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Olivier Massin

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Olivier MASSIN
Université de Grenoble (France)
Department of Philosophy
massinolivier@free.fr

> Colour is the special object of sight, sound of hearing, flavour of taste. […]
> Nevertheless, we are unable clearly to detect in the case of touch what the single subject is which corresponds to sound in the case of hearing." Aristote, *De Anima*.

> "[Touch] might be considered to be essentially a *sense of force*." Ernst Heinrich Weber, *Der Tastsinn*.

Abstract. The aim of this paper is to give a description of the objects of the sense of touch. Those objects, it is argued, are forces, rather than flesh deformation, solidity or weight. Tangible forces, basically tensions and pressures, are construed as symmetric and non-spatially reducible causal relations. Two consequences are drawn: first, the perception of heat and cold falls outside the sense of touch; second, muscular sense (together with a large part of proprioception) falls inside the sense of touch.

Each sense modality has a *proper* object, that is, a kind of entity that we cannot (directly) perceive by any other modality[1]. Colours are the proper objects of sight and sounds are the proper objects of hearing. Of course, there is a sense in which we can *see* that someone is screaming, but arguably this is only *indirect* perception: we see the scream *by seeing* the expression of the face, and we see the expression of the face by seeing its different colours. At the most direct level of perception, sounds can only be heard and colours can only be seen. Moreover, these proper objects are what individuates sensory modalities: sight is the perception of colours, and hearing is the perception of sounds. I shall assume this broadly Aristotelian picture according to which (i) there is a distinction between direct and indirect perception[2] (ii) there is a distinction between proper and common sensibles or objects (such as colours and sounds and the one hand and shape and other spatial properties on the other hand) (iii) sensory modalities are individuated by their proper sensibles. The question I address is

[1] I use the term *object* in a very generic sense in which qualities and events such as colours, sounds or flavours qualifies as objects (as opposed to a more specific sense of "object", which refers to tri-dimensional hunk of matter).
[2] or between *kath'auto* and accidental perception in Aristotle's terminology.

the following: *what are the proper objects of the sense of touch*? Contrary to what happens with sight or hearing, this question has no spontaneous or uncontroversial answer. Nevertheless, I will argue that *forces* are the basic tangible properties.

But since the third claim about sensory individuation has became highly controversial, let me first say a few words about it. First, a clarification: by "proper object" I mean the intentional objects of perceptual experiences, tactual phenomena or appearances: these intentional objects are what is subjectively perceived[3]. My aim here is to give a phenomenological description of the objects of tactile perception. The description intended is *phenomenological* in the sense that it tries to describe how the objects of touch *appear* to the subject of these experiences, independently of any ontological decision about their real nature (whether they are physical or not for example). Therefore, this description of appearances is only a part of the story, since the ontological work has yet to be done. I believe that felt forces and physical forces shared all their properties so that they are very plausibly identical[4]. But since I won't try to characterise physical forces here, I won't be able to reach this conclusion.

Second, the claim that proper objects individuate sensory modalities has been challenged by H.P. Grice (1989 [1962]), who claims that such a solution cannot account for the distinction between seeing or feeling (tactually) a certain spatial property such as the shape of a penny. There is a difference between feeling the roundness of the penny and seeing it, though in both cases, we perceive the same property, namely roundness. So the phenomenal difference between these two experiences can't be explained by a difference in their intentional objects. The very existence of common sensibles and of a distinction between perceiving them through different sensory modalities implies that senses can't be individuated by proper sensibles. Ironically, the good answer to this objection is advanced by Grice himself: in substance, the relation between shape and colour, or between shape and the proper object of touch is not one of mere conjunction but one of dependence[5]: one can't see a shape

[3] Notoriously, this raises a methodological problem: what if someone's argue that, in the same circumstances, he doesn't feel forces, but weights, solid objects, movements in its body or even sounds? The appeal to the inner experience of the subject reach a deadlock, or so it seems. Nevertheless, I take it that descriptive psychology, the description of our inner experience and its objects, is methodologically problematic but not desperate. We cannot *prove* that objects of consciousness are Fs rather than Gs, but we can at least give good reasons in favour of Fs rather than Gs. I follow Brentano's optimism: in case of disagreement between two subjects concerning their phenomenal reports, each can reasonably hope to convince the other that he's made an error of observation, for example, that he has mixed up what is directly experienced with what is inferred (Psychology: 200). We have to be confident in the fact that some phenomenological descriptions are closer to the truth than others.

