On a Puzzle about Relations between Thought, Experience and the Motoric

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Abstract

Motor representations live a kind of double life. Although paradigmatically involved in performing actions, they also occur when merely observing others act and sometimes influence thoughts about the goals of observed actions. Further, these influences are content-respecting: what you think about an action sometimes depends in part on how that action is represented motorically in you. The existence of such content-respecting influences is puzzling. After all, motor representations do not feature alongside beliefs or intentions in reasoning about action; indeed, thoughts are inferentially isolated from motor representations. So how could motor representations have content-respecting influences on thoughts? Our aim is to solve this puzzle. In so doing, we shall provide the basis for an account of how experience links the motoric with thought. Such an account matters for understanding how humans think about action: in some cases, we have reasons for thoughts about actions that we would not have if we were unable to represent those actions motorically.

1. Introduction

Motor representations live a kind of double life. Although paradigmatically involved in performing actions, they also occur in individuals who are not acting other than in observing others act and sometimes influence their thoughts about the goals[1] of these actions (as we explain in section 2). There

[1] We always use the term 'goal' to refer to an outcome to which an action is directed. Note that goals in this sense are not intentions or states of agents but rather things specified by such goal-states.

is reason to suppose that these influences are content-respecting: what you think about an action sometimes depends in part on how that action is represented motorically in you (see section 3). But the existence of such content-respecting influences is puzzling. After all, motor representations are inferentially isolated from thoughts. How could motor representations have content-respecting influences on thoughts despite their inferential isolation?

Our aim is to solve this puzzle. Why bother? Solving the puzzle matters for understanding how we are able to think about actions, others' and our own. On the face of it, the inferential isolation of thought from motor representation indicates that, as is typically assumed among philosophers, motor representations concerning actions are entirely cut off from thoughts about them. But reflection on the puzzling discovery that motor representations can have content-respecting influences on thoughts requires us to reconsider this view. Our proposal will be that these influences go via experience. Sometimes when you observe or perform an action, your experiences provide reasons for certain thoughts about the action and which reasons your experience provides depends on how the action is represented motorically, or so we shall argue (in sections 4 to 6). It is experience that links the motoric to thought.

2. The Double Life of Motor Representation

Suppose you are reaching for, grasping, transporting and then placing a pen. Performing even relatively simple action sequences like this involves satisfying many constraints that cannot normally be satisfied by explicit practical reasoning, especially if performance is to be rapid and fluent. Rather, such performances require motor representations. These representations are paradigmatically involved in preparing, executing and monitoring actions.[2] But they also live a double life. Motor representations concerning a particular type of action are involved not only in performing an action of that type but also sometimes in observing one. That is, if you were to observe Ayesha reach for, grasp, transport and then place a pen, motor representations would occur in you much like those that would also occur in you if it were you—not Ayesha—who was doing this.

Converging evidence for this assertion comes from a variety of methods and measures. Single cell recordings in nonhuman primates show that, for each of several types of action, there are populations of neurons that

[2] See Wolpert et al. (1995); Miall & Wolpert (1996); Jeannerod (1998); Zhang & Rosenbaum (2007). Note that motor representations sometimes occur in an agent who has prepared an action and is required (as it turns out) not to perform it: although she has prevented herself from acting, motor representations specifying the action persist, perhaps because they are necessary for monitoring whether prevention has succeeded (Bonini et al. 2014).

discharge both when an action of this type is performed and when one is observed (di Pellegrino et al. 1992; Gallese et al. 1996; Fogassi et al. 2005). Relatedly, in humans enhancing motor activation during action observation can produce patterns of muscle activation in the observer similar to those in the agent (Fadiga et al. 1995). And behaviourally, observing one action sometimes interferes with the simultaneous performance of a second action in much the way that performing the first action oneself would (Kilner et al. 2003). All of this and more shows that motor representations sometimes occur in action observation (for reviews, see Rizzolatti & Sinigaglia 2008, 2010).

