PSYCHE

Replies to our Critics[1]

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1. Introduction

We are grateful to José Bermúdez and to Andrea Cristiano Pierno, Caterina Ansuini and Umberto Castiello for reading and criticizing our book. They offer us an opportunity to clarify some of our views. Bermúdez discusses aspects of our version of the two-visual systems model of human vision bearing on the separation between the content of visuomotor representations and the content of visual percepts. Pierno, Ansuini and Castiello discuss our interpretation of the contribution of mirror neurons to the content of an observer's representation of an agent's intentions. In accordance with the structure of our book, we shall discuss these issues in this order.

[1] We are grateful to Frédérique de Vignemont for her interesting comments.

2. Reply to José Bermúdez

As Bermúdez correctly points out, we do not accept what Clark (2001) has dubbed the thesis of *experience-based control*. Instead, we subscribe to what he calls the thesis of *experience-based selection*. We do not believe that the nonconceptual content of the visual experience of an object is geared towards the visual guidance and control of actions directed towards this object. Rather, we think that the nonconceptual content of the visual experience of an object is geared towards the visual selection of an object that can in turn be either a target for a visually guided action or food for conceptual thought. In particular, we believe that the nonconceptual content of the visual experience of an object serves to encode information about its enduring properties that matter to its recognition over time from different perspectives. By contrast, the nonconceptual content of a visuomotor representation of an object contributes to the fine-grained online guidance of actions directed towards this object. As Bermúdez rightly notes, we believe that, unlike the content of a visual percept of an object, the content of a visuomotor representation of the same object does not contribute to the agent's visual awareness of the object. As Bermúdez puts it, on our view, "the content of a visuomotor representation is not part of visual experience".

Bermúdez thinks that these claims are far too strong to be true. He makes two basic criticisms of our views. On the one hand, he argues that the empirical evidence only supports the weaker uncontroversial claim that "many aspects of the fine-tuned control of grasping behavior are controlled by forms of information-processing that never make their way to consciousness". On the other hand, he argues that our claim that one major difference between the content of a visual percept and the content of a visuomotor representation lies in the way the spatial position of the object is being represented is conceptually flawed.

We tend to agree with Bermúdez that the empirical evidence cannot and does not conclusively prove that we are right to claim that the content of visuomotor representations makes no contribution to one's visual awareness of objects. Bermúdez offers two grounds for his claim that the empirical evidence only shows that some (not all) aspects of the control of visually guided actions are non-conscious. In response, we want to point out why we think that one of his two considerations about the empirical evidence is less convincing than the other.

We agree with Bermúdez when he insists that the existence of such double dissociations as between visual form apperceptive agnosic patients and optic ataxic patients does not conclusively prove that "visuomotor content is not part of conscious visual experience" in healthy human subjects. What Bermúdez may have in mind here are the two following points. It may well be that although apperceptive agnosic patient DF can visually compute the size and shape of an object for the purpose of grasping it, her inability to visually recognize the shape and size of objects may impair her ability to perform some more complex hand actions, such as using a tool according to its function. Conversely, it remains an open question whether in optic ataxic patients, who are impaired in tasks of reaching-to-grasp objects, the visual experience of objects is really the same as that of healthy subjects. If this is what Bermúdez has in mind, then we agree that this is an empirical issue. But of course Bermúdez will surely recognize that from

what is known so far, the existence of such double dissociations is not incompatible with the view that visuomotor content is not part of the conscious visual experience of an object.

