The autonomic nervous system
and Dretske on phenomenal consciousness

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Title page

Representational theories propose a set of sufficient conditions for a state to be phenomenally conscious. It turns out that insofar as these conditions have been worked out in detail, the autonomic nervous system (ANS) ought to be conscious - but of course it's not. In this paper, we'll describe only a tiny portion of the complexities of the ANS, using these to counterexample only a single theory of phenomenal consciousness, namely, Fred Dretske's. But we think the ANS comparison strategy is a fruitful one in general, and we hope to convince you of this too.

2. "Representationalism" on handout

Our target here is theories of phenomenal consciousness, or qualia. Representationalism is such a theory. In a nutshell, the representationalist proposes to explain qualia in the same way that Fodor explains belief. Coming to have the belief that there's a green patch in front of you involves tokening a mental representation with the content "there's a green patch in front of me", where that representation token occupies the functional role characteristic of belief. Similarly, the representationalist claims that having a qualitative experience of a green patch in front of you involves tokening a mental representation – a "sensory representation" - with the content "there's a green patch of such-and-such a size at such-and-such a location with respect to my body." Again, that mental representation token occupies a characteristic functional role, though not (it is usually maintained) the functional role of a belief.

One difference between the belief and the sensory representation is that the sensory representation contains more information. This, in part, is supposed to explain the distinctive "feel" of sensory representations. Another contrast between belief representations and sensory representations is that having a belief also requires having the concepts required to specify its content; this is not so for sensory representations. Going back to our example of the green patch, in order to have an occurrent belief that there's a green patch in front of me, I must possess the concepts [green], [patch], [in front of], and [me]. However, in order to sensorily represent that there's a green patch of such-and-such a size at such-and-such a location with respect to my body, I need not possess the concepts [green], [my], [body], etc. This explains why, intuitively, we can share sensory experiences with non-human animals even if we share few (if any) beliefs with them.

The representationalist strategy is steadily gaining adherents – Gilbert Harman, Fred Dretske, Michael Tye, Bill Lycan, and Georges Rey, for example. Also, the standard neuroscientific view may be seen as a representationalist thesis, with an informational construal of representation.

In this paper, we are recording neither agreement nor disagreement with the broad strokes of the representationalist's picture. (Well, actually, I think representationalism is true, and Charlie thinks representationalism is false. So *jointly*…) What we're going to do is to exploit a counterexample - the autonomic nervous system - which shows at least that representationalists have a lot of work to do. (Specifically, we think we've got a clear counterexample to Dretske's theory – which is the most fully worked out version of representationalism. We think we've also shown that other representationalists owe us a better story of exactly what the crucial difference is between the ANS and conscious systems.) But first: a short introduction to the system that will serve as a counterexample.

3. Welcome to the ANS (on handout)

This (fig. 1 on overhead) is the textbook picture of the ANS many of you are familiar with. (Describe some of the effectors.) The description accompanying it goes something like this: "The ANS is a motor system divided into two parts, the sympathetic and the parasympathetic. Sympathetic action is associated with fight or flight responses; the parasympathetic division counteracts these. The system operates in only two different ways, either by: 1) Basic reflexes (e.g. a bright light leads to pupil contraction), or 2) Simple top-down commands - 'get excited' or 'take a rest' - that cause generalized action of either the sympathetic or the parasympathetic division."

This description of the ANS is so woefully inadequate that it hardly even qualifies as a caricature. The *real* ANS differs in almost every particular:

First: The standard textbook account of the ANS typically ignores the input side of things altogether. Due to an historical accident the ANS has been viewed as a purely motor system, which is odd since its homeostatic functions (like the maintenance of body temperature and blood pressure) could hardly be performed without afferent information and feedback.

Second: Both the sympathetic and parasympathetic divisions are operative at all times, from sleep to strenuous activity, and they can work simultaneously and cooperatively.