[4] I'm here following Evan Fales (1990: 16) and David Armstrong (1997: 213).

[5] A similar view of the relations between between (proper) qualities and space has been developed by Austen Clark in his book *A Theory of Sentience*, where here argues that this relation must be more than mere conjunction (see especially chap. 2). I think that the story is indeed a little more complex that the one he suggests since we have to distinguish between spatial particulars (such as places) and spatial properties (such as shapes).

without seeing a colour; and one can't feel a shape without feeling a tangible quality, whatever it is. So whether a given shape is seen or felt is determined by the proper sensible on which it depends: it is seen if it depends on a colour; and it is felt if it depends on a tangible quality. To put it another way: if the shape is coloured, it is seen ; and if it is, say, pressing, it is felt. If it is both coloured and pressing, it is seen and felt.

I come now to my main point, namely, that forces are the proper objects of the sense of touch. In the first part, I give a description of phenomenal forces according to which they are non-spatially reducible symmetrical relations between our body and the world. In the second part I reject three rival answers that claim that the proper and primary objects of the sense of touch are rather spatial properties, solidity or weight. In the third part I draw some consequences of the force hypothesis concerning the extension of tactile sense: on the one hand, the perception of heat no more falls into the sense of touch. It becomes a *sui generis* sense of thermoception, whose object is temperature. One the other hand, muscle sense, which is essential for proprioception, now falls into the sense of touch, widely conceived as a sense of force.

→ il faut inverser et commencer par la deuxième partie : les autres candidates.

1. Description of felt forces

1.1. Felt forces

When someone gives you a little tap on the back, you feel a *pressure* on your skin. When your heft a melon, you feel a pressure on your skin but you feel also a tension in your muscles. Pressure and tensions are the two kinds of forces that we perceive by touch. How are we to describe them? These felt forces have seven characteristics[6]:

(i) The first point to be noted is that felt forces are *relations*. Forces are felt as connecting two entities at least: something is pressing on something else; something is pulling

Spatial properties and proper qualities (colours, sounds…) are in a relation of mutual and generic dependence: everything that has a colour must have a shape, whatever it is, and everything that has a shape must have a colour, whatever it is. A coloured-shape is a complex property that is in turn generically dependent on a place: every coloured-shaped property require a place, but not every places are exemplify (or are occupied by) a coloured-shaped property.

[6] I take up characteristics (iii) and (iv) from Evan Fales, *Causation and Universals*, 1990.

on something else. We feel the pressure of the melon on our flesh, that is, a relation between these two entities. One term of these force-relations at least must be a part of our body. The other term may be an entity external to our body or another part of our body.

(ii) Felt forces aren't spatially reducible: pressure is something else than mere contact or flesh deformation. Forces are *dynamic* properties (together with mass, weight, inertia…), as opposed to kinematic ones (such as motion, momentum, velocity). (I shall come back to this issue in the third section).

(iii) Although not spatially reducible, felt forces are *located*, most often somewhere in our body. In case of a cutaneous stimulation, this location —the point (or surface) of application of the force— is at the point (or surface) of contact between the external stimulus and the body. In case of muscular exertion, this location is felt somewhere in the muscle.

(iv) Felt forces have a *magnitude*: the pressure of a pen on our thumb can be more or less intense.

(v) Felt forces have a *line of action*: there is a line along which they exert. When we heft a melon, this line, for cutaneous impression, is vertical. When we push a chess piece, it is horizontal (for cutaneous sensations again).

(vi) Felt forces have a *pole*: they are either pressure forces, either tension forces. If you pinch you ear lobe with a clothes peg, you experiment a pressure. If someone pulls your hairs, you experiment a tension (possibly painful). It may be that muscular felt forces are always tensions.

