

CHAPTER 5

Skill, corporality and alerting capacity in an account of sensory consciousness

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Abstract: We suggest that within a skill-based, sensorimotor approach to sensory consciousness, two measurable properties of perceivers' interaction with the environment, "corporality" and "alerting capacity", explain why sensory stimulation is experienced as having a "sensory feel", unlike thoughts or memories. We propose that the notions of "corporality" and "alerting capacity" make possible the construction of a "phenomenality plot", which allow to chart in a principled way the degree to which conscious phenomena are experienced as having a sensory quality.

Introduction

Although knowledge is rapidly accumulating concerning the neurobiological mechanisms involved in consciousness (cf. Rees et al., 2002 for an overview), there still remains the problem of how to capture the "qualitative" aspects with a scientific approach. There would seem to be an unbridgeable "explanatory gap" (Levine, 1983) between what it is like to have a sensory experience, and the neural correlates or physical mechanisms involved.

The purpose of this paper is to show how a step can be made toward bridging this gap. We purposefully leave aside many interesting problems of consciousness, such as self-awareness, the distinction between awake and unconscious states, being aware of facts, etc., and concentrate on the question of the nature of sensation. The fact that con-

trary to other mental phenomena, sensations have a distinctive qualitative character or sensory "feel" lies at the heart of the explanatory gap problem. Indeed philosopher Ned Block has noted that being conscious of something involves two aspects: it involves having "conscious access" to that thing, in the sense that one can make use of that thing in one's decisions, judgments, rational behavior and linguistic utterances (Block, 1995, 2005). This "access consciousness" is amenable to scientific explanation, since it can be formulated in functional terms. On the other hand, being conscious of something also involves a second "phenomenal" aspect, which corresponds to the enigmatic "what it's like" to experience that thing. It is not clear how this "phenomenal consciousness" could be approached scientifically.

Our approach to this question of sensation will be to suggest that there is a way of thinking about sensations that is different from the usually accepted way. A first aspect of this new way of

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1 thinking involves taking a counterintuitive stance
 2 at first sight, namely that sensation consists in the
 3 exercise of an exploratory skill (cf. O'Regan and
 4 Noë, 2001a; Myin and O'Regan, 2002; see Tor-
 5 rance, 2002, for further references to skill theories).
 6 Taking the skill approach allows a first problem
 7 about the experiential quality of sensation to be
 8 addressed, namely why the experienced qualities of
 9 different sensations differ the way they do.

10 Second, when skill theories are supplemented by
 11 two concepts, which we refer to as “corporality”
 12 and “alerting capacity”, then a second, more pro-
 13 found problem about the experienced quality of
 14 sensations can be addressed, namely why they
 15 have an experienced sensory quality at all.

16 We have organized our paper in a main body in
 17 which the concepts crucial to our approach are
 18 introduced and described, and three “application”
 19 sections, in which they are put to use in the context
 20 of more specific issues, namely intra- and inter-
 21 modal differences, dreaming and imagery, and
 22 change blindness. In a final section, we consider
 23 the issue of whether our approach really consti-
 24 tutes an explanation of phenomenal sensory con-
 25 sciousness.

26 **Sensation as a skill: explaining intra- and** 27 **intermodal sensory differences**

28 The basic tenet of the skill theory from which we
 29 take our start is that having a sensation is a matter
 30 of the perceiver knowing that he is currently ex-
 31 ercising his implicit knowledge of the way his bod-
 32 ily actions influence incoming sensory information
 33 (O'Regan and Noë, 2001a).

34 An illustration is provided by the sensation of
 35 softness that one might experience in holding a
 36 sponge (Myin, 2003). Having the sensation of
 37 softness consists in being aware that one can ex-
 38 ercise certain practical skills with respect to the
 39 sponge: one can, for example, press it, and it will
 40 yield under the pressure. The experience of soft-
 41 ness of the sponge is characterized by a variety of
 42 such possible patterns of interaction with the
 43 sponge, and the laws that describe these sensori-
 44 motor interactions we call, following MacKay
 45 (1962), laws of sensorimotor contingency (O'Re-

gan and Noë, 2001a). When a perceiver knows, in
 an implicit, practical way, that at a given moment
 he is exercising the sensorimotor contingencies as-
 sociated with softness, then he is in the process of
 experiencing the sensation of softness.

Note that in this account, the softness of the
 sponge is not communicated by any particular
 softness detectors in the fingertips, nor is it char-
 acterized by some intrinsic quality provided by the
 neural processes involved, but rather it derives
 from implicit, practical knowledge about how sen-
 sory input from the sponge currently might change
 as a function of manipulation with the fingers.

This approach to sensation has a tremendous
 advantage. It avoids a fundamental problem that
 is encountered by any approach that assumes that
 sensation is generated by a neural mechanism:
 namely the problem why this particular neural
 process (whatever its neural specification) should
 give rise to this specific sensation (and not to an-
 other one). In addition, the skill-based sensorimo-
 tor description of experiencing softness in terms of
 an exploratory finding out that the object yields
 when one presses “fits” the experience of softness
 in a way a description in terms of a correlated
 neural process cannot. Thus, for example, while
 under a “neural correlate” explanation it is always
 possible to imagine the presumed neural process
 for softness to be paired with the sensation of
 hardness (i.e., nothing of the specifics of the neural
 description seems to forbid this), it would seem
 impossible to imagine one is going through the
 exploratory pattern of softness, yet experiencing
 hardness.

