imply that there is nothing intrinsic to the conscious state or episode in virtue of which it represents itself (and is thus conscious). Vary merely its apparently extrinsic relations, and the very same state, identified by its intrinsic properties, passes from being conscious to being unconscious. But this counter-intuitive consequence is common to all varieties of representationalism that assume reductive, naturalistic theories of representation. If one finds this consequence implausible, the ostensible advantages of reductive self-representationalism will hardly matter. If one is willing to accept some version of the doctrine of internal relations, which is no more and no less mysterious than the view that some things are intrinsically representational, then some version of self-representationalism may well be a superior theory of consciousness.

Some have argued, however, that the form of ubiquitous, non-introspective self-consciousness in question cannot be literally identified with a kind of self-*representation* (e.g. Zahavi 1999). They have either held that reflexive representation is impossible or that a representation relation is unable to account for the kind of intimacy with which consciousness primitively knows itself. Accordingly, these theorists maintain that primitive self-consciousness is an irreducible and unanalysable feature of consciousness, and they would be uncomfortable with the appellation 'self-representationalist'. But the claim that reflexive representation is impossible is implausible, and, to date, no compelling arguments for it have been produced. The point about intimacy does merit careful consideration, for, depending on how one construes the representation relation involved, it is far from obvious how its reflexive instantiation could account for subjectivity and, in particular, for the sense that one knows oneself in a direct and primitive way.

Several routinely raised objections apply to all versions of self-representationalism. First, it is often claimed that the view implies that *animals and *infants are not consciousness because they are too unsophisticated to be self-conscious. But the mode of self-consciousness in question is generally held to be primitive and, perhaps, non-conceptual. Moreover, the objection is insensitive to the distinction between introspective and merely marginal self-consciousness. Second, it is sometimes claimed that the view implies either that there is an infinite hierarchy of conscious mental states or that a single conscious mental state has an infinite representational content. But the first suggested regress is, in fact, dispensed with by the theory. Again, the view is that each conscious episode represents *itself*. The second suggested regress presupposes some premise to the effect that each conscious episode represents individually all of its representational properties. But there is no reason to accept that premise. Relatedly, some have thought that the view commits one to the very implausible thesis that one can know one's consciousness infallibly and exhaustively. But an episode of consciousness could represent itself without providing its possessor with such knowledge. Finally, some would argue that the claim involves vicious circularity. This could either be taken to mean that the view is incompatible with a reductive construal or taken to mean that reflexive representation is impossible because it involves some kind of regress. Both claims are false.

Whether or not one is interested in reductive versions of self-representationalism, the phenomenological datum upon which the theory rests is an important one. If the subjectivity of consciousness can indeed be construed in terms of non-introspective, self-representation (of some sort), this will mark an important advance over theories of subjectivity that contain no structural elucidation. If it is true that consciousness involves a form of self-representation, then any structural model of consciousness ought to include this feature. As Hofstadter (1979) and others have argued, this suggests that the conceptual tools useful for understanding self-reference, self-membership, self-application, and other phenomena of the sort, might be useful for modelling and extending our knowledge of consciousness itself. As long as such models provide conceptual clarity, powerful analogies, and, eventually, generate empirically testable predictions, they ought to be explored, even if, as some allege, the proponents of self-representationalism mistake a contingent feature of a good deal of human consciousness for a necessary feature of all consciousness.

See also INTENTIONALITY; PHYSICALISM; REPRESENTATION; SELF, PHILOSOPHICAL THEORIES

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sensorimotor approach to (phenomenal) consciousness. The sensorimotor approach is concerned with elucidating *only one particular* aspect of the problem of consciousness, namely the problem of phenomenal consciousness or *sensory feel*. Phenomenal consciousness is the **what-it-is-like* or *phenomenality* associated with sensory stimulation (most typically visual, auditory, tactile, olfactory, and gustatory sensations). Unlike what the philosopher Ned Block calls **access consciousness,* which seems amenable to analysis in scientific terms, phenomenal consciousness poses a problem for science (the **hard problem*) because one cannot see how biological

systems obeying known laws of physics could generate sensory feel: sensory feel seems to be something outside the realm of science (hence the **explanatory gap*).

