping moths avoid predation by bats, and there is no higher-level function with a normal condition that the detectors are causally sensitive to.

The case of frogs' fly detectors is analogous. The *movements* that trigger *R* are ultimately caused, in function-conferring occasions, by *self-propelled fly locomotion*. The fly *produces* such movements *qua* fly. Its flying movement is the effect of a complex causal mechanism that involves its wings, muscles, nervous system, etc. The system causally responsible for the flight is a living fly. Flies are SMOs, but the causes of their movement differ from those of other kinds of SMOs. A moving fly is a normal cause of *R*, while a leaf moved by the wind is not a normal cause *qua* leaf moved by the wind. Neander neglects that the events she regards as being represented have underlying causes that the sensory systems are also supposed to respond to, given their selective history.

But how can CBTS explain the content of *R* in real frogs, which prey on various kinds of small animals? I suggest that the same considerations that apply to flies apply to *each* other kind of small animal that frogs have evolved to hunt—e.g., the self-propelled locomotion of a beetle *qua* beetle is a normal cause of *R*. While *R* is causally sensitive to small moving animals of *any* kind, only the presence of the kinds of animals that frogs have been selected for hunting will be among the normal causes of *R* and among the normal conditions for *R*'s use. As a result, *R* will represent the *presence of either a fly, a beetle, an ant*, etc.<sup>9</sup> We can express such content

<sup>7</sup> I endorse the principle adopted by Neander, according to which if *A* causes *B* and *B* causes *C*, then *A* causes *C*. It does not seem objectionable in the causal chains Neander and I rely on.

<sup>8</sup> Following Martínez (2013), we may characterize the bat as the homeostatic property cluster responsible for the emissions.

<sup>9</sup> This disjunctive solution is similar to, and inspired by, a suggestion made by Artiga (2021: Sec. 3.2.4).

by saying that *R* represents *prey animals*. But the property of being prey is not causally involved in *R*'s activation. Strictly speaking, “prey” is a label for the animals that the frog has been selected for detecting and catching. I take this to be consistent with what biologists mean when they characterize animals as having the capacity to recognize their prey.

Neander (2017: 136–137) discusses a challenging case. Cleaner ants remove the corpses of dead ants from the nest, in response to the detection of the oleic acid they exude. Neander says they represent the presence of *oleic acid*. According Millikan they would represent the *risk of bacterial contamination*. How can CBTS handle this case? The exudation of oleic acid is caused by the decomposition that occurs due to the unique structure, composition, and the cessation of life processes in ant bodies (i.e., their death). So, cleaners are causally sensitive to the corpses *qua* ant corpses. The cleaner represents an *ant corpse*, according to CBTS, insofar as its presence is a normal cause of the perceptual state and a normal condition for necrophoric behavior. (Removing objects that exude oleic acid is a lower-level function.) However, since bacteria are causes of corpse decomposition and removing infected corpses is a more crucial function of necrophoric behavior, CBTS may further entail that cleaners represent *ant corpses infected with bacteria*. This would not be an overly fine-grained content. As biologists Diez et al. (2013: 1431) suggest, “one may wonder whether differences in chemical cues [including oleic acid] on the cuticle of diseased workers can be used by ants to discriminate infected corpses”.<sup>10</sup>

## More on Neander

If the causal sensitivity of sensory mechanisms reaches beyond the most superficially detectable properties of perceived objects, this undermines Neander's assessment about what contents her own theory delivers. I briefly discuss this and focus on Neander's verificationism, which conflicts with CBTS.