Bermúdez's second point has to do with what is shown by the experimental dissociations between perceptual and visuomotor responses in healthy subjects to Titchener illusory displays. (Incidentally, in Aglioti et al.'s 1995 seminal experiment and other such experiments, subjects are presented with a 3D central disk surrounded by an annulus of 2D circles, not 3D disks). On Bermúdez's view, what such dissociations show is that "the information determining maximum grip aperture is not part of conscious visual experience". He agrees that healthy subjects do not have conflicting (or "cognitively dissonant") visual experiences of the visual illusory display. Hence he agrees that they do not have contradictory beliefs about the size of the central disk in the visual illusory display. If asked (as Bermúdez recognizes), subjects will express their belief that a central disk surrounded by an annulus of circles larger than it is smaller than a central disk (of equal diameter) surrounded by an annulus of circles smaller than it. As recognized by Bermúdez, however, subjects' MGA is immune to the visual illusory experience. The question is: is this dissociation evidence that visuomotor content is not part of normal visual experience? We think that it is and the reason we think so is that we think that there is evidence that subjects' visuomotor responses are guided by genuine visuomotor *representations* with visuomotor *content*. We suspect that this is where Bermúdez may part company with us. As Bermúdez's own account of the dissociation between perceptual and visuomotor responses to Titchener illusory displays shows, he fully recognizes that there is visual information processing that controls grasping behavior and that fails to make its way to consciousness. But he seems to think that such sub-personal information processing does not deserve the status of genuine representation with visuomotor content. If so, then we disagree with him and here is why.

Our reasons for thinking that in a visuomotor task of grasping, subjects form genuine visuomotor representations with visuomotor content are based on an interesting experiment by Haffenden et al. (2001) (reported in our book, chapter 6, section 7 pp. 196-201). Haffenden et al. (2001) noticed that in traditional displays of the Titchener circles illusion, the gap between the central 3-D disk and the surrounding annulus is 3 mm when the surrounding circles are smaller than the disk and 11 mm when the surrounding circles are larger than the disk. What Haffenden et al. (2001) did was to invent a non-standard *hybrid* Titchener condition in which the central disk was surrounded by an annulus of smaller circles but in which the gap between the central disk and the annulus was 11 mm (the same as when the surrounding circles are larger than the disk). They presented subjects with three Titchener disk displays one at a time, two of which were the traditional displays, and the third of which was the non-standard hybrid condition just described (cf. Figure 1). They found a dissociation between the perceptual and the motor responses to the display of the third condition. Subjects' perceptual response to the hybrid condition was like their perceptual response to the disk surrounded by the smaller circles with a small gap. Subjects' motor response to the hybrid condition was like their motor response to the disk surrounded by the larger circles with a large gap. If so, then what matters to the visuomotor processing of the display is not the relative size of the central disk relative to the size of the circles in the annulus. Rather, it is the gap between the disk and the annulus (which matters to the positioning of the agent's fingers). This result

strongly suggests that the visuomotor processing treats the 2D annulus as if it were a 3D obstacle for positioning the fingers on the target disk. Thus, the visuomotor processing, just like the perceptual processing of an object, can be *fooled* by selective features of the display, since arguably it can misrepresent 2D features of the visual display as a 3D obstacle. It follows that the output of the visuomotor processing is a genuine representation of the visual display with visuomotor content. But such representation with visuomotor content does not make its way into subjects' visual consciousness (as embodied by their beliefs).

In our book, we further argue that unlike a visual percept, a visuomotor representation fails to make an agent visually aware of her target because, unlike the former, the latter fails to satisfy the constraint of contrastive identification. The reason why a visual percept does satisfy, and a visuomotor representation fails to satisfy, the constraint of contrastive identification is that the former represents the spatial position of an object in an allocentric frame of reference and the latter represents it in an egocentric frame of reference. Bermúdez argues that our distinction is flawed because our use of the distinction between an allocentric and an egocentric frame of reference is confused. We plead not guilty.

Consider one example from our book discussed by Bermúdez. We claim that one could not form a visual percept of a glass being to the left of a bottle unless one represented the spatial position of the glass relative to the bottle in some allocentric frame of reference centered e.g., on the bottle. So representing the spatial position of a glass relative to a bottle in some allocentric frame of reference is different from representing the spatial position of the same glass in some egocentric frame of reference centered on the agent's body, which is necessary for the agent to reach and grasp the glass. Now Bermúdez objects to our description of the example on the grounds that

> the to-the-left-of relation is a canonical example of a spatial relation that seems to make most sense on an egocentric frame of reference. No two things stand in this relation *simpliciter*. They only do so relative to a third thing, which is typically the perceiver. I perceive that the glass is to the left of the bottle relative to me.

There are at least two things going on here: on the one hand, it seems as if Bermúdez is claiming that one *cannot* see a glass to the left of a bottle *unless* one is representing the fact that the glass is to the left of the bottle relative to the perceiver. On the other hand, Bermúdez asserts that one can visually represent the fact that the glass is to the left of the bottle relative to the perceiver in an egocentric frame of reference centered on the agent's body. We do not agree with the first claim and we think that the second is more controversial than Bermúdez seems to realize.