The sensorimotor approach takes the somewhat counter-intuitive stance that the problem of feel can be solved by adopting the view that for a person to have a feel amounts to (1) the person currently being engaged in exercising a certain sensorimotor skill, and (2) attending to the fact that they are engaged in exercising that skill.

1. Differences in sensory quality
2. Why feels have a quality at all
3. Ineffability
4. How feel is generated by the brain
5. Relation to attention and access consciousness
6. Note on the essential role of skill in the theory
7. Proponents and opponents of the theory

1. Differences in sensory quality

A first example of how this skill-based approach can be applied to the problem of phenomenal consciousness concerns differences in sensory quality. Classically, an explanation for the fact that input in different sensory channels provokes different types of sensation is sought in the different cortical areas that are involved (see *neural*correlates of consciousness*). However, this hypothesis leaves open the question of what exactly it is about these cortical areas or nerve channels that produces the particular sensations. Additional 'linking hypotheses' always have to be made to justify e.g. why particular neurons or neural mechanisms should produce particular sensory qualities, or why particular firing patterns should produce particular modulations in feel. But there would appear logically to be no way of making such a link in a scientifically testable fashion, since neural states are only physical characteristics of the firing patterns of neurons, and have no natural relation to facts of phenomenology. Thus, so claim the proponents of the sensorimotor approach, the search for a neural explanation for sensory quality will logically always fail through lack of such a scientifically testable link. Appealing to mechanisms like *gamma oscillations, *re-entrant processing, or quantum theories of consciousness, or *microconsciousness in particular cortical areas is not a solution, since there is logically no way to link properties of such mechanisms to the different varieties of feel that accompany sensations.

In the sensorimotor theory this logical problem of linking physical mechanisms to experienced feel is, it is claimed, obviated by appealing to the notion of sensorimotor interaction or *skill*. The sensorimotor approach proposes that having a feel involves attending to the fact that one is currently engaged in a particular skill or mode of sensorimotor interaction with one's environment. Taking this definition of feel, the quality of a feel will then be constituted by the particular laws that potentially govern the interaction. Take as analogy the feel of driving a Porsche as compared to driving a Volkswagen: the difference in feel is not generated anywhere in the brain, it is constituted precisely by the different things one can do, potentially (that is, one need not actually be doing them at any moment), when one drives these different cars. And now, it is claimed, there is a way of making a link between the phenomenology and the objective, sensorimotor interaction, because to every aspect of the phenomenology of driving there corresponds an objective physical characteristic of the interaction one has with the car. Of course it is difficult to precisely pinpoint what characterizes the feel of Porsche driving: clearly epithets such as 'invigorating', 'light touch', 'responsiveness', or 'sensitive steering' might be used. But whatever can be said about the feel of Porsche driving will, according to the sensorimotor theory, ultimately boil down to objective facts about the way the car behaves when one acts upon its controls. It is precisely the car's potentialities under our control, that is, the laws that govern our sensorimotor interaction with the car, which, it is claimed, constitute the feel of Porsche driving.

The sensorimotor approach now applies this idea to all sensory feels. By doing this, it provides a way of explaining similarities and differences between different sensations, and so escapes the failings of neural correlate approaches, which had to appeal to arbitrary linking hypotheses between physical mechanisms and different feels. Thus, to understand the felt difference between different sensory modalities, the sensorimotor approach considers the example of seeing and hearing. Seeing is a form of interaction in which blinks, movements of the eyes, of the body, and of outside objects provoke very particular types of change in sensory input. The laws governing these changes are quite different from the laws governing sensory input in the auditory modality. For example, when one sees, moving forward potentially produces an expanding flow-field on the retina, whereas when one hears, the change in sensory input is now mainly an increase in amplitude of the signal. The claim is now that the sum total of these differences constitute precisely what differentiates the sensations of seeing and hearing. (Note that in this explanation, the theory does not require continuous motor involvement. It suffices that the perceiver should have sufficient information to know, implicitly, that if a movement were made, then particular sensorimotor laws would apply.)