Application 1 on intra- and intermodal differ-
 ences in sensory quality (see below) describes how
 the sensorimotor way of thinking can be applied to
 perceptual sensations in general, even to cases like
 color perception where no active exploration ap-
 pears necessary. Just as the difference between
 hard and soft can be accounted for in terms of the
 different exploratory strategies required to sense
 hard and soft objects, the differences between red
 and blue, for example, can be accounted for in
 terms of the different exploratory strategies in-
 volved in exploring red and blue surfaces.

Another, related question can also be dealt with
 by this approach, namely the question of the dif-

ferences between the sensory qualities of the different sensory modalities. As suggested in Application 1, the difference, for example, between hearing and seeing is accounted for in terms of the different laws of sensorimotor contingency that characterize hearing and seeing. Again, under this approach, no appeal is necessary to special, as yet unexplained intrinsic properties of neural mechanisms.

The sensorimotor theory and its explanation of intra- and intermodal sensory differences, as just reviewed, has previously been treated in a number of papers (O'Regan and Noë, 2001a, b, c; Myin and O'Regan, 2002; Noë, 2002a, b; Noë, forthcoming). We now come to the main purpose of this chapter, which is to address a more profound question, namely the question of why sensations have a sensory experiential quality at all.

Corporality and alerting capacity: explaining sensory presence

What is special about sensory experience that makes it different from other mental phenomena, like conscious thought or memory? In particular, consider the difference between actually feeling a terrible pain and merely imagining or thinking that you are feeling one. Or consider actually feeling softness or seeing red, compared to thinking that you are feeling softness or seeing red (see Application 2 for a discussion of dreams, imagery and hallucinations).

Theorists have tried to describe and capture such differences in various ways. Hume, for example, opposed (perceptual) sensations and “ideas” (recollections of sensations and thoughts), in terms of “vivacity” and “force” (Hume, 1777/1975). Husserl proposed the notion of an object being experienced as “being present in the flesh” (having “Leibhaftigkeit”) as an essential ingredient for truly perceptual experience (Husserl, 1907/1973; Merleau-Ponty, 1945; cf. Pacherie, 1999) for similar use of the notion “presence”. In contemporary descriptions of perceptual consciousness, such a distinction is often made in terms of “qualia”, those special qualitative or phenomenal

properties that characterize sensory states, but not cognitive states (Levine, 1983; Dennett, 1988).

While these notions seem descriptively adequate, we propose they should and can be complemented with an explanatory story that accounts for why sensory experience differs in these respects from other conscious mental phenomena. Our claim is that, within a skill-based, sensorimotor theory, the notions of corporality and alerting capacity provide precisely this missing explanatory addition. Corporality and alerting capacity are complementary aspects of an observer's interaction with the environment: corporality concerns the way actions affect incoming sensory information, and, conversely, alerting capacity concerns the way incoming sensory information potentially affects the attentional control of behavior.

Again we wish to claim that corporality and alerting capacity are not merely descriptive, but actually possible first steps toward explanations. We will return to this distinction later.

Corporality or “bodiliness”

We define corporality as the extent to which activation in a neural channel systematically depends on movements of the body (in previous publications we used the term “bodiliness” (O'Regan and Noë, 2001b; Myin and O'Regan, 2002; O'Regan et al., 2004). Sensory input from sensory receptors like the retina, the cochlea, and mechanoreceptors in the skin possesses corporality, because any body motion will generally create changes in the way sensory organs are positioned in space, thereby causing changes in the incoming sensory signals. Proprioceptive input from muscles also possesses corporality, because there is proprioceptive input when muscle movements produce body movements.

Note that we intend the term corporality to apply to any neural channels in the brain whatsoever, but because of the way it is defined, with the exception of muscle commands themselves and proprioception, only neural activation that corresponds to sensory input from the outside environment will generally have corporality. For example, neural channels in the autonomic nervous system that

1 measure parameters such as the heartbeat or di-
 3 gestive functions, because they are not very sys-
 5 tematically affected by movements, will have little
 7 corporality even though they may carry sensory
 information. Note also that memory processes or
 thinking have no corporality, because body move-
 ments do not affect them in any systematic way.

9 We shall see below that corporality is an im-
 11 portant factor that explains the extent to which a
 13 sensory experience will appear to an observer as
 15 being truly sensory, rather than non-sensory, like a
 17 thought, or a memory. In Philipona et al. (2003) it
 is shown mathematically how this notion can be
 used by an organism to determine the extent of its
 own body and the fact that it is embedded in a
 three-dimensional physical world in which the
 group-theoretic laws of Euclidean translations and
 rotations apply.

19
 21 ***Alerting capacity or “grabbiness”***

23 We define the alerting capacity of sensory input as
 25 the extent to which that input can cause automatic
 27 orienting behaviors that peremptorily capture the
 29 organism’s cognitive processing resources. Alert-
 31 ing capacity could also be called: capacity to pro-
 33 voke exogenous attentional capture, but this
 would be more cumbersome. In previous papers,
 we have also used the term “grabbiness” (O’Regan
 and Noë, 2001b; Myin and O’Regan, 2002; O’Re-
 gan et al., 2004).