(vii) Felt forces are *symmetrical* relations: the pressure that the melon is felt to exert on our hand isn't different from the pressure that our hand is felt to exert on the melon. This claim may sound odd because we intuitively distinguish between active forces (the forces that we exert) and passive ones (the forces that are exerted on us).

This leads Evans Fales (1990:17), to the conclusion that felt forces are asymmetric relations. The problem with this view is that the distinction between active and passive forces

only point to *extrinsic* properties of those forces. By themselves, forces are symmetrical: it is only their volitional and their cinematic context that determine that active or passive character. Take the example of someone's being punched in the nose. It is clear that to be punched is not the same thing as to punch. But does this difference appear at the level of cutaneous and muscular sensations? I don't think so. There seems to be two reasons why we distinguish the two: the first it that to punch is an intentional or voluntary act, whereas to be punched is not something that we do but something that happens to us. That is, active forces are preceded by a volition or an intention. Clearly, this isn't an intrinsic properties of the felt force: the very same pattern of pressure on the skin may be perceived, whether it results from a voluntary action or from an external impingement. One may replies that such an answer only works for the cutaneous sensation: as soon as muscular sensations are involved, it seems clear that the feeling of effort is an intrinsic property of the felt force, which is then asymmetric. But here again, it is not clear at all that the feeling of effort is intrinsic to the muscular felt force. It is rather an *accompanying feeling* of this force, to take up the expression of Brentano. You can hear a sound that causes you some pleasure, but the pleasure is not part of the sound you hear. Likewise, a muscular tension may cause a feeling of effort, but the effort is not part of the perceived force. Actually we sometimes experiment muscular forces that are not effortful: for example when a muscle spontaneously contract when we have cramp (then the accompanying feeling is painful, but not effortful) or when it is artificially excited. This shows that we can experiment muscular forces without experimenting them as active forces, that is, as force that we voluntarily exert.

Besides the volitional context of a felt forces, the cinematic context in which it is perceived also determine their active or passive status. The last thing that has moved tend to be considered as the one that has acted. Thus, in order to punch, we have to move, but not in order to be punched. The forces resulting of a movement tend to be considered as active ones.

By themselves, forces are symmetrical: it is only their volitional and their cinematic context that determine their active or passive character. If we put aside these extrinsic features, there is no phenomenal difference between being punched in the nose and deliberately hitting a fist with its nose. The patterns of pressures and tensions felt in the skin and in the muscle may be exactly the same. Hence, they are no good reasons to consider felt forces as asymmetrical. Moreover, there is a good reason to consider them as symmetrical: for each cutaneous and muscular experience, we can give two equally acceptable descriptions.

We can describe them either as the force *a* exerts on *b*, or as the force *b* exerts on *a*. From the strict point of view of what is felt, we have no reason to prefer one description to the other. For example, when you push against a wall, are you experiencing the force you are exerting on it, or the force it's exerting on you (which is the resistance of the wall)? These two reports seem equally acceptable. Similarly, when you heft a melon, the force you feel is as well *your* muscular tension than *its* weight. Felt force have no direction, but have only a pole: they are tension or pressure, attraction or repulsion. So felt forces are *symmetrical relations*.

To sum up, felt forces are non-spatially reducible and symmetrical relations. These relations have a location, a pole, a magnitude and a line of action. Before considering some competing accounts of the intentional objects of muscular and cutaneous experiences, I turn now to what seems to me to be the most important objection against the present account.

1.2. Are we really perceiving three entities at once?

According to this objection, such a relational description of the *tangibilia* leads to an extravagant phenomenology of touch. The argument runs as follows:

> (i) We cannot perceive a relation without perceiving its terms. Following the present account, this implies that each tactile experience as a threefold object: the force relation and its two relata.
>
> (ii) But whatever the right phenomenology of the sense of touch may be, it is clear that we don't perceive three things at once. What we feel is quite simple.
>
> ∴ Hence, the force relation, if it exists, cannot be felt: we can perceive only its terms. either the external ones or the internal ones. At best, the force is an unperceived mediator between us and the world.