Third: (Far Side) Even if they do acknowledge an afferent side, the stereotype of the ANS isn't much more than this. Though there *are* simple autonomic reflexes, the operation of the system is primarily under the control of a complex central autonomic network (CAN) in the brainstem, midbrain, and even the forebrain (show brainstem and 2 diagrams of CAN. Don't need to pay attention to details – just go wow, that's complicated.). None of the higher CAN nuclei can be classified as purely sympathetic or parasympathetic, and they don't merely issue simple "get excited" or "calm down" commands, but engage in the subtle analysis of input patterns and the formulation and coordination of complicated output patterns.

The operation of the ANS can be usefully compared to the cortical control of skeletal muscle – researchers in the area actually do this (show comparison diagram, cover half). Sensory information comes to early cortical areas where simple features of the input are detected. Integrative cells and populations in later or "higher" cortical areas are sensitive to higher order combinations of simple features; that is, they indicate complex features of the environment that are more relevant to the organism's behaviour. Premotor and motor cortex compute over both the basic and complex indicators in exerting their effects on skeletal muscle. All this occurs with multilevel feedback (see the double arrows).

The ANS operates in just the same way. Afferents that feed into the CAN travel in sympathetic nerves, parasympathetic nerves, and even in somatic nerves. This "sensory" input (note " " - no implications of consciousness, of course!) arrives at the CAN early sensory area: the nucleus of the solitary tract (NTS). (Show in CAN diagram, then NTS figure.) The NTS receives inputs from every last nook and cranny of the body. Integration occurs there and in the higher CAN. (Back to comparison figure.) As in cortical control of skeletal muscle, the current "perceptual" state – or anticipated perceptual state - and current "goals" determine a spatially and temporally differentiated output. You can see this in the control of the vasculature, for which the motor cortex equivalent is the topographically organized rostroventrolateral medulla (RVLM). The RVLM exerts its effects by targeting the constriction and dilation of blood vessels to control blood flow and pressure in response to variations in heart rate, the pressure in various blood vessels, temperature, somatic and vestibular inputs, and more. Sometimes these different modalities make *competing* demands on the CAN, which must prioritize its responses. For example, in exercise, the demands of metabolism and blood supply may compete with the demands of temperature control.

So: the ANS is exposed to an indefinitely large number of sets of environmental conditions that require different responses; *prima facie*, it's hard to imagine how a non-representational system could accomplish all this. Believe me, it's a good thing that *we* don't have to do it. We wouldn't have time for anything else! (As an aside: it might remind you of Dennett's complicated thermostat that we can take the intentional stance towards. Except ANS is a lot more than a thermostat!)

4. The ANS as a counterexample to Dretske's theory

Dretske's theory of sensory representation and qualia in *Naturalizing the Mind* has two components (on handout). First, there's the theory of representation. Second, there are conditions on the use of these representations that are required for them to be conscious – they have to be available for use by a cognitive, belief-desire system.

I'll start with the theory of representation.

Dretske first requires that representations be *indicators*. An indicator is something that carries information. Tracks of a certain size and shape indicate that quail have been in the vicinity only if they *carry the information* that quail have been in the vicinity. There has to be a lawful relation between the tracks and quail, and there has to be a dependency of the tracks on quail, that is, non-quail must not leave tracks like that. If there are some really small pheasant around that leave similar tracks, then the tracks don't indicate/carry the information that quail have been in the vicinity, though they may indicate/carry the information that *either* quail or pheasant have been in the vicinity.

In the same way, a sensory representation indicates the fact it represents, for example that there is a red patch right *here*. Patterns of retinal activation indicate facts about light intensity and wavelength, while patterns of striate cortex activation indicate the presence of edges, surfaces and surface features.

Now, just as states of the visual system indicate conditions in the environment, states of the CAN indicate conditions in the body. For example, the main autonomic "sensory" nucleus, the NTS, receives many different types of afferents from different parts of the body. For example, it indicates blood pressure in the aorta, in the pulmonary artery, and elsewhere. Also, just as the visual system indicates different aspects of visual stimuli – like colour, shape, and motion - the NTS indicates different aspects of cardiovascular stimuli - like heart rate, mean arterial blood pressure, the change in mean arterial blood pressure, and the rate of change of mean arterial blood pressure. It also indicates some surprising things, like movement in skeletal muscle and postural changes. The hypothalamus indicates (amongst many other things) temperature in different parts of the core, various organs, and locations in the skin. Finally, though some afferent fibres may split in two and terminate in both the CAN and the cortex, we are conscious of none of the indicators activated in the CAN.