As Dretske has emphasized in many of his writings, to say of someone that she sees *that* the glass is to the left of the bottle is to say that she *believes* that the glass is to the left of the bottle and furthermore that she formed her belief by visual perception (as opposed to e.g., testimony). Such a belief has conceptual content and, as such, it involves the concept of the to-the-left-of-relation. We of course agree with Bermúdez that the conceptual content of such a belief may include the concept of a three-place relation involving an argument for the perceiver. But we do not agree with Bermúdez that possession of such a concept is a *necessary* condition for a creature to see a glass to the

left of a bottle. Whether or not this is presupposed by Bermúdez's own account, we do not agree that there must be room for some conceptual representation of the *self* in one's visual percept representing a glass to the left of the bottle. We think that a creature who does not possess such a three-place predicate (and even a creature who does possess it) can perfectly well enjoy the visual experience of a glass to the left of the bottle without forming the belief (or thought) that the glass is to the left of the bottle *relative to herself*. To take an analogy, consider one's thought in the morning that it is 7:00 AM (and time to get up). Assuming that one's thought is being entertained in Paris, Bermúdez might point out that the *complete* logical form of one's thought is that it is 7:00 AM in the time zone in which Paris is located. Following Perry (1986), however, we would argue that one can think that it is 7:00 AM, without explicitly representing the fact that it is 7:00 AM in Paris, not in Boston.

In the book, we argue for a distinction between *perceiving* the glass to the left of the bottle and *thinking* that the glass is to the left of the bottle relative to oneself. One may form the latter thought e.g., in the context of drawing a relevant contrast between the fact that the glass is to the left of the bottle from the standpoint of someone facing the window, not of someone whose back is against the window. One's visual experience of the glass to the left of the bottle depends on the fact that one occupies a particular standpoint. One could not visually experience the glass to the left of the bottle unless one were facing the window. However, one can think of (or imagine), but one cannot visually perceive, the standpoint which one is currently occupying. Conversely, one can visually perceive the standpoint of someone whose back is against the window while one is facing the window. One might also imagine what it is like to enjoy the visual experience of the spatial relation between the glass and the bottle with one's back against the window while one faces the window. In order to do so, one might pretend to be sitting with one's back against the window while one is facing the window (by performing a mental rotation of one's standpoint). But imagining what it is like to have a visual experience is more like visual *imagery* than visual *perception*.

Bermúdez also claims that one can represent the spatial position of an object relative to another object either on an egocentric or an allocentric frame of reference. This is not how we use the concept of an egocentric frame of reference for visual processing. Bermúdez further claims that we are confused about this. Perhaps we are. But in any case here is our diagnosis of the difference between Bermúdez and us on this score. First of all, we are willing to grant that one might represent the spatial relation between two objects on an egocentric frame of reference if one directly represents the separate spatial positions of each object on a given egocentric frame of reference and then one geometrically derives a representation of their spatial relation from their egocentrically represented respective positions. But this seems more complex than the direct representation of the spatial relation between them on an allocentric frame of reference centered on one of them. Of course, this is an empirical issue, and as Burgess (2006) suggests, the developmental issues are not yet settled.

Secondly, the predicate "egocentric" can be used in two fairly distinct contexts to make two different sorts of assertions. On the one hand, it can refer to a special frame of reference centered on some of an agent's bodily part, relative to which the spatial location of a target is visually represented by the agent. This is the sense in which Poincaré used