It is well worth noting that this conclusion is strongly humean: we cannot perceive the causal relation itself, but only the cause or the effect[7].

[7] John Bigelow, Brian Ellis and Robert Pargetter (1986: 615-6) take this conclusion to be the orthodox position concerning the perception of forces: "[According to the standard picture]We feel the surges and other distortions which are caused by gravitational force, but not the force itself. Likewise, we feel the body that touches us, not the forces which mediates between that body and ours. […] So we have two competing accounts of our experiences: (1) that we do experience forces directly, and (2) that a force is just that which mediates between our experience, and the objects and properties that we experience. It is now fairly standard to accept the second of these stories, though we find it difficult to find compelling reasons which favor this story, or even to find a completely satisfactory explanation for its common acceptance".

I agree with the first point: if we were to perceive a relation without its terms, then we would not perceive a relation as such. But I think the second point is mistaken: it is not clear at all that the phenomenology of touch is simple in the sense in which we would feel a single entity. The simplest way to emphasize this is to point out that our body is always part of our tactile experience: each time we feel something external we also feel our body. Now the body and the external object are not perceived as mere conjuncts in space and time. There is a closer relation between them than contiguity: they stand in a force relation. In other words, we are not perceiving a melon just near our hand, but a melon *pressing* on our hand. So it is true that we perceive three things: the melon, our body, and the force relation between them. Felt forces are precisely the kind of necessary connection between two felt entities that Hume was seeking in vain.

2. Rejection of three others answers

I come now to the examination of three alternative proposals: since there're all facing important objections, this will provide a new reason to adopt forces as primary object of touch. I can imagine three concurrent descriptions of the proper objects of touch. The first claims that kinematic (or spatial) properties, rather than dynamical ones, are the proper objects of the sense of touch. Tangible objects would be spatially reducible. The two other proposals agree at first sight that tangible object aren't spatially reducible, but claim that they are monadic properties such as solidity or weight rather than dyadic properties such as forces.

2.1 The spatial reduction of the tangibilia

David Armstrong, who has rejected this position since then, has advanced the idea of a spatial reduction of the primary objects of touch. "All the tangible qualities, he wrote, reduce to *spatial* properties of objects" (1962: 21)[8]. Perceiving pressure, according to Armstrong, is nothing more than perceiving a spatial change of our body (such as the distortion of our flesh). Two objections may be raised against this conception.

[8] see *A Materialist Theory of the Mind*, p. 98).

Armstrong himself formulated the first one: what are the *demarcators* of the spatial properties we tactually perceive? In order to see spatial properties such as shape, size or motion, we need to see some qualitative property such as colour. Spatial discrimination strongly depends on the perception of qualitative difference: to see a shape requires to see some contrast between colours. But if spatial properties are the proper objects of touch, there is no quality that allows us to demarcate them. After some aborted attempts, Armstrong comes to the conclusion that we must accept that contrary to what happens with sight, there is no demarcator, or secondary quality, associated with touch. This honest conclusion seems however difficult to accept: how can I feel the shape of nothing? It is to be doubted whether we can discriminate two places or two shapes if both are equally bare. Moreover, this introduces a gap between touch and other sense modalities, which we may want to avoid. These difficulties disappear if we admit the force hypothesis: we discriminate places where forces are felt from places where no forces are felt. We feel pattern of pressure on our skin, what we may call shapes of forces.

Recent psychological studies have stressed the importance of force cues in the haptic perception of spatial properties. Robles-de-la-Torre & Hayward (2001) have shown that when geometrical cues conflict forces cues, the *shape* is perceived accordingly to the forces cues. Wydoodt & Gentaz, (forthcoming) show that the haptic perception of length is influenced by the presence of opposition force or traction force during the exploration. Likewise, the works of the gibsonian psychologists M. T. Turvey and C. Carello on "dynamic touch" show that the perception of the length of an object through wielding depend on the extraction of *dynamic* properties. All these works clearly underlines the importance of the dynamical properties such as forces in the understanding of touch. They make it clear that the perception of spatial properties is highly dependent on the perception of forces.