Price (2014: 590) and Artiga (2015: 681) point out that Neander's distality principle fails to deliver the contents that she intends, since frogs respond to flies *by* responding to SMOs. Peter Schulte (2018: 357) replies that this overlooks that the presence of flies is not *causally relevant* for the production of *R*. My considerations about causal sensitivity vindicate Price and Artiga. Interestingly,

<sup>10</sup> Ants recognize their nestmates, dead or alive, by another chemical (Diez et al. 2013). They behave differently towards alien ant corpses (*Ibid.*). Nestmates *produce* the chemical *qua* nestmates or family members, as it results “from the expression of a common allele” (*Ibid.*: 1425). Thus, cleaners are causally sensitive to dead nestmates *qua* nestmates. CBTS can account for ants representing the corpses as *nestmates*: the presence of a nestmate is a normal cause of the detection, which is also a normal condition for the relevant behavior. Neander (2017: 136–137) points out that oleic acid is also involved in foraging. In this case, the ant's detector is part of another sensory-motor system. The underlying causes of oleic acid in an insect that the ant treats as prey are *different*, as well as the normal conditions for foraging behavior. Moreover, the prey insect lacks the “nestmate” chemical cue, and oleic acid may trigger prey retrieval “in combination with other cues” (Diez et al. 2013: 1424). CBTS can explain why prey insects are represented differently than corpses, even though both are detected (at least in part) by their oleic acid.

Schulte argues that there are *other* cases where Neander's distality principle delivers mid-level contents that she intends to reject (*Ibid.*: 358–359). Numerous animals locate other animals *by* the sounds and smells *produced* by the latter; in these cases, Neander's distality principle entails that the located *animals* are represented, since they cause the relevant sounds and smells (*Ibid.*: 359n). Moths' bat detectors are a case in point. However, these objections consider the distality principle in isolation from Neander's verificationism about discriminative capacities, which rules out any mid-level contents—but, problematically, also any distal ones, as I will argue below.

Neander argues that frogs cannot represent prey animals because *normal* frogs cannot *distinguish* between SMOs that are prey animals and those that are not. CBTS rejects the verificationist principle that this consideration relies on. Recall that CBTS identifies a normal cause only as one that triggers a representation on function-conferring occasions. So it does not matter whether frogs' detectors cannot distinguish moving prey animals from leaves carried by the wind and are functioning properly when triggered by the latter. Insofar as only the former cause *R* in the situations that contribute to selection for the sensory-motor system, they are normal causes of *R* while the latter are not. In this regard CBTS has an important advantage over Neander's teleosemantics. As Millikan (2013: 40) objects, misrepresentation can occur without malfunctioning, due to the absence of the right external conditions. Similarly, Godfrey-Smith (1989: 546) points out that the interesting cases of misrepresentation are those that occur because “the world is deceptive”. Neander's theory cannot account for these cases of misrepresentation, while CBTS handles them properly. But why should we accept a reasoning against the verificationist principle based on the alleged plausibility of mid-level contents and the kinds of misrepresentations they make room for, rather than accepting Neander's reasoning against mid-level contents based on the alleged plausibility of the verificationist principle? Because biological accounts of animals' recognitional capacities and failures provide independent support for mid-level contents and for characterizing animals as being deceived by external circumstances.

Moreover, Neander's verificationism undermines her distality principle. Since malfunctioning is an internal matter, only functions involving purely internal events can always be performed without malfunctioning. In contrast, a perceptual mechanism may fail to perform *any* of its distal functions while functioning properly. As Price (2014: 589) notes, *R* may be caused in the absence of an SMO “even without malfunctioning... in shifting lighting conditions”. For example, a large flying bird may cast a small moving shadow in front of the normal frog or even directly on its retina, thereby triggering *R* in the absence of an SMO and with no malfunctioning of the detectors. If there is no misrepresentation without malfunctioning, there are no distal contents. Neander's theory collapses into an account of proximal contents, failing to deliver the distal contents she expects. CBTS avoids this serious problem by explaining what is supposed to cause a representation in terms of what triggers it during function-conferring occasions, rather than in non-malfunction scenarios. Attention to the functions of the consumers is crucial to determine function-conferring occasions, which are instances where all functions of the sensory-motor system are successfully performed.

## More on Millikan

Paul Pietroski (1992) and Neander (1995) present interesting cases where Millikan's theory delivers implausible contents. I briefly discuss these cases, Millikan's replies, and how CBTS handles them.