the word. Note that strictly speaking, given one agent, there is no unique egocentric frame of reference in this sense: an egocentric frame of reference may be centered on the agent's head, arm, hand, and so on. On the other hand, it can also be used more liberally to characterize a frame of reference necessary for entertaining subjective conceptual thoughts, not visual representations as such. The thoughts thereby entertained are thoughts expressible by the use of indexical (or demonstrative) expressions such as "I", "he", "here", "there" or "now". Clearly, indexicals and demonstratives express concepts, as illustrated by the inference rule: "If something is there, then it is not here". When a speaker utters a sentence containing the indexical "here", she expresses an egocentric thought, whose conceptual content depends on some egocentric frame of reference in the liberal sense: by her use of "here" (as opposed to "there"), she expresses a thought whose conceptual content depends on the frame of reference centered on her spatial location at the time of utterance. But the frame in question must be broad and flexible enough to enable the speaker to intend to refer to any of the following things: the chair (on which she is currently sitting), the room (containing the chair), the building (containing the room), the street (containing the building), the city (containing the street), the country (containing the city) and so on and so forth. We restrict ourselves to the narrow visual sense. Bermúdez opts for the more liberal sense in which one can be said to form the egocentric thought that the glass is to the left of the bottle from one's perspective as one faces the window, not from the perspective of someone whose back is against the window.

3. Reply to Pierno, Ansuini and Castiello

In their paper, Pierno, Ansuini and Castiello argue for a "unified approach to the understanding of social action": they are skeptical of our hypothetical distinction between the contributions made respectively by the so-called "mirror system" and by what, following Allison et al. (2000), we call "the social perception" system to the representation of human actions. In their paper, Pierno, Ansuini and Castiello invite us to attenuate (or weaken) our distinction between the respective contribution of the "social perception system" and the "mirror system" to the representation of human action. We shall explain why we want to decline their kind invitation. We think that the crucial issue raised by Pierno, Ansuini and Castiello's paper is whether brain mechanisms with *mirror* properties are necessary and sufficient for representing an agent's *prior* intention. Pierno, Ansuini and Castiello offer some reasons for thinking that they are. We want to explain why we disagree with them. We shall first review our conceptual grounds for distinguishing motor intentions from prior intentions (some of which, but not all, are social intentions). Secondly, we shall offer our grounds for thinking that brain mechanisms with mirror properties might perhaps enable an observer to compute and represent an agent's motor intention, but not her prior intention (*a fortiori* not her social intention, if she has any). Finally, we shall discuss the question to what extent the experiments reported by Pierno, Ansuini and Castiello corroborate their plea in favor of a "unified approach to the understanding of social action".

Let us consider first our distinction between what we call a "motor" intention and a "social" intention. Let us start with the standard philosophical distinction between basic and non-basic acts: the non-basic act of killing a victim can be performed by performing any of a variety of more basic acts (e.g., pulling the trigger of a gun aimed at the victim,

dropping a poison into the victim's wine glass, etc.). An agent's motor intention, which is pretty much like a motor instruction, should be distinguished from her so-called "prior" intention. As emphasized in Jacob and Jeannerod (2005) and in Jacob (in press), an agent's motor intention to press an electrical switch with her right finger stands to her "prior" intention to turn on the light in pretty much the same relation as a basic act stands to a non-basic act. Furthermore, an agent's prior intention stands to her motor intention in a one-to-many relation. Now, some (not all) of an agent's prior intentions are social: an agent's social intention is an agent's prior intention directed towards a conspecific (i.e., an object that can act back), as opposed to an inanimate target. It is constitutive of an agent's social intention that part of its content is about a conspecific. Since humans act out of their mental representations, many of an agent's social intentions involve the representation of another's mental representation. For example, an agent's intention to create sexual arousal in a partner is a social intention. And so is an agent's intention to inspire fear.

We fully agree with Pierno, Ansuini and Castiello that actions "not explicitly directed towards a conspecific […] and the different motor intentions that can be inferred from the observed actions may affect a conspecific's behavior by causing a new mental state or representation in the observer's brain". It is uncontroversial that "the intention to grasp an inanimate object carries a social component" if this means that an agent's motor intention to grasp an inanimate object can be perceived (and hence be represented) by a conspecific. But the fact that an agent's motor intention to grasp an inanimate object can be represented by a conspecific falls short of showing that there is no room for the distinction between an agent's motor intention and her social intention (if she has any). Nor (contrary to what they suggest) does it follow that what Pierno, Ansuini and Castiello construe as the "social component carried" by an agent's motor intention should be coded by what we call the "social perception system". An agent's prior intention counts as social only if what it represents involves a conspecific. If an agent intends to grasp an inanimate object and does not have any intention to affect a conspecific, then the agent's intention counts as non-social. The fact that a conspecific may represent another agent's non-social intention fails to turn the agent's non-social intention into a social intention.