The second objection against the spatial reduction of *tangibilia* can be found in Moreland Perkins (1983). Perkins endorses the present thesis, according to which proper objects of touch are pressures. His argument is that feeling pressure cannot be reduced to perceiving motion, because we can feel pressure even where there is no motion or spatial variation.

> When a portion of our body reaches a position of static equilibrium with some object pressing steadily against it, we continue to feel the pressure of the external object (and the internal stress of our flesh) after the motion of the object inward on our flesh and the resultant motion of our flesh have stopped. So we can feel pressure by touch without perceiving motion. (Perkins, 1983 : 248)

The same kind of example can be presented in case of the muscular forces. Imagine two equally strong people arm wrestling against each other. By hypothesis, at the time they begin their efforts, nothing moves. And yet both feel something new: if not a force, what could it be? Hence, felt forces are not spatially reducible[9].

2.2. Solidity

The second competing description of the proper objects of touch says that they are instances of solidity, rather than forces. But solidity is an ambiguous concept that means either hardness, or impenetrability. Hardness, in the Lockean sense, is a *spatial* notion: *x* is hard if and only if it doesn't easily change its shape. So the above argument against spatial reduction of felt forces also applies to hardness. In the second sense, solidity means impenetrability. An entity is impenetrable if no other entity can occupy the place that it occupies at the same time. There are two main difficulties with impenetrability being the proper object of touch. First, impenetrability seems too strong. There are entities which are penetrable but that we can feel. Think of the field around a magnet that we can feel when playing with a metal object. This field is felt, but is not impenetrable: is we exert a sufficient force, we can go though and reach the magnet with the metal object. Second, impenetrability is a disposition. The manifestation of this disposition is either the motion of the impenetrable entity (for instance when we plunge our hand in the water), or the resistance of the impenetrable entity to any motion (for instance when we push against a wall).

Arguably, we can perceive only the manifestation of disposition.

[9] Any other attempts to reduce spatial force would have to face these two objections. Notably, contact is sometimes held to be the proper object of touch. But contact is a spatial notion (two entities are in contact when there is no distance between them), so this won't do.

In this case, solidity is a dispositional notion that only means "able to exert a force", or, more precisely "able to enter into a force relation". Thus Locke defines it in term of felt *resistance*[10]. The claim that we feel impenetrability

It follows that impenetrability is derived from forces, which, phenomenally, are the primitive entities. Perception of impenetrability depends on perception of forces.

2.3. Weight

The third competing account claims that weights are the proper and primary object of touch. This suggestion raises two problems.

First, from a physical point of view, the weight of an object is nothing else that the gravitational force that acts on it. So weights cannot replace forces because weights are forces. Second, insofar as weight are forces, they may be considered as *proper* objects of the sense of touch. Nevertheless, it is essential to realize that the weights can't be the *primary* object of touch, that is, the most primitive entities that we perceive by touch. The first reason for this is that we perceive other forces that the gravitational ones. The second and main reason is that on earth, the gravitational force being constant, the weight of an object is also constant. But our most basic cutaneous and muscular feelings are continuously varying. When we heft a melon, the pattern of pressure that we feel on our skin and the tensions that we feel in our muscles are far from constant[11]. Then weight, as a constant property of and object, isn't the primary and direct object of these experiences. Rather, it is a higher-level invariant property that is extracted or inferred from varying patterns of pressure and tension on the skin and in our muscles[12].

The analogy with sight is here straightforward: there is also a primary or proximal level of seeing where we see the colours as constantly varying, where the snow appears tinged with different shades of grey. This proximal level is the one that interests what Plato called

[10] *Essay concerning human understanding*, II, iv, 1 ; II, iv, 5.
[11] When we heft a melon, there is a "proximal" mode of perception in which the pressure on our skin and the tension in our muscles is constantly varying. But there is also a "distal" mode of perception, of higher level, in which the force that the melon exerts on our body is perceived as constant. This invariant force, extract from the proximal forces, *is* what we call weight.
[12] E. L. Amazeen and M.T. Turvey (1996) claim that the invariant that allows the perception of the weight of an object is its inertia tensor.