But representation is not mere indication for Dretske. An indicator state, in order to be a representation, has to be *for* indicating what it does, it has to have that purpose or function. (The state gets this function indirectly, by being a state of a device whose function it is to indicate a type of fact or range of related types of facts.)

Normally, the function of something is given by its designers or users, as for a speedometer. It's present in a car because of what it indicates (that's why we put it there!) so it has the function of indicating speed. In the case of natural sensory representations, evolution plays the role of designer. A heart has the function of pumping blood (rather than making thumping noises) because the pumping capacity conferred a selective advantage upon an organism's ancestors. It's capacity to pump blood explains why it is present in a population - it's there because it pumps blood, so its function is pumping blood.

A sensory indicator, in order to be a representation, must have the function of indicating that P. Its indicating capacity must have conferred a selective advantage, so it's there *because* it indicates what it does, and thus has the function of indicating that P.

The ANS is obviously a product of evolution. So e.g. the state of the NTS that indicates a pressure of 70 mm Hg in the carotid sinus has the *function* of indicating this, because a portion of the NTS has the function of indicating pressure in the carotid sinus. So according to Dretske, this state of the NTS represents that the carotid sinus is at 70 mm Hg. That "sensory" systems in the ANS have evolutionary indicator functions is perhaps even more obvious than for cortical sensory representations, since many of them are so immediately relevant to life and death.

4.2. Requirements on the use of sensory representations

Recall that the representationalist typically holds that phenomenal character is the content of a *non-conceptual* sensory representation. But the representationalist also claims that, in order for these non-conceptual representations to form part of a conscious sensory *experience*, they have to be available for use (Dretske) or poised for use (Tye) by a conceptual/cognitive/belief-desire system.

For Dretske's account of concepts and belief-desire systems, we have to look to an older book - *Explaining Behavior*. Beliefs play a special kind of role in behaviour - they *explain* it. Dretske tries to develop a model in which reasons can be causes, so the content of a belief can explain why a particular behaviour occurs. Or, in Dretske's language, a belief-type representation must cause some movement *because* it indicates what it does. (Compare that to: a sensory representation is present in a population because it indicates what it does.) For Dretske, this is for an indicator state to be *recruited* as a cause of a movement because it indicates what it does. This recruitment occurs through learning (show Dretske diagram).

In this recruitment, an association between an indicator state and some movement gets strengthened. Let's say our indicator state indicates the presence of something sugary. It is thus a candidate for the belief that something is sugary. The movement that gets reinforced is, say, licking. We want to say that the rat licks a cube because it believes it to be sugary. The content of the indicator state must explain the behaviour. That is, the indicator state (a representation), must be recruited to cause licking because it indicates sugar.

The first thing to notice is that the indicator state-movement connection only gets reinforced when there really is sugar in the environment. That's because the rat is rewarded when it licks sugar, and not something else. If there's nothing sweet there, there's no reward in the offing, that is, the rat doesn't get to ingest sugar. (Dretske says it doesn't matter much how we specify the reward.) The sugar indicator is recruited as a cause of licking, and it is so recruited *because* it indicates sugar - because licking sugar is rewarding.

Why is licking sugar rewarding? Because the rat wants sugar! Licking sugar is only rewarding if it satisfies some desire the rat has, its "state of receptivity for the reward." Without this state of receptivity, no reinforcement of the behaviour occurs, even if the cube is sugary and the rat licks it. The indicator state only gets recruited to cause the movement when the system is in a state of receptivity for the reward. This state of receptivity can come and go.

Our complete explanation of the rat's behaviour is as follows: His sugar indicator was recruited as a cause of licking because, on average, this resulted in a reward for which the rat was in a state of receptivity. This recruitment occurs *because* the indicator indicates sugar, so the fact that it indicates sugar explains the licking behaviour. (It's a structuring cause of it – show on overhead, explain what Dretske identifies behaviour with.) He licks the sugar cube because he believes the cube is sugary, and he wants sugar.