Pietroski (1992) offers a thought experiment that challenges Millikan's teleosemantics. Kimus are color-blind animals that live in a valley where snorfs, their main predators, hunt during the day. Kimus are utterly unable to recognize snorfs, but they eventually evolve red detectors and the instinct to head towards red things, exclusively because this helps them to avoid snorfs by making them climb a nearby hill every morning, attracted by "something red on the hilltop" (Pietroski 1992: 273). Millikan's theory entails that kimus' activated detectors represent *snorf-free areas*, since avoiding snorfs is the most crucial benefit of climbing the hill. But such content cannot play a role in a plausible explanation of kimus' behavior; indeed, "all the behavioral evidence" goes against the claim that kimus represent *snorfs*, since they cannot "discriminate snorfs from non-snorfs" and their representations are tokened "in the absence of *any* causal interaction" with snorfs (*Ibid.*: 276–277). Millikan replies that the content delivered by her theory is plausible, since the *correlation* between red light and the direction free of snorfs explains selection for the trait (Millikan 2000: 236). She points out that certain desert tortoises find their food, edible vegetation, by its green color, which is merely correlated to, rather than caused by, its nutritional characteristics (*Ibid.*). However, the kind of behavioral evidence Pietroski mentions against kimus representing *snorfs* also counts against tortoises representing *nutritious objects* and is precisely the type used by biologists to determine recognitional capacities. Thus, his argument, though based on a thought experiment, aligns with biological identifications of representational contents.

CBTS handles these cases very differently. The absence of snorfs is the normal condition for the performance of the highest-level function of the consumers of kimus' detectors. However, it is not a normal cause of the activation of the detectors, because kimus are not causally sensitive to snorfs or their absence. So it cannot be the content of their activated state. The implausible content signaled by Pietroski is properly discarded. Suppose that the red thing over the hilltop that kimus are attracted to is the rising sun. Then, kimus avoid snorfs *by* going to the hilltop *by* moving towards the rising sun *by* moving towards objects that emit red light. According to CBTS, kimus represent *the location of the rising sun*. This is the normal condition for the consumers to guide kimus towards the rising sun and also a normal cause of their perceptual states. There is no normal condition for a higher-level function that the perceptual mechanisms are causally sensitive to.<sup>11</sup> Pietroski's fictional case is similar to real cases of what biologists call "indirect anti-predator defenses", such as habitat selection, which are adaptive because they

<sup>11</sup> An anonymous reviewer suggests that kimus may represent an ecological "real kind" that grounds the correlation between what they are attracted to and the absence of snorfs. If there is such a real kind, however, there is no evidence that kimus can recognize it as such. I doubt that the biology of perception would support such a recognitional capacity.



prevent encounters with predators, but do not involve responses to predators (Kruuk 1964). Such “behavioral mechanisms... do not demand that prey recognize predators” (Caro 2005: 2).

Now consider the tortoise. It gets nutrients *by* eating plants *by* eating green things. While the presence of plants and green objects is causally relevant to the tortoise’s visual perception, nutrients are not. Plants *produce* chlorophyll, which causes them to be green and thereby to cause tortoises’ states. CBTS entails that the tortoise represents the various kinds of *plants* that it has evolved to eat and that it misrepresents when it eats a green plastic bag found in the desert. Neander’s theory cannot treat the state triggered by the plastic bag as a misrepresentation. Millikan’s account implausibly treats the tortoise as representing something that its sensory mechanisms are unresponsive to. CBTS seems more plausible, given biological standards for perceptual recognition.

Neander (1995) raises another concern about Millikan’s teleosemantics: it delivers implausibly fine-grained contents. Consider male moths, which locate female conspecifics to mate with *by* detecting the pheromones that they emit. As Neander points out, Millikan’s theory entails that the activated mate detectors represent *fertile females*, since ancestor male moths only became ancestors when they mated with fertile females (Neander 1995: 127).<sup>12</sup> Millikan (2004) does not concede that her theory delivers such content. For the activated detectors to represent *fertile females*, she argues, there must be a normal explanation of how they track fertile females, which requires them to be “sensitive to some kind of recurrent natural sign” of fertile females; but male moths, she claims, “do not encounter... [such] signs” (Millikan 2004: 85). For Millikan (2004), *X* can be a recurrent natural sign of *Y* when *X* has a *correlation* with *Y* (*Ibid.*: 49) that recurs often enough for some system to be selected for using *X* as a sign of *Y* (*Ibid.*: 44). But male moths’ activated detectors *are* correlated often enough with fertile females. What they represent, on Millikan’s theory, depends on which correlations their consumers exploit. Since the most crucial function of the consumers is to assist moths in reproducing, and only mating with fertile females can help them to achieve this goal, presumably they use the activated detectors as signs of fertile females, according to Millikan’s theory.<sup>13</sup>