35 Pain channels, for example, have alerting ca-
 37 pacity, because not only can they cause immediate,
 39 automatic and uncontrollable withdrawal reac-
 41 tions, but they also can cause cognitive processing
 43 to be modified and attentional resources to be at-
 45 tributed to the source of the pain. Retinal, cochl-
 47 ear and tactile sensory channels have alerting
 capacity, since not only can abrupt changes in in-
 coming signals cause orienting reflexes, but the
 organism’s normal cognitive functioning will be
 modified to be centered upon the sudden events.
 For example, a sudden noise not only can cause
 the organism to turn toward the source of the
 noise, but the noise will also additionally, premp-
 torily, modify the course of the organism’s cog-
 nitive activity so that if it is human, it now takes

1 account of the noise in current judgments, plan-
 3 ning, and linguistic utterances. Autonomic path-
 5 ways do not have alerting capacity, because
 7 sudden changes in their activation do not affect
 9 cognitive processing. For example, while sudden
 11 changes in vestibular signals cause the organism to
 13 adjust its posture and blood pressure automatical-
 15 ly, these adjustments themselves do not generally
 17 interfere in the organism’s cognitive processing
 19 (interference occurs only indirectly, when, for ex-
 21 ample, the organism falls to the ground and must
 23 interact in a new way with its environment). Like
 25 corporality, we take alerting capacity to be an ob-
 27 jectively measurable parameter of the activation in
 29 a sensory pathway.

17
 19 ***Using corporality and alerting capacity to explain
 “sensory presence”***

21 We now consider how the notions of corporality
 23 and alerting capacity can contribute to under-
 25 standing what provides sensory experiences with
 27 their particular sensory quality, and more precise-
 29 ly, what makes for the difference between truly
 31 sensory and other experiences.

33 To see our notions at work, consider the differ-
 35 ence between seeing an object in full view, seeing
 37 an object partially hidden by an occluding object,
 39 being aware of an object behind one’s back, and
 41 thinking, remembering or knowing about an ob-
 43 ject. It is clear that these different cases provide
 45 different degrees of sensory “presence” (Merleau-
 47 Ponty, 1945; O’Regan and Noë, 2001a; Noë,
 2002b). Our claim is that these different degrees
 of sensory presence precisely reflect different de-
 grees in corporality and alerting capacity.

Thus, when an object is in full view, it comes
 with the fullest intensity of sensory presence. But it
 is precisely in this case that observer motion will
 immediately affect the incoming sensory stimula-
 tion. Also, any change that occurs in the object,
 such as a movement, a shape, color, or lightness
 change, will immediately summon the observer’s
 attention. This is because low-level transient-de-
 tection mechanisms exist in the visual system that
 premporarily cause an attention shift to a sudden
 stimulus change. In terms of the concepts we de-

1 fined above, this means that an object in full view
 3 has both high corporality and high alerting capacity.

5 Contrast this with just knowing that an object is
 7 somewhere, but out of view. While knowledge
 9 about an object in another room might certainly
 11 be conscious, it lacks real sensory presence. Clearly,
 13 in this case, there is no corporality, since the
 stimulus changes caused by bodily movements do
 not concern that object. Similarly, there is no
 alerting capacity, as the changes that the object
 might undergo do not immediately summon the
 perceiver's attention.

15 An object that is only partially in view because
 17 of an occluding object or an object known to be
 19 behind one's back provides borderline cases. For
 21 example, the occluded part might be said to still
 23 have some presence (Merleau-Ponty, 1945; Gregory,
 1990; O'Regan and Noë, 2001a; Noë and O'Regan,
 2002; Noë, 2002b) because it has a degree of
 25 corporality, as we can easily bring it into view
 27 by a slight movement. The "boundary extension"
 29 phenomenon of Intraub and Richardson (1989),
 according to which observers overestimate what can
 be seen of a partially occluded object, is coherent
 with this view. Amodal completion may be an
 example where one has an intermediate kind of
 "almost-visual" feeling of presence of a shape
 behind an occluder. Application 3 gives examples
 of "change blindness", showing that when alerting
 capacity is interfered with, the experience of
 perception ceases.

33 These examples show that the differing degrees
 35 of what one might call "sensory presence" (perhaps
 37 Hume's "vividness" or Husserl's "Leibhaftigkeit")
 can be accounted for plausibly in terms of the
 physically measurable notions of corporality and
 alerting capacity.

41 **The "sensory phenomenality plot"**

43 The exercise of contrasting sensations with other
 45 mental phenomena can be systematized in a "sensory
 phenomenality plot" (Fig. 1).

47 By plotting the degree of corporality and alerting
 capacity for different mental phenomena, such a
 figure reveals that those states that possess both

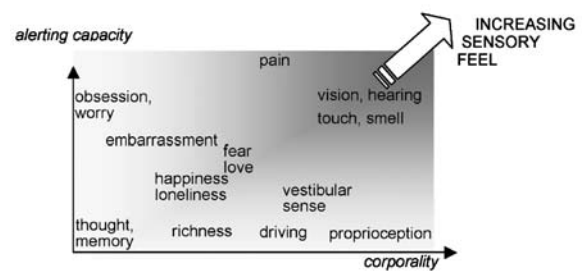


Fig. 1. A sensory phenomenality plot.

corporality and alerting capacity correspond precisely
 to cases that provide true sensory experiences. (But
 note, importantly: we consider that our plot only
 charts the degree to which mental phenomena have
 sensory or perceptual quality, and not consciousness
per se. In particular, when we claim that thought
 has no sensory quality, we are not saying that
 thought is not conscious, more on this in section
 "Consciousness".

Thus, vision, touch, hearing, and smell are the
 prototypical sensory states and indeed have high
 corporality and high alerting capacity, as mentioned
 above in the definition of these terms. High
 corporality derives from the fact that changes in
 head or limb positions have an immediate effect on
 visual, auditory or tactile sensory input (smell is
 less clear, but sniffing, blocking the nose, and
 moving the head do affect olfactory stimulation;
 Steriade, 2001). High alerting capacity is provided
 by the fact that sudden changes in visual, tactile,
 auditory, or olfactory stimulation provoke
 immediate orienting behaviors that preemptorily
 modify cognitive processing.