To understand the felt difference between red and pink, for example, the sensorimotor approach notes that when one moves a coloured piece of paper under different illuminants, or when one moves one's eyes on

or off the paper, there are precise laws that govern the changes in photon catches made by the three photoreceptor types that humans possess. In the case of red, for example, the changes in photon catches are confined to a single dimension of variation (Philipona and O'Regan 2006), suggesting why red is in some sense a special colour as compared to, say, orange, where three dimensions of variation are observed. In general all differences in experience will, under the sensorimotor approach, be constituted by differences in the sensorimotor laws or dependencies (also called 'sensorimotor contingencies') governing interaction with sensory stimuli.

A notable point about the theory is the way it explains humans' experience of a very rich and continually present visual world. Instead of supposing, as does the classic approach to vision, that this requires continuous activation of a rich internal representation of the world (this, the theory claims, would be to make a confusion between the *vehicle and the *contents of consciousness), the theory says that the experience of richness and continuity can in many cases be due to the fact that a perceiver has immediate *access*, via a flick of attention or an eye movement, to any information about the outside world. The analogy is the *refrigerator light: the light is on every time you open the fridge, so you assume it is on continually. Similar arguments are put forward in the theory to explain the filling in of the blind spot. In both cases, the theory claims it is not necessary for all parts of the visual field to be represented in the brain in order for a person to have the sensation of seeing the whole field.

2. Why feels have a quality at all

Classically in the philosophy of phenomenal consciousness it is said that 'there is something it is like' to have a sensory experience. One of the mysteries of phenomenal consciousness is considered to lie in explaining why the brain processes involved in sensory experiences give rise to this special quality—also referred to as *sensory presence* or *vividness*—while most other brain processes do not possess it.

The sensorimotor approach deals with this problem in the following way. If, as the approach claims, having a feel is precisely attending to the fact that one is engaged in exercising a sensorimotor skill, and if the quality of the feel is *constituted* by the laws of sensorimotor interaction that the skill involves, then by the very definition of feel, the feel must have a quality, namely the quality constituted by exercising the particular sensorimotor law involved.

Then, just as the sensorimotor approach invokes differences in skills to account for differences between sensations, the approach will also invoke differences in skills to account for the difference between experiences involved in perceptual acts and the experiences involved in *mental* activities like thinking, remembering, or deciding. In particular, it is immediately clear that whereas perceptual acts invariably involve, at least potentially, changes caused by motor behaviour, this is not true of mental activities. What we call sensory experience can always potentially (if not actually) be modified by a voluntary motion of the body: sensory input to the eyes, ears, or any other sensory system is immediately changed in a systematic and lawful way by body motions. On the other hand, mental activities like thoughts, memories, and decisions, to the extent that these can be considered as skills, are not skills that intrinsically involve body motions. This then is what makes the skills constituting sensory experiences special as compared to other brain processes: they are by nature sensori*motor*. Even if at any particular moment there need be no motion, they have what the sensorimotor approach calls *corporality* or *bodiliness*.

A second notable characteristic that distinguishes the skills involved in sensory experience from those of mental functions is what is termed *alerting capacity* or *grabbiness*: this is the fact that sensory systems are genetically endowed with the capacity to deflect our cognitive processing. A loud noise or bright flash will automatically, incontrovertibly, attract our attention to the locus of the event. We are thus, in some sense, 'cognitively at the mercy' of sensory input. This is not generally the case for mental activities. If a change occurs in the visual field, e.g. a mouse flitting across the floor, one's attention will immediately be caught by it. But if one has forgotten a word, one only discovers this if one actively tries to recover the word from memory. *Memory, and in general other mental activities, possess no alerting capacity or grabbiness (an exception might be, for example, obsessive thoughts).

Thus: a characterization of the differences in skills associated with sensory acts, as compared to those involved in mental acts, reveals differences which naturally account for the difference in felt quality of sensations as compared to other mental processes. What has been called the 'presence' of sensations seems precisely to consist in the fact that they are both under our control (in that we can modify sensory input by our bodily actions—they have corporality or bodiliness), and also *not* under our control (they can cause uncontrollable alerting reactions that interfere with our normal cognitive processing: alerting capacity or grabbiness). The sensorimotor approach suggests that this captures the idea of there being 'something it is like' to feel, as opposed to other mental activities. The notions of bodiliness and grabbiness can also be used to account for the particular feel associated with pain (pain has a particularly high degree of grabbiness).