We now turn to the central issue: what is the contribution of brain mechanisms with mirror neuron properties to the representation of an agent's prior intention (whether social or not)? Now, the crucial relevant characteristic of mirror neurons (MNs), first discovered in the ventral premotor cortex of macaque monkeys (area F5), and then also discovered in the monkey inferior parietal lobule, is that they are sensori-motor neurons with both motor and perceptual properties. MNs fire both when the animal performs some transitive actions (directed towards a target) and also when the animal observes a conspecific (or a human experimenter) perform the same kind of action. We know that the ventral premotor cortex and the inferior parietal lobule in the monkey are reciprocally connected. And so are the inferior parietal lobule and the STS. But the STS and the ventral premotor cortex are not. The STS in turn has projections towards the amygdala and the orbito-frontal cortex (known, in humans, to be active in third-person mindreading tasks). So far, MNs have not been discovered in the monkey STS, known to respond, in the monkey, to the perception of a wider class of actions than MNs, including in particular head- and eye-movements (cf. Perrett et al., 1982). The crucial issue is partly clouded by talk of the so-called "mirror system" in humans because this system is

supposed to encompass both brain areas believed to contain MNs (such as the ventral premotor cortex and the inferior frontal gyrus) and the STS, which is known not to contain MNs.

In their paper, Pierno, Ansuini and Castiello do not explicitly consider social intentions in our sense, i.e., intentions directed towards conspecifics. In Jacob and Jeannerod (2005), however, we considered the hypothetical case of Dr Jekyll and Mr Hyde. Dr Jekyll is a renowned surgeon who performs appendectomies on his anesthetized patients. Mr Hyde is a dangerous sadist who performs exactly the same hand movements on his non-anesthetized victims. It turns out that Mr Hyde is no other than Dr Jekyll. Dr Jekyll alias Mr Hyde may well execute twice the same motor sequence whereby he grasps his scalpel and applies it to the same bodily part of two different persons (one anesthetized, the other suitably paralyzed). If so, then Dr Jekyll's motor intention will match Mr Hyde's. However, Dr Jekyll's social intention clearly differs from Mr Hyde's: whereas the former intends to improve his patient's medical condition, the latter intends to derive pleasure from his victim's pain. In this case, one and the same motor intention can serve divergent social intentions. Suppose that the activity of MNs in an observer's brain matches onto the observer's motor repertoire the hand movement whereby Dr Jekyll alias Mr Hyde grasps his scalpel. Suppose further that this motor resonance enables the observer to represent the agent's motor intention. We argue from this hypothetical case that this matching would fall short of enabling the observer to discriminate Dr Jekyll's social intention from Mr Hyde's.

Pierno, Ansuini and Castiello take the view that the brain imaging experiments by Iacoboni et al. (2005) demonstrate that MN activity in human observers generates a representation of what we call an agent's *prior* intention. Iacoboni et al. (2005) showed human subjects pairs of films divided into three conditions. In the Context condition, subjects saw objects (a tea-pot, a mug, cookies, etc.) arranged as if either before tea (the "drinking" Context) or after tea (the "cleaning" Context). In the Action condition, subjects saw a human hand grasp a mug using either a precision grip or a whole-hand prehension (with no contextual elements present). In the intention condition, subjects saw one or other of the two acts of prehension embedded in either the drinking context (intention to drink condition) or the cleaning context (intention to clean condition). Thus, subjects saw a single motor act of prehension that could be part of the more complex act of either drinking or cleaning. Viewing the intention condition led to the strongest activation in the right inferior frontal areas (known to be rich in MNs). Furthermore, viewing the intention to drink condition caused a significantly stronger activation of the same brain area than the Intention to clean condition. In our terminology, the agent in the intention condition can be said to have the motor intention either to grasp the mug with full-hand prehension or with precision grip and the prior intention either to drink or to clean. Iacoboni et al. (2005) conclude that their experiment shows that the activity of areas known to contain MNs generates a representation of the agent's prior intention to e.g., drink. The reason why we think that these interesting results do *not* prove that areas with mirror properties generate a representation of the agent's prior intention is that Iacoboni et al. (2005) have not ruled out the possibility that the perception of contextual cues gives rise to a perceptual representation of the agent's prior intention (e.g., to drink), which could be formed prior, and contribute, to the representation of the agent's motor

intention. The enhanced MN activity might itself result from the existence of an independent representation of the agent's prior intention, rather than generating it.