In her reply to Neander, Millikan combines her consumer-based account with considerations about what the producers are *sensitive* to. This is a reasonable approach, which seemingly departs from Millikan’s earlier formulations of her theory. But her attempt to resolve the issue fails because her account of perceptual sensitivity is merely *correlational* and not *causal*. Frogs’ *R* is correlated with nutritious objects, so it would be sensitive to them by Millikan’s (2004) standards. These standards do not align with those used in the biology of perception. CBTS, in contrast, combines considerations about consumption with *causal* considerations about production. This allows it to avoid the problem. The mate detectors of male moths are not causally sensitive to the fertility of females. So the implausible content is

<sup>12</sup> Neander’s (1995) original counter-example and Millikan’s (2004) reply are about male hoverflies’ mate detectors, following Millikan’s (1990b) discussion of the case.

<sup>13</sup> See Martínez (2013) for further objections to Millikan’s (2004) reply to Neander (1995).

ruled out. According to CBTS, the activated detectors represent the presence of a *female conspecific*. Since female moths *produce* the pheromone *qua* female moths, their presence is the most crucial normal condition for the consumers to assist male moths in reproducing that is also a normal cause of the activation of their detectors.

Millikan's teleosemantics is vulnerable to the objections raised by Pietroski (1992) and Neander (1995) because it treats the causes that producers of representations *respond* to as irrelevant to content. CBTS avoids these problems by combining Millikan's consumer-based account with a crucial causal constraint on content determination. Such constraint seems to be reasonable and required in the case of simple representations that are directly produced by perceptual mechanisms.

## Recent approaches

There have been other recent attempts to show how teleosemantics can deliver mid-level contents. I will briefly discuss proposals by Papineau (2017), Martínez (2013) and Artiga (2021). All of their proposals are ingenious and I sympathize with their goals. But I hope to motivate CBTS by showing that it has advantages over these other approaches.

Papineau (2017), argues that a benefit-based teleosemantics *can* deliver mid-level contents for simple representations—abandoning his earlier opinion that representations of creatures that lack a belief-desire psychology are indeterminate (Papineau 1998). His new proposal is that the content of a simple representation depends on the *specific function*, in Neander's sense, of its *consumers*. The appeal to the specific function is intended to prevent the approach from identifying content with the normal conditions for the performance of the highest-level functions of the consumers. This is an ingenious idea, but it does not seem ultimately to work as intended. Somewhat simplifying his characterization of the case, Papineau describes the consumers of frogs' *R* states as helping frogs to get nutrients *by* catching flying insects. The latter is their specific function, he argues, so *R* represents the presence of a *flying insect* (Papineau 2017: 105–108). He mentions no lower function of the consumers than catching flying insects. But the *lowest* function presumably is making frogs snap their tongue given certain proximal stimuli. Insofar as the specific function of a trait is the *lowest* of its nested functions (Neander 1995), Papineau's suggestion seems to deliver implausibly proximal contents: *R* represents *SMI*s. But perhaps he intends the specific function of the consumers to be the *highest* one they perform without collaborating with other systems.<sup>14</sup> This does not seem to work either. Helping the frog get nutrients into the bloodstream involves collaboration with the digestive system, but merely catching a nutritious object does not. The tongue-snapping mechanism does this by itself. So, *R* would represent *nutritious objects*.<sup>15</sup> Either way, it is unclear that Papineau's suggestion delivers mid-level contents, while CBTS does offer a plausible way of doing this.

<sup>14</sup> I thank an anonymous reviewer for pointing out this plausible interpretation.