What characterizes pain is its particularly large
 amount of alerting capacity. Here it is virtually
 impossible to prevent oneself from attentively
 focusing on the noxious stimulation. Pain also has
 corporality, but to a lesser extent. Moving one's
 body can generally modify the pain (one can
 remove one's finger from the fire; rub the aching
 limb and change the incoming sensations), but
 there are cases like headaches or toothaches,
 which are more problematic. Headaches and
 toothaches are characterized by the fact that
 associated sensory input changes only moderately
 as a function of things that one can do such as
 press on the head

1 or chew with one's teeth. This lack of an ability to
 3 easily modulate the sensory stimulation by body
 5 motions, lie, a reduced corporality, could possibly
 7 correspond to a particular aspect of pain, such as
 9 headaches, which distinguishes them from vision,
 11 touch, hearing, and smell, namely that they have
 an interior quality, often not clearly localized.

We have plotted thinking and recalling from
 memory at the other extreme, because they have
 neither corporality or alerting capacity, as we have
 pointed out above.

Proprioception is the neural input that signals
 mechanical displacements of the muscles and
 joints. Motor commands that give rise to move-
 ments necessarily produce proprioceptive input, so
 proprioception has a high degree of corporality.
 On the other hand, proprioception has no alerting
 capacity: changes in body position do not per-
 emptorily cause attentional resources to be divert-
 ed to them. We therefore expect that
 proprioception should not appear to have an ex-
 perience sensory quality. Indeed it is true that
 though we generally know where our limbs are,
 this position sense does not have a sensory nature.

The vestibular system detects the position and
 motion of the head, and so vestibular inputs have
 corporality. However, they have no alerting ca-
 pacity. This is because although sudden changes in
 body orientation immediately result in re-adjusting
 reactions, these do not *per se* interfere with current
 cognitive processing. Coherent with our expecta-
 tions, therefore, the vestibular sense is not per-
 ceived as corresponding to an experience. We
 know we are standing vertical, but we do not have
 the experience of this in the same sense as we have
 the experience of hearing a bell or seeing a red
 patch.

Speculatively, we suggest our plot also can track
 phenomena intermediate between sensory and
 mental states. Richness is one of the several ex-
 amples very tentatively included as points in Fig.
 1. The feeling of being rich is a case where there is
 a limited form of corporality (there are things one
 can do when one is rich, like getting money from
 the bank teller, buying an expensive car, but this is
 nothing like the immediate and intimate link that
 action has on visual perception, for example), and
 little alerting capacity (there is no warning signal

when one's bank account goes empty). As a con-
 sequence, the feeling of being rich is somewhat,
 though not entirely, sensory.

**Application 1: intra- and intermodal differences in
 sensory quality**

One important aspect of sensory experience con-
 cerns the differences and the similarities between
 sensations of a same modality. Why, for example,
 is the sensation of red different from the sensation
 of blue? It seems that any account in terms of dif-
 ferent neural processes correlated with red and
 blue immediately encounters an insurmountable
 problem: why should this particular neural proc-
 ess, say (whatever its specification in neural terms),
 provide the red sensation, rather than the blue
 sensation?

In the preceding sections, it was claimed, with
 reference to the example of softness, that an ac-
 count in terms of sensorimotor contingencies side-
 steps such difficulties. This same approach can
 now be applied to color. The incoming sensory
 data concerning a fixated patch of color depend on
 eye position. Because of non-uniformities in mac-
 ular pigment and retinal cone distributions, eye
 movements provoke different patterns of change
 in sensory input, depending on which colors are
 being fixated. Such sensorimotor contingencies are
 part of what constitute the sensations of the dif-
 ferent colors. Another type of sensorimotor con-
 tingency associated with colors depends on body
 motions. Consider the light reflected from a colo-
 red piece of paper. Depending on where the ob-
 server is positioned with respect to ambient
 illumination, the paper can, for example, reflect
 more bluish sky light, more yellowish sunlight, or
 more reddish lamplight. Such laws of change con-
 stitute another type of sensorimotor contingency
 that constitute the sensations of different colors.
 The fact that color sensation can indeed depend on
 body motions has been suggested by Broackes
 (1992) and further philosophical work on color
 from a related perspective is reported in (Myin
 (2001); cf. also Pettit, 2003). A mathematical ap-
 proach applied to the idea that the differences be-
 tween color sensations are determined by

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1 differences in sensorimotor laws has recently been
 2 used to quantitatively predict the structure of human
 3 color categories (Philipona and O'Regan, in
 4 preparation).

5 Research by Ivo Kohler (1951) provides empirical
 6 confirmation for this application of the sensorimotor
 7 approach to color. Kohler's subjects wore goggles in
 8 which one side of the field was tinted one color (e.g.,
 9 red) and the other another color (e.g., blue). Within
 10 a period of some days the subjects came to see colors
 11 as normal again. The sensorimotor theory would indeed
 12 predict such an adaptation to the new sensorimotor
 13 contingencies associated with each color. Kohler's
 14 experiments have been criticized (e.g., McCollough,
 15 1965), but recent further work using half-field tinted
 16 spectacles (see Fig. 2) shows that adaptation of this
 17 kind is indeed possible (O'Regan et al., 2001; Bompas
 18 and O'Regan, submitted).

19 A second important aspect of sensory experience
 20 concerns intermodal differences in sensory quality:
 21 the fact that hearing involves a different quality as
 22 compared with seeing, which has a different quality
 23 as compared with tactile sensation.