In fact, as one of us has recently argued (cf. Jacob, in press), these recent experiments create an interesting dilemma for the nature of mirroring processes. The explicit purpose of the experiment is to show that the activity of MNs goes beyond the mere recognition of a motor act and enables an observer to represent the agent's underlying ("global") intention. In their own terms, the purpose of the experiments is to show that MN activity enables an observer not merely to respond to the question of *what* the agent is doing, but also of *why* he is doing it. But now, if MN activity does enable an agent to discriminate between two observed instances of a single motor act of grasping, then MN activity cannot be pure motor resonance. Strict congruence (or motor resonance) would require that the very same MNs that fire during the execution of a motor act of grasping also fire during the observation of an act of grasping performed by another. However, what the experiment shows is that MNs that fire in response to the observation of an act of grasping do not fire during the execution of the same motor act: rather, they govern the execution of a "functionally related act" (e.g., drinking). The fundamental property of MNs cannot, therefore, be the strict congruence between their motor and perceptual properties. Iacoboni et al. (2005) do recognize this and this is why they endorse a new model, which they label the model of "chains of logically related MNs". In such a chain, MNs coding an observed motor act are linked to "logically related" (i.e., probabilistically related) MNs coding the motor act that is most likely to follow its observed immediate predecessor in a given context. The dilemma is: one cannot both claim that MN activity is a strict resonance mechanism and that it extends beyond the mere recognition of a motor act towards the representation of the agent's underlying intention.

We now turn to the results of the fMRI and the behavioral experiments which Pierno, Ansuini and Castiello report. In the fMRI experiment they conducted, they compared three conditions: in the grasping condition, subject saw an actor grasp a target. In the gaze condition, they saw an actor gaze towards the target. In the control condition, they saw an actor remain still with his eyes fixed forward. They report that, relative to the control condition, in both the grasping and gaze conditions, they found bilateral activation in areas known to contain MNs (such as the frontal gyrus and the inferior parietal lobule). We agree that perceiving an agent's gaze is a good cue towards representing the object of the agent's attention and her prior intention (whether social or not). The experiment shows a correlation between enhanced activity of MNs and the observation of the agent's gaze (which does contribute to an observer's representation of the agent's prior intention). But this correlation does not prove that enhanced MN activity in the observer's brain *generates* a representation of the agent's prior intention in response to the perception of the agent's gaze. The correlation would only show this if we had independent evidence that there are MNs for eye-gaze and eye-movement. But as we said above, single cell recordings have shown that there are cells in the STS that respond selectively to eye-movements and eye-gaze in the monkey, but these cells are not MNs.

Pierno, Ansuini and Castiello also report a behavioral experiment in which both normal and autistic children were requested to grasp an object after they had observed a model either grasp the same object or gaze towards it. In normal children, they found

motor facilitation for the observation of both the grasping and the gazing conditions, relative to the control condition. However, children with autism failed to exhibit such motor facilitation effects in either the grasping or the gazing condition. Again, we do not think that this experiment shows that brain areas with mirror properties take an agent's gaze direction as input and generate a representation of the agent's prior intention as output. The results of this experiment are consistent with the hypothesis that the STS (which, so far as we known, does not contain MNs) generates a representation of the agent's prior intention from either the agent's gaze direction or contextual cues. In normal children, the motor facilitation might result from the prior activity of the STS. In children with autism, the lack of motor facilitation might reflect an impaired STS.

To conclude: on the one hand, we think that our conceptual distinction between motor intentions and prior intentions, some of which are social, is not put into question by the fact that an agent's motor intention can be represented by a conspecific and thereby modify the latter's mental representations. On the other hand we have argued that the crucial issue is whether brain mechanisms with mirror properties can represent an agent's prior intention. We have offered our reasons for thinking that such mechanisms are not sufficient for representing an agent's prior intentions. We have already discussed, and leave for another occasion, the issue of whether such mechanisms are necessary for the task.

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