the arts of "likeness-making", like painting or, more recently, the production of haptic displays for virtual reality (imagine you have to build a virtual melon: you have to stimulate an extremely varying pattern of pressures and tension on the body). Colour constancy, like weight, only appears at a higher or distal level. Though I've been here concerned exclusively with the primary or proximal level of cutaneous and muscular perception, I don't want to suggest that this level is the most salient in cognition. On the contrary, it seems that attention spontaneously focuses on the distal level of perception, where we find constant properties and maybe where objects, here in the sense of bodies, appear. It may require an effort to focus on the proximal level, but the point is that it is possible: the proximal level of perception is phenomenally accessible.

To sum up, neither barely spatial properties, nor solidity, nor weight are likely to be the objects of our cutaneous and muscular experiences. The proper and primary objects of the sense of touch are rather felt forces construe as symmetric and non-spatially reducible relations.

3. Proprioception as part of the tactile sense

What are the implications of all this concerning the extension of tactile sense? On the one hand, touch is deprived of the perception of heat and cold. It seems clear that temperatures are not (experienced as) forces. We must then admit a special sense dedicated to the perception of hot and cold. The reason why this sense of temperature has often been confounded with the sense of touch[13] is probably that temperatures and forces are often felt at the same places. If thermoreceptors and mecanoreceptors had been located at different places, we would have made the distinction between touch and thermoperception (I borrow this term from Perkins). On the contrary, if the chemical receptors associated with smell had been located in the skin, we would probably have confounded touch and smell.

On the other hand, if touch is a sense of force, then it is enriched with muscle sense.

[13] E. H. Weber (1905) and M. Perkins (1983) are significant exceptions.

Muscle sense, I take it, informs us about the tensions of our muscles[14]. Tensions are forces, so muscle sense is a part of tactile sense. The importance of muscle sense in proprioception has been ignored for a long time. Proprioception was held to be essentially a matter of trigonometric calculations: joint receptors, rather than muscular ones, were thought to be at its core. But recent works have shown that actually muscle sense is more important than "joint sense" for proprioception[15]. So it seems that proprioception is to a great (if not full) extent a matter of force perception.

The works of the gibsonian psychologists M. T. Turvey and C. Carello on "dynamic touch" can easily be called for the thesis that touch is essentially a detection of dynamical properties and that there are no essential differences between touch and proprioception. "The understanding of dynamic touch, they write, may apply not only to how one perceives "attachments to the skin", such as tools and instruments and the hand's relation to them, but also to the very traditional concern of how one perceives the body itself" (1995: 440). Whether we touch an object (by wielding it for detecting its length) or detect the position of our arms, we are always extracting a same invariant. This invariant, according to Turvey & Carello, is an inertia tensor. Very grossly, an inertia tensor is a matrix that represents the rotational inertia of an object (or part of the body) around three perpendicular axes. The resistance of rotation of an object around one axe is called his moment of inertia. His inertia tensor is a symmetric matrix that captures the moments of inertia of the object around *three* of his axes[16]. It is a physical invariant. Actually, Turvey and Carello's work doesn't concern cutaneous touch, but only dynamic touch —defined as the use of the muscle sense in the detection of properties of external objects. So this research only gives reason to identify proprioception with dynamic touch. But since proprioception, dynamic touch, and cutaneous touch are all concerned with the perception of dynamical properties, it seems justified to take

[14] The term "muscular sense" seems to have made its apparition around 1820 in the works of Charles Bell (1826) and Maine de Biran (2001—1812). Bell was wondering if this sense was presenting us with the tension of the muscles or with the degree of effort that our will was exerting on them. Maine de Biran was also distinguishing between the passive muscular sensation and the "central spring", the will, which we know by an "intimate feeling" . But whereas Bell finally inclined toward the peripheralist solution (we feel the tension of our muscle), Maine de Biran stressed the importance of the centralist thesis: we feel above all the force of our will. Müller and Wundt come round to the centralist position. William James defended a pure peripheralist one. Here I take it that James view was correct in that the muscle sense is purely centripetal (precisely because it is a *sense*) but I consider the existence of an acquaintance with the force of our will, what Müller called the "innervation sensation", as an open question. (For a very useful presentation of the still alive debate between peripheralists and centralists, see Jeannerod 1996, 2002).