24 We propose to again apply the idea that sensation
 25 involves the exercising of sensorimotor contingencies:
 26 differences between modalities come from the different
 27 skills that are exercised. The difference between
 28 hearing and seeing amounts to



29 Fig. 2. Half-field tinted spectacles worn by A. Bompas.

30 the fact that among other things, one is seeing if,
 31 when one blinks, there is a large change in sensory
 32 input; one is hearing if nothing happens when one
 33 blinks, but, there is a left/right difference when one
 34 turns one's head, etc. Some other modality-specific
 35 sensorimotor contingencies are specified in Table
 36 1.

37 In addition to providing a more principled
 38 account of sensory modality, the sensorimotor
 39 approach leads to an interesting prediction. According
 40 to this approach, the quality of a sensory modality
 41 does not derive from the particular sensory input
 42 channel or neural circuitry involved in that modality,
 43 but from the laws of sensorimotor contingency that
 44 are implicated. It should, therefore, be possible to
 45 obtain a visual experience from auditory or tactile
 46 input, provided the sensorimotor laws that are being
 47 obeyed are the laws of vision (and provided the brain
 48 has the computing resources to extract those laws).

49 The phenomenon of sensory substitution is coherent
 50 with this view. Sensory substitution has been
 51 experimented with since Bach-y-Rita (1967) constructed
 52 a device to allow blind people to "see" via tactile
 53 stimulation provided by a matrix of vibrators
 54 connected to a video camera. Today there is renewed
 55 interest in this field, and a number of new devices
 56 are being tested with the purpose of substituting
 57 different senses: visual-to-tongue (see Fig. 3, from
 58 Sampaio et al., 2001); visual-to-auditory (Veraart
 59 et al., 1992); auditory-to-visual (Meijer, 1992);
 60 and auditory-to-tactile (Richardson and Frost,
 61 1977). One particularly interesting finding is that
 62 the testimonials of users of such devices at least
 63 sometimes come framed in terms of a transfer of
 64 modalities. For example, a blind woman wearing a
 65 visual-to-auditory substitution device will explicitly
 66 describe herself as seeing through it (cf. the
 67 presentation by Pat Fletcher at the Tucson 2002
 68 Consciousness Conference, available on
 69 <http://www.seeingwithsound.com/tucson2002.html>).
 70 Sensory substitution devices are still in their
 71 infancy. In particular, no systematic effort has
 72 been undertaken up to now to analyze the laws of
 73 sensorimotor contingency that they provide. From
 74 the view point of sensorimotor approach, it will
 75 be the similarity in the sensorimotor laws, which
 76 such devices recreate, that determines

Table 1. Some sensorimotor contingencies associated with seeing and hearing

Action	Seeing	Hearing
Blink	Big change	No change
Move eyes	Translating flowfield	No change
Turn head	Some changes in flow	Left/right ear phase and amplitude difference
Move forward	Expanding flowfield	Increased amplitude in both ears

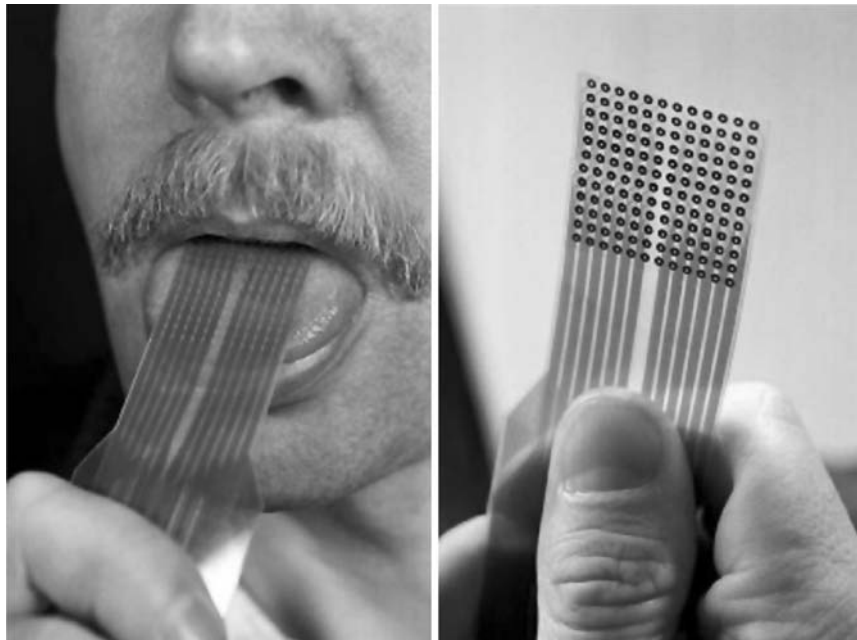


Fig. 3. Tongue stimulation device. This device, connected to a video camera, creates a 12 × 12 sensory pattern on the tongue (from Sampaio et al., 2001).

the degree to which users will really feel they are having sensations in the modality being substituted.

Related phenomena which also support the idea that the experience associated with a sensory modality is not wired into the neural hardware, but is rather a question of sensorimotor contingencies, comes from the experiment of Botvinick and Cohen (1998), where the “feel” of being touched can be transferred from one’s own body to a rubber replica lying on the table in front of one (see Fig. 4; also related work on the body image in tool use: Iriki et al., 1996; Farne and Ladavas, 2000; Yamamoto and Kitazawa, 2001). The finding of the Sur group (Roe et al., 1990), according to which ferrets

can see with their auditory cortex can also be interpreted within the context of the present theory (Hurley and Noë, 2003).

Application 2: dreaming and mental imagery

Dreams are characterized by the fact that while people are dreaming they seem to assume that they are having the same full-blown perceptual experiences that they have in real life. Clearly, however dreams do not involve corporality or alerting capacity in the normal fashion, since there is no sensory input at all.