3. Ineffability

In the sensorimotor approach, appealing to skills is also taken to provide a natural way of accounting for the fact that sensations are ineffable. The reason is that the sensorimotor approach claims that while we have mastery of our sensorimotor skills, the mastery we have is implicit: we do not have cognitive access to each and every muscular contraction or change in sensory input that occurs. Indeed, muscular contractions (e.g. the lengths of particular muscle fibres) and sensory inputs (e.g. retinal photoreceptor firings) are not, it is claimed, in themselves things that we can become aware of. The situation is like tying your shoelaces: you know that you are tying your shoelaces, but you cannot say exactly how you are doing it, exactly what are the positions of your fingers, exactly what are the muscle movements involved. You may attend to different ways of tying your shoelaces, like differences occurring when the shoelaces are of different rigidity, length, thickness, etc., but though you can identify that there are these differences, and that these differences provide different feels to the shoelace tying action, you cannot describe in detail what these differences consist in.

Similar considerations, it is claimed, then apply to sensory feels: the sensorimotor dependencies involved in seeing are even less accessible to you than the intricacies of shoelace tying: you know that moving your eyes provokes changes in the information available to you, but you do not know in detail the changes in optic flow that are produced on your retina. You have a notion that when you move coloured surfaces under different lights, changes occur that depend on the particular surface reflectances, but the precise laws that govern those changes are not cognitively accessible to you. Nevertheless, the brain can distinguish between the different laws governing interaction with coloured surfaces, and can classify the associated surfaces as corresponding to different colours—just as you can recognize the feel of driving different cars without being able to cognitively pinpoint what causes these differences. Furthermore the brain structures the similarities and differences between the colour interactions in ways that correspond to the dimensions of brightness, hue, and saturation, and this structure determines the structure of the classifications and colour differences to which we have cognitive access.

4. How feel is generated by the brain

In the sensorimotor approach, this question is considered not to be an appropriate question to ask about feel. The sensorimotor approach considers that the idea that feel might be generated in the brain is a category error similar to the error of thinking that something about the shape of a word might generate its meaning. The idea is that if we think properly about feel, then we realize that feel is not an 'essence' that can be generated: we have a feel when we attend to the fact that we are interacting with our environment in a particular skilful mode. The quality of the feel is constituted by the characteristics of the mode of interaction.

5. Relation to attention and access consciousness

Why do we feel the feels *ourselves*? Whereas the essential ingredient of the sensorimotor approach is the appeal to skill—which provides the basis for an explanation for experienced differences in feel—the theory also stipulates that to experience a feel, one must have cognitive access to the skill that one is exercising. Thus simple sensorimotor automata, e.g. thermostats, missile guidance systems, and presumably insects, cannot, by definition, have feels: it is not sufficient for a system to be exercising a sensorimotor skill, it must in addition have sufficient cognitive capabilities to attend to the sensorimotor contingencies involved. If a system has sufficiently complex capacities for it to make sense to say that it has a *self, then it will be this self that has cognitive access to the ongoing sensorimotor interaction, and thus it will be this self that feels. However, it is claimed that these appeals to cognitive access or attention, and to the notion of self, do not necessitate any scientifically mysterious mechanisms: attention is a notion already widely used in psychology, where it is considered difficult, but not in any way 'magical' or impossible to implement or understand scientifically. The 'self' is a complex construct corresponding to an agent's capacity to reason about its own potential cognitive and social behaviours, but it is also not magical.

To the extent that the sensorimotor approach makes use of the notion of cognitive access and attention, it bears resemblance to theories of consciousness such as the *global workspace theory (see also *attention). Such theories are probably able to provide an acceptable explication of access consciousness. However, it is the addition of the notion of skill which provides the essential element that allows the sensorimotor approach to go further than access consciousness, and to provide insights into what has been considered beyond the reach of functional accounts, namely phenomenal consciousness.