<sup>15</sup> Schulte (2019) also suggests that Papineau's account may deliver such high-level content.

Martínez (2013) and Artiga (2021) also expect teleosemantics to deliver mid-level contents. But they propose an entirely new approach. Their shared strategy is to find what *underlying* property (or set of properties) of a represented object best explains the presence of all the properties involved in both its detection by and its beneficial effects for the representing organism. Martínez (2013) formulates the idea in terms of homeostatic property clusters that are responsible for the co-instantiation of all the detected and beneficial properties, while Artiga (2021) generalizes it to apply independently of whether what explains such co-instantiation is a homeostatic property cluster or some other source. They both argue that such underlying property is the best candidate for what is represented. Consider again the case of the frog's *R* state. The properties more immediately involved in the detection of an object by an activation of *R* include its small size and its motion, while the property of this same object responsible for the main benefit of an activation of *R* is that it has certain chemical composition that makes it nutritious. The underlying property that explains the co-instantiation of *all* of these properties presumably is the object being a prey animal. This innovative approach delivers the results that were originally regarded as the correct ones in the debate about simple representations. I take their proposals to be among the most important contributions to teleosemantics in recent times.

Both Martínez and Artiga combine properties relevant to the production and the consumption of a representation in such a way that their theories deliver mid-level contents which are often in tune with the contents delivered by CBTS, at least in cases like the frog. But I wonder how their approach can handle cases like Pietroski's, where there seemingly is no common underlying property that explains what is detected and what is beneficial. CBTS handles these cases easily and delivers plausible contents. More importantly, consider cases where there is an underlying property, *D*, that best explains the cluster of superficially *detected* properties, but a different property, *C*, which best explains the *complete* set of detected and beneficial properties. In such a case, the Martínez/Artiga approach will regard *C* as what is represented. But notice that what the sensory mechanism is causally sensitive to is *D* instead. *C* cannot be reasonably said to be actually *detected* or *recognized*—based on biological standards for recognitional capacities, which rely on what animals are able to *respond* to and serve as the source of our best independent *identifications* of *explananda* for philosophical theories of content. Here the theories of Martínez and Artiga seem to deliver contents that, like Millikan's, are implausible given the perceptual capacities of the creatures involved. CBTS avoids this problem altogether by identifying content with a *normal cause* of tokens of the representation. This ensures that the delivered content is *always* aligned with what creatures are causally sensitive to and can therefore be said to detect.

## Conclusion

By combining key aspects of Millikan's and Neander's teleosemantics, CBTS delivers contents that are more plausible than either of their theories and avoids the main problems each faces. Millikan's teleosemantics provides contents that are

implausible given the causal sensitivities of the sensory mechanisms that produce representations. CBTS avoids this problem by including the causes of representations in the determination of content. Neander's teleosemantics cannot account for cases of misrepresentation that occur in the absence of malfunctioning, due to deceptive external circumstances, and ultimately seems to deliver merely proximal contents. CBTS overcomes these limits by explaining normal causes as those that sensory mechanisms respond to only in those function-conferring occasions where all the functions of the sensory-motor system are successfully performed. Crucially, CBTS, unlike Millikan's and Neander's theories, delivers contents aligned with what biologists studying perception and behavior regard animals as recognizing.

CBTS also seems to have advantages over more recent proposals with which it shares explanatory goals. It is unclear whether Papineau's recent suggestion delivers the plausible results he expects. The theories of Martínez and Artiga, on the other hand, align with CBTS in delivering plausible contents in most cases. However, there seemingly are cases where they deliver contents that are not properly tied to the animal's recognitional capacities. I conclude that CBTS provides a plausible framework that holds potential for addressing some of the most significant challenges encountered in teleosemantics.

CBTS applies exclusively to simple representations. While the approach seems promising for perceptual outputs that feed inferential processes, it needs adjustment to consider the normal conditions related to these consumers' functions. The resulting theory could contribute to explaining the content of those concepts whose meanings depend on direct or indirect links to perception.

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## Declarations

**Conflict of interest** The author has no competing interests to declare that are relevant to the content of this article.

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