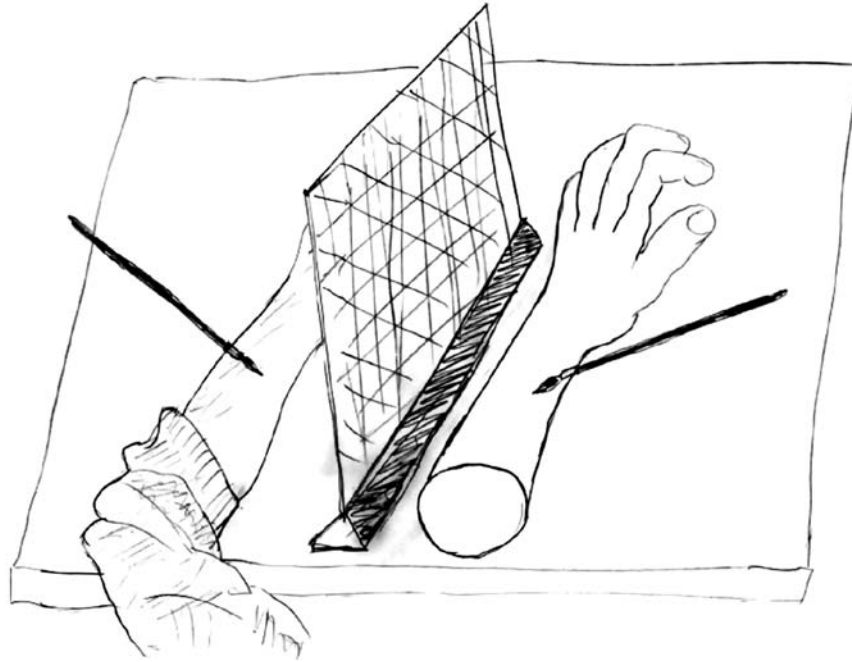


Fig. 4. Illustration of the experiment of Botvinick and Cohen (1998). The subject's arm is placed behind a screen. The subject only sees a rubber arm replica placed in front of him. The experimenter simultaneously stimulates the replica and the arm with a brush. After a few minutes the subject has the impression that the rubber arm is his own arm.

On the other hand, it is also clear that it is precisely corporality that ultimately allows people to realize that they are actually dreaming — the classic way of knowing that you are dreaming is to try to switch on the light: this kind of “reality-checking” is nothing more than testing for corporality — checking that your actions produce the normal sensory changes expected when you are having real sensory experiences.

It is important to note however that what counts in giving the particular “sensory” feel of sensation is not the actual sensory input itself, but the knowledge that the sensory input possesses corporality and alerting capacity. This means that an observer can have a sensation even though he is, at a given moment, doing nothing at all, and even though he is receiving no sensory input at all. It suffices for this that he be in the same mental state that he would usually be in when he has implicit knowledge that the sensorimotor contingencies associated with a sensation are currently applicable.

We can therefore understand how it might happen that a person would have experience of reality without sensory input, and therefore no corporality and alerting capacity. The person merely has to be in a state where he thinks (in point of fact incorrectly) that if he were to move, then those changes would occur that normally occur when he moves. He just has to implicitly think (incorrectly) that were there to be a sudden event, his attention would be automatically attracted to it.

Dreaming therefore poses no problem for the sensorimotor approach that we are proposing. Indeed the approach actually makes it easier to envisage brain mechanisms that engender convincing sensory experiences without any sensory input, since the sensation of richness and presence and “ongoingness” can be produced in the absence of sensory input merely by the brain implicitly “supposing” (in point of fact incorrectly) that if the eyes were to move, say, they would encounter more detail. This state of “supposing where one can get more detail” would be a much easier state

1 to generate than having to actually recreate all the
 3 detail somewhere in the brain. In dreaming, fur-
 5 thermore, the state would be particularly easy to
 7 maintain because what characterizes dreaming
 9 would seem to be a lack of attention to the ab-
 11 sence of disconfirming evidence, which is quite
 13 unsurprising, since one is asleep. This lowering of
 15 epistemic standards implies that, while dreaming,
 17 one is easily led into thinking one is perceiving,
 19 while — if only one were to pay attention — it
 21 would be obvious that one is not. Thus one can
 23 remain convinced for the whole duration of one's
 25 dream that one is experiencing reality. A whole
 series of different bizarre dream events may be
 taken at face value simply because nothing dis-
 confirms them.

Similar remarks apply to mental imagery. As for
 dreams, mental imagery would correspond to a
 kind of perceptual action without an actual stim-
 ulus and without “going through” the motions —
 it would involve having implicit expectancies with-
 out these being actually fulfilled by worldly re-
 sponses (for a detailed account of mental imagery
 along roughly “sensorimotor” lines, see Thomas,
 1999).

Application 3: spatial and temporal completeness of the visual world — “change blindness”

When one looks out upon the world, one has the
 impression of seeing a rich, continuously present
 visual panorama. Under the sensorimotor theory,
 however, the richness and continuity of this sen-
 sation are not due to the activation of a neural
 representation of the outside world in the brain.
 On the contrary, the “ongoingness” and richness
 of the sensation derive from implicit knowledge of
 the many different things one can do (but need not
 do) with one's eyes, and the sensory effects that
 result from doing them. Having the impression of
 seeing a whole scene comes, not from every bit of
 the scene being present in the mind, but from every
 bit of the scene being immediately available for
 handling by the slightest flick of the eye. In terms
 of the core concepts of this paper: the “feeling of
 seeing everything” comes from exercise of implicit-
 ly knowing one is in a relation with the visually

perceived part of the environment which has a
 high degree of both corporality (moving the body
 causes changes in sensory input coming from the
 visual field) and alerting capacity (if something
 suddenly changes inside the visual field, attention
 will immediately be drawn to it).