Note that the sugar indicator might make use of more basic indicators, say of colour and texture. This is what it is for these more basic sensory representations to be available for use by a belief/desire system.

It turns out that the ANS learns too, according to Dretske's model. Dretske thinks the ANS follows fixed action patterns, but this is just false. He doesn't care how the reward and the corresponding desire or “state of receptivity” get specified (and remember he can't use any intentional notions to specify it) so it is fine if we take the ANS to have a state of receptivity for, say, perfusing the brain with blood. As a simple example, we would contend that the CAN learns to associate somatic, vestibular, and baroreceptor inputs (which indicate standing) with anticipatory behaviour aimed at compensating for loss of blood to the brain.

There is, in the CAN, an indicator state that indicates and represents standing (let's say. It doesn't matter how we specify the content. For the relevant indicator states see Convertino and Robertson 1995, Wieling and Shepherd 1992, Yates et al. 1995.) The behaviour that is reinforced is haemodynamic. The indicator of standing is recruited as the cause of the haemodynamic behaviour because it indicates what it does - only when standing occurs are gravitational effects counteracted by the haemodynamic behaviour, satisfying the ANS's desire to perfuse the brain with blood. (If this desire is not present, e.g. if temperature regulation takes precedence, then no reinforcement occurs.)

This example could be dismissed as a developmental, preprogrammed, genetically determined response, i.e. not learned (despite the fact that plasticity has been demonstrated in the ANS - Hammill and LaGamma 1992). But we have a better case, where it is extremely unlikely that the response could be innate. The cardiovascular system is not likely to be adapted to respond in space!

When the astronaut in microgravity moves from a sitting position to a standing position, what do you think happens? All the blood goes to her head, of course. The ANS is used to counteracting the effects of gravity so it overperfuses the brain when there is no gravitational force. However, over time, the same indicator state (that indicates standing), with the same desire's help (the desire to adequately perfuse the brain), is recruited to cause a different behaviour. This new behaviour ensures perfusion of the brain in a microgravitational environment. Upon returning to earth, the old behaviour must be relearned (which happens rather quickly this time, Convertino and Robertson 1995). *This* must count as learning for Dretske, so the somatic, baroreceptor, and vestibular detectors in the CAN that indicate standing are available for use by a "belief-desire system". So Dretske must say they are conscious - but they are not.

5 Conclusions

We have now shown that both the theory of representation component, and the requirements on use component of Dretske's theory of qualia are paralleled in the ANS. That is, according to Dretske's theory of phenomenal consciousness, the ANS has qualia! If you are familiar with some other representationalist theories, you may have noticed that they will have difficulty contending with the ANS counterexample as well. Whence from here, then?

There are several possibilities. First, one might draw the conclusion that representational theories of qualia are radically false.

Second, one might conclude that the ANS has phenomenal consciousness. One would then have to provide reasons for why *we* are not conscious of autonomic stimuli, i.e. show how our consciousness and the ANS consciousness form two different unities.

Third, one might improve upon Dretske's conception of "availability to a conceptual system" so as to rule out the ANS as phenomenally conscious.

These last two options are rather similar. Given the extensive interactions between the ANS and the thalamocortical system, they would involve complicated theory and some careful neuroscience. We are owed an account of why certain inputs to cortex give rise to sensations while other do not.[1] In fact, the theory of why certain representations are conscious while others are not

[1] Even within the cortex, some representations result in conscious sensation, while others do not. Some concrete proposals have been made for why this is the case (e.g. the conscious

would greatly overshadow the representationalist thesis itself. We recommend that the representationalists focus their efforts on this project, one that ought to concern others too (e.g. Kirk 1994, Dennett 1991). The ANS provides a good foil for evaluating the success of such a project.

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representations are those that fire in synchrony - Gray et al. 1989, Singer and Gray 1995). The point is that the representationalist has a *lot* more work to do here.

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