[15] The reappraisal of muscular informations for proprioception began with the word of Goodwin, McCloskey and Matthews (1972); and Matthews and Simmons (1974). For a presentation of this come-back of the muscle sense, see Turvey (1995).

[16] For a clear presentation, see Turvey & Carello (2000).

the plunge and to consider them as species of the genus "sense of touch". I shall now address two objections against this hypothesis.

Nevertheless there is an important objection against the of proprioception by touch. It points out that proprioception is supposed to be a sense of *ownership* of our body. If we identify it with touch, we face a dilemma: either we are committed to the view that our body is only presented to us as a part of the external world; either we have to say that external objects are presented as belonging to our body. The first horn of this dilemma would have seem quite acceptable to Bertrand Russell : "the subject's body is as distinct from the subject as tables and chairs are, and is in fact merely a part of the material world" (1925:152). As far as proprioception is concerned, I agree. I don't deny that there is a crucial difference between our body and the external world. But I don't understand why the perception of the position and movement of this body should make it appear as ours. Proprioception seems to have too many irons on the fire: it is supposed to inform us upon the forces and movements of our body *as well as* to explain the ownership of this body. This is too much for a single sense. Our own body is better defined in a Cartesian (or Lockean way) as the sum of all the places where we can feel bodily *qualia* such as pain, pleasures, itches or tickles (these experiences may have intentional objects —and these objects may sometimes be forces—, but their objects, I assume, don't exhaust their phenomenal character). A second, maybe more fundamental way to define our proper body, is to say that it is everything on which our intentions or volitions are directly efficient. Once we free proprioception from the difficult task of explaining ownership, it becomes easier to identifying it with touch.

Conclusion

I hope to have shown that forces, rather than solidity, weight or spatial properties are the proper and primary objects of the sense of touch. This leads us to a second question, which I only mention here, concerning the ontological nature of those phenomenal forces. Is it possible to identify phenomenal forces with physical ones? In other word, are phenomenal forces real? Following Fales (1990) , Newman (1992), Bigelow, Ellis, Pargetter (1996) and Armstrong (1997) I suggest that the answer is positive: phenomenal forces, construe as non-spatially reducible symmetrical relations share all their characteristics with physical ones (including symmetry, see Newman, 1992). Then, arguably, felt forces *are* physical forces.

This has an interesting consequence regarding the specificity of the sense of touch. Following Hume, many philosopher have claimed that causation cannot be perceived. Nevertheless, since physical forces may plausibly be count as causal relation, we may directly perceive phyical causation by touch. Hume might be right in the case of sight: visual world is a purely cinematic, spatial one. But he's wrong in the case of touch: the world of touch is a dynamic, causal one.

, I want to mention two consequences of this definition of touch as a sense of force. The first one concerns *causation*. Since Hume (and Berkeley), it has been widely accepted that causation cannot be perceived[17]. This has lead to many attempts to redefine causation (in terms of counterfactual dependence, transference, transmission, process, manipulability, probability etc.). But, if forces are actually experimented, there are good reasons to consider causation as a phenomenally and ontologically primitive entity[18]. Identification of causation with forces has interesting consequences. Since forces are symmetrical relations, this implies that the notion of a direction of production is not intrinsic to causation. Nothing is intrinsically a cause or an effect: this may depend on volitional or kinematic context (what is perceived to be moving tends to be considered as a cause).

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[17] There are exceptions, such as Michotte (1954) or Ducasse (1926).

[18] E. Fales (1990) and D. Armstrong (1997) defend such a conception of causation. M. Tooley (1990) endorses also primitivism, but only in the ontological domain, because he doesn't think we are acquainted with causation. We know it only via an inference to the best explanation. Identification of forces with causal relations is claimed by J. Bigelow & R. Pargetter (1990).

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