But now a curious prediction can be made. Only
 one aspect of the scene can be “handled” at any
 one moment. The vast majority of the scene, al-
 though perceived as present, is not actually being
 “handled”. If such currently “unhandled” scene
 areas were to be surreptitiously replaced, such
 changes should go unnoticed. Under normal cir-
 cumstances, the alerting capacity of visual input
 ensures that any change made in a scene will pro-
 voke an eye movement to the locus of the change.
 This is because low-level movement detectors are
 hard-wired into the visual system and detect any
 sudden change in local contours. Attention is per-
 emptorily focused on the change, and visual “han-
 dling” is the immediate result. But if the alerting
 capacity could be inactivated, then we predict that
 it should indeed be possible to make big changes
 without this being noticed.

An extensive current literature on “change
 blindness” confirms this prediction (for a review
 see Simons, 2000). By inserting a blank screen or
 “flicker”, or else an eye movement, a blink, “mud-
 splashes” (see Fig. 5), or a film cut between suc-
 cessive images in a sequence of images or movie
 sequence, the local transients that would normally
 grab attention and cause perceptual “handling” of
 a changing scene aspect are drowned out. Under
 such conditions, observers remain unaware of very
 large changes. Another method of obviating the
 usual alerting action of local changes is to make
 them so slow that they are not detected by the low-
 level transient detectors in the visual system (see
 Fig. 6, from Auvray and O'Regan, 2003; also
 Simons et al., 2000). Demonstrations of change
 blindness phenomena can be found on the web
 sites: <http://nivea.psycho.univ-paris5.fr> and <http://viscog.beckman.uiuc.edu/change/>.

A related phenomenon is the phenomenon of
 “inattention blindness” pioneered by Neisser
 and Becklen (1975) and Mack and Rock (1999)
 and recently convincingly extended by Simons and
 co-workers (Simons and Chabris, 1999). In this, a

QA :2

QA :3

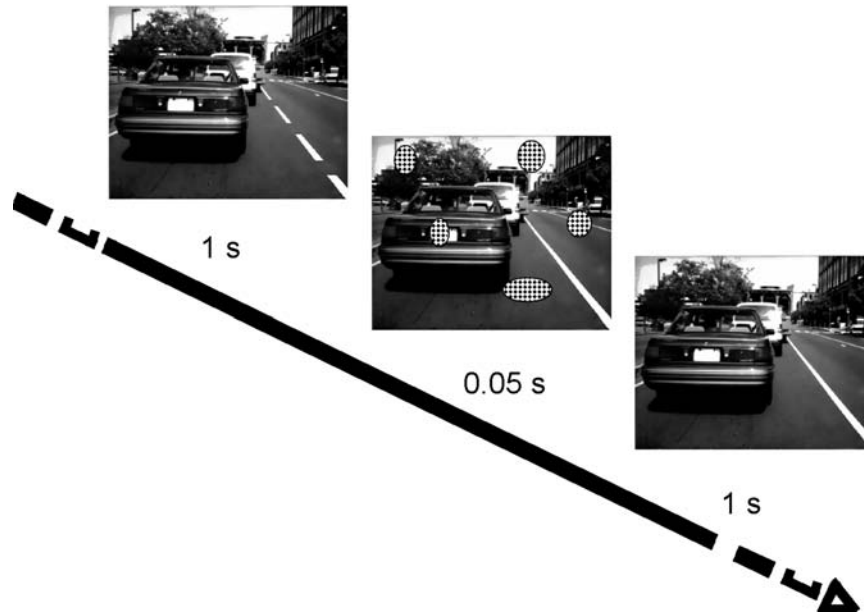


Fig. 5. Change blindness using “mudsplashes” from O’Regan et al. (1999). If the white line in the street changes simultaneously with the occurrence several brief splashes on the screen, the change is very difficult to notice unless it is known in advance.

movie sequence of a complex scene is shown to observers, and they are told to engage in an attentionally demanding task, like counting the number of ball exchanges made in a ball game. An unexpected event (like an actor dressed in a gorilla suit) can go totally unnoticed in such circumstances, even though the event is perfectly visible and in the very center of the visual scene. Demonstrations can be seen on <http://nivea.psychu.univ-paris5.fr> and http://viscog.beckman.uiuc.edu/djs_lab/demos.html.

Consciousness

The argument made in this paper concerns the nature of sensation: what gives sensation its “experienced” quality, what makes sensory qualities the way they are. But note that we have purposefully not touched upon the question of why and when sensations are conscious. Our claim would now be that a sensation is conscious when a person is poised to cognitively make use of the sensation in their judgments, decisions, and rational behavior.

Why does this constitute progress toward answering the question of the explanatory gap, namely the problem of how a physicochemical mechanism in the brain could ever give rise to an experience? The answer is that first, having cognitive access to a fact is something that is generally considered to not offer particular problems with scientific description and explanation (see Dennett, 1978, Baars, 1988). It amounts to what Block (1995) has called Access Consciousness, and is something which, though it may constitute a difficult thing to implement in a machine, is nevertheless describable in broadly functionalist terms. There is no a priori logical difficulty (although there may be practical difficulties) in using scientific methods to understand Access Consciousness.