6. Note on the essential role of skill in the theory

The reason that invoking skill in the theory provides help in explaining phenomenal consciousness is that differences and similarities between skills are objective facts about an organism's interaction with the world. Since in the theory the quality of experience is taken to be constituted by the exercise of skills, differences and

similarities between qualities are describable in terms of these objective differences in skilful modes of interaction. Making the connection between skill and feel is now easy to do because sensorimotor laws are both describable in terms of objective facts about the perceptible world, and they also have a natural correspondence with what people generally agree characterizes sensory feels as compared to other mental phenomena, in particular their perceptual presence.

In contrast, if the onus of explanation in explaining feel is put on neural states, as is done in the classical 'neural correlate' approach to phenomenal consciousness (cf. neural correlates of consciousness), then there is no natural way of making the connection between similarities and differences of feel and similarities and differences in the neural states. Even something so simple as supposing that increased neural firing should cause increased intensity of feel would require providing an explanation for that particular choice of link between feel and neural activity.

7. Proponents and opponents of the theory

The sensorimotor approach, as set out originally by O'Regan and Noë (2001a, 2001b) and more recently by O'Regan et al. (2006), has also been called the *enactive approach* (Noë 2005). The notion of enaction involves the idea that one can only adequately describe the functioning of the mind in the context of a system with a body acting and sensing in its environment.

However, it should be noted that some other authors have associated the notion of enaction with dynamical systems, and with the idea that re-entrant processing, chaos, and complexity in neural systems might be the key to consciousness. This would be contrary to the sensorimotor approach, which considers that if one thinks carefully about consciousness and feel, one realizes that no appeal to such mechanisms can help to understand why feels feel the way they do.

The sensorimotor approach is sometimes compared to Gibson's ecological approach to perception, with both approaches emphasizing the role of action and sensorimotor dependencies in perception (see *action and consciousness), and both approaches rejecting some senses of the notion of 'internal representation' (see *homunculus). But the two approaches have very different agendas, with the sensorimotor approach being aimed at solving a problem that Gibson was not concerned with, namely the problem of the origin and nature of phenomenal experience.

Like Gibson's ecological theory, the sensorimotor approach is sometimes labelled as being behaviourist: a relation to behaviourism might lie in the fact that to explain sensations, which are generally thought to be inner states, the theory makes use of the concept of skills, which are sensorimotor dispositions. However, to the extent that the theory invokes cognitive capacities and the concept of attention, it is not behaviourist in the sense of rejecting the causal role of internal mental states.

There are points of similarity between the sensorimotor approach and aspects of the thinking of French philosopher Maurice Merleau-Ponty (see *phenomenology), who also wanted to replace the idea of perception as a primarily internal event (involving an iconic replica in the case of vision), with a conception of vision as an active, and further-action-oriented, exploration of the environment. Some of the metaphors used by Merleau-Ponty, such as vision consisting in having a visual grasp on the world, and the analogy between touch and vision, anticipate aspects of the sensorimotor theory. On the other hand, there are clearly points of dissimilarity: the idea that cognitive access or attention is required for consciousness would be rejected by Merleau-Ponty as a piece of 'intellectualist thinking' about the mind.

A different link to behaviourism (and to *functionalism and Dennett's *heterophenomenology) might be the attitude of the theory to *qualia: the theory rules out qualia if they are meant to be in principle unobservable and in principle unrelated to behaviour. On the other hand, if qualia are considered to be the phenomenal experiences that are involved in sensation and perception, then far from eliminating qualia (see *eliminativism), the theory attempts to explain why they are the way they are. The theory claims that compared to other functional approaches, the appeal to skill provides an advantage in accounting for the phenomenology of sensory experience: Sensory feels have a quality rather than no quality because of the bodiliness and grabbiness of sensory systems. The quality of sensation is an objective fact about the way an agent interacts with its environment. For this reason there is also a link with *externalism.