Second, we have defined sensation in a way that does not seem problematic from a scientific point of view, namely in terms of sensorimotor skills. The different types of sensations and their experienced characteristics — their similarities and differences, their experienced “presence” — can all be accounted for in terms of the differences between the skills, and in terms of way the neural channels are tuned to the environment, namely by the

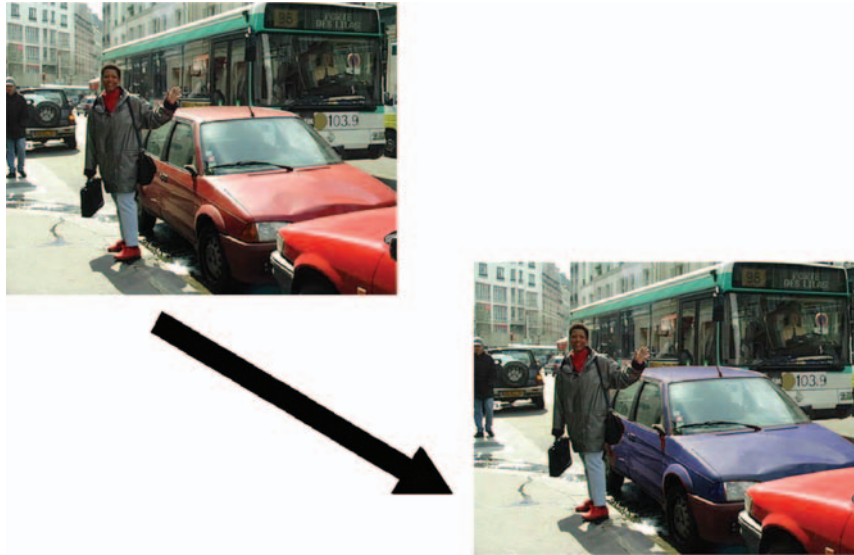


Fig. 6. Progressive change from red to blue is very difficult to notice if it occurs very slowly (10 s from Auvray and O'Regan, 2003).

properties of corporality and alerting capacity. If having a conscious experience amounts to having cognitive access to sensations, then what has previously been considered mysterious, namely what Block has called Phenomenal Consciousness, can now be decomposed into two scientifically tractable components: conscious experience would in our approach consist in having Access Consciousness of sensations. Since Access Consciousness is amenable to scientific methods, and since sensations, being sensorimotor skills, are also amenable to scientific methods, under our approach Phenomenal Conscious now also comes within the domain of science.

Description or explanation?

It is interesting to consider finally the explanatory status of the concepts put forward in this paper. The question of accounting for the experienced quality of sensation is the question of accounting for why certain mental processes are taken to have a sensory nature, while others, like doing arithmetic or making a decision, are not. If one does not espouse a sensorimotor approach, one could claim that saying that sensations involve neural channels possessing corporality and alerting capacity is sim-

ply describing something about sensations, and has no explanatory status.

But if one espouses the sensorimotor approach, then the question of accounting for the experienced quality of sensation becomes tractable by the scientific method, since we can see that each of the aspects of the experienced quality of sensory experience, which previously seemed difficult to explain, actually correspond to objectively describable aspects of the skills that are involved. One important such aspect, one which has posed many problems to classical approaches to phenomenal consciousness, is the problem of "presence". We have dealt with this in the sensorimotor approach by noting that sensory stimulation possesses corporality and alerting capacity, thereby providing the skills involved in exploring sensory stimulation with its particular intimate, vivid, inescapable quality. These seem to deal adequately with what we mean by "presence".

We also think our approach holds the promise of accounting for further fine-grained features of sensation that have been noticed by various theorists (see, for example, the list of features in Humphrey, 1992, 2001; O'Regan and Noë, 2001b; Myin and O'Regan, 2002). Consider, for example, ineffability and subjectivity: Under an approach

1 where sensation is neurally generated, it would be
 3 difficult to explain why certain neural processes
 5 generate qualities which are felt, but which cannot
 7 be described (ineffability); equally, it would be
 9 difficult to explain why certain neural processes
 11 appear to generate subjective quality, whereas
 13 others do not.

15 Within the sensorimotor approach, the appear-
 17 ance of both properties is predicted and is thus
 19 explainable: sensory experiences are subjective,
 21 and are the sole property of the experiencer be-
 23 cause they involve the experiencer himself poten-
 25 tially undertaking actions and exercising
 27 sensorimotor skills (see Humphrey (1992, 2001)
 29 for a similar explanation). Similarly, sensory ex-
 31 periences are ineffable because they involve ex-
 33 ercising implicit, practical skills. Like tying one's
 35 shoe laces, exercising the sensorimotor contingen-
 37 cies associated, say, with red, involves putting into
 39 practice a practical skill that one cannot describe
 41 with words, but that one knows one possesses.

43 While it may at first sight be unclear how we
 45 have made the passage from description to expla-
 47 nation by changing our view of what sensation is,
 it should be noted that such a shift in theoretical
 paradigm occurred in the 20th century as regards
 the question of life. Whereas at the beginning of
 the 20th century, cell division, metabolism, respi-
 ration, etc., were considered to be caused by an as
 yet unexplained vital essence, today we consider
 these phenomena to be constitutive of life. The
 notion of life has been redefined: instead of being
 caused by some underlying mechanism, it is con-
 sidered now to be constituted by all the various
 ways the organism can act within its environment.
 In the same way, by changing one's viewpoint on
 what sensation is, and espousing the sensorimotor,
 skill-based approach, one can avoid the issue of
 generation and thus of the explanatory gap, and
 immediately see how each of the characteristics
 that people attribute to sensation arise from as-
 pects of neural machinery and their interaction
 with the environment.

Thus, we think we have shown that, contrary to
 the idea that there is an unbridgeable gap between
 neural processes and "sensory consciousness", a
 connection may be made between the two domains
 if neural systems are conceived not as generating

sensations, but as allowing organisms to deploy
 sensorimotor skills.

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