The sensorimotor approach invokes a two-level mechanism to explain phenomenal consciousness: (1) the exercise of a skill, and (2) cognitively accessing the fact that one is exercising the skill. If attending to something can be considered to be a form of cognitive access, the theory might be considered to be related to the *higher-order thought theory of consciousness. Thus it could be said that under the sensorimotor approach, having a feel is having a higher-order thought about the fact of exercising a skill. But the main ingredient of the theory are the skills themselves, since their similarities and differences allow similarities and differences in phenomenal experience (including the difference between feel and no feel) to be explained in a natural way.

An important aspect of the sensorimotor approach is its emphasis on making empirical predictions. The original experiments on *change blindness were motivated by the sensorimotor approach, which is also compatible with the phenomenon of *inattentional blindness. The approach claims to find support in empirical results on *sensory substitution, and in the changes in phenomenal experience caused by sensorimotor adaptation in touch found in the *rubber hand illusion and in *mirror therapy used in reducing *phantom limb pain. A sensorimotor approach to understanding tetrachromacy (see *colour, tetrachromacy) and the phenomenal structure of colour space (Philipona and O'Regan 2006) as well as predictions concerning eye movement contingent modifications of colour sensation (Bompas and O'Regan 2006) have also proved successful.

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sensory substitution. We see with the brain, not with the eye. Blindness typically results from the loss of retinal function, but the visual cortex remains intact. Likewise, deafness and bilateral vestibular dysfunction (BVD) usually arises from the loss of transduction processes. Since the cognitive capacity to experience the sensation remains intact, all that is needed restore lost sensory function is an alternative source of sensory data and a human–machine interface to couple the data to the nervous system (Bach-y-Rita 2005).

1. Brain rewiring
2. Vision substitution.
3. Vestibular substitution
4. A curious phenomenon

1. Brain rewiring

In sensory substitution, data from a set of artificial receptors coupled to the sensory cortex via sensory substitution in a form of controlled *synaesthesia that depends on brain plasticity (Hurley and Noë 2003, Bach-y-Rita 2005). This 'rewiring' of the brain has been observed experimentally. Horng and Sur (2006) observe that in response to visual cortex damage the brains of ferrets are rewired to route retinal input to the auditory cortex, and the auditory cortex is remodelled to accommodate visual information.

Although Sur's observations involve the re-routing of information from properly functioning sense organs to a novel cortex to compensate for the loss of function in the normal cortex, the rewiring can occur the other way around. If the flow of information from a sense organ fails while the cortex remains intact, the brain can rewire itself to use the still-functioning cortex to process information from other senses. Positron emission tomography (PET) has been used to study tactile visual sensory substitution (TVSS) in congenitally blind persons (Ptito *et al.* 2005). The results showed that the visual cortex was activated after, but not before, the one-week training period. No visual cortex activation occurred in blindfolded controls. They concluded that *cross-modal plasticity can occur quickly in the adult brain and that the tongue can act as a portal to convey somatosensory information to the visual cortex. Previously, Bach-y-Rita (2005) had demonstrated the existence of pathways from the skin to the visual cortex.

Many cross-modal sensory substitution schemes are feasible. Bach-y-Rita has done extensive work in TVSS and electrotactile vestibular sensory substitution (EVSS). As another alternative, data from tactile sensors mounted at the fingertips were coupled to skin sensory receptors on the forehead of a leprosy patient. After acclimation, the patient experienced the machine-generated data as if they originated in the fingertips. In addition, various technologies for coupling camera data into the brain via the auditory system have been demonstrated (Meijer 1992).

Hurley and Noë's (2003) model of a sensorimotor cycle appears to be a powerful description of our observations of sensory substitution. One reason for this claim is that our subjects must have motor control and be able to interact with the scene. If not, the electrotactile stimulation is never experienced as anything more than tingling on the tongue. Clark and Eilan (2006) make a rather curious criticism of the model; they do not claim it to be wrong, but suppose it to be 'extreme'. Their objection is that the model fails to accommodate the fractionation of brain function required to support a computational model of the brain. However, our observations lead us to the conclusion that computation does not account for brain function (Kercel *et al.* 2005) and that Hurley and Noë's model points the way toward a credible alternative paradigm.

2. Vision substitution

The experience of seeing can be partially generated by using an image data from a camera, provided the image