The double life of motor representations involves more than their mere presence in observation: sometimes motor representations concerning particular observed actions influence thoughts about to which goals those actions are directed. Imagine that on a pitch black night there is a cyclist who has cautiously attached tiny lights to her hands, feet, elbows, knees and shoulders. As she soundlessly crosses your path you see only points of light from her body (so none from the bicycle). Now suppose that she has specially configured her bicycle so that pedalling backwards makes it move forwards. Assuming that you have only ever ridden standard bicycles, there is a relatively small chance that you will recognise to which outcome her movements are directed, namely cycling. But now suppose you are trained to cycle on her specially configured bicycle and that, to ensure there is no visual learning, you are blindfolded during training. After training (assuming you survive, of course) you are significantly more likely to recognise observed movements as directed to cycling just by seeing the tiny lights on the agent.[3] This effect is perhaps surprising given that your judgement ultimately rests on purely visual information (this is the point of the lights) whereas nothing could be seen during the training.

What explains this difference in judgement before and after training? Training of this kind typically alters the way things are represented motorically (Calvo-Merino et al. 2006). For this reason, the increase in the probability of making accurate judgements about the goals of others' actions is plausibly a consequence of differences in motor representations in the observer.

The view that thoughts about the goals of others' actions are sometimes influenced by motor representations in the observer is further supported by considering selective impairments to the motoric. Suppose you are observing some bodily actions. You are asked to determine which outcome these actions are directed to, and also which body parts you are observing. A temporary lesion to a motor area of your brain involved in planning and performing actions will affect your ability to make judgements about goals but

[3] Casile & Giese (2006) did an experiment like this, but with activities less dangerous than reverse cycling blindfolded. See also Beets et al. (2010).

not body parts; whereas a temporary lesion to an area involved in higher-order visual processing will have the converse effect (compare Urgesi et al. 2007). Permanent lesions to motor areas of the brain involved in planning and performing actions have the same type of effect, as research contrasting different forms of apraxia shows. In one study apraxic patients were asked to identify goals such as the cutting of some paper or the use of a straw for drinking on the basis of the sounds actions produced. Patients with limb apraxia showed an impairment in recognising the goals of hand-related actions whereas patients with buccofacial apraxia were impaired in recognising the goals of mouth-related actions; but no patients showed a general impairment in recognising sounds and their significance (Pazzaglia et al. 2008). Apparently, then, it is not just your long-term expertise but also the occurrence of motor representations in observation that matters for making judgements about goals.[4]

There is, then, a variety of evidence that motor representations concerning the goals of observed actions sometimes influence thoughts about them. Reflection on how these influences occur leads to a puzzle.

3. A Puzzle

How do motor representations influence thoughts about the goals of actions? To answer this question we need to understand what motor representations occurring in observation represent. It may be natural to assume that these represent joint displacements and bodily configurations only. However, some motor representations represent outcomes other than these, outcomes that could be identified in thought as the goals of actions. These include outcomes such as the reaching for, grasping, transporting and placing of an object like a pen.

How do we know this? How can we distinguish representations of outcomes such as the grasping of a pen from representations of mere joint displacements and bodily configurations? This is possible because outcomes such as the grasping of a pen might be realised by indefinitely many sequences of joint displacements and bodily configurations; and, conversely, actions involving arbitrarily similar joint displacements and bodily configurations can realise different outcomes in different contexts. To illustrate, the grasping of a pen could be realised by any of at least three types of action which vary kinematically: a hand action, a foot action or a tool-using action. If we had marks we could use to identify motor representations in-

[4] Note that we are not claiming that motor representations are necessary for all observational judgements about goals. The findings cited show only that motor representation sometimes influences such judgements. Even if this influence only rarely occurred, the puzzle identified below would still arise.

dependently of knowing what they represented, and if we had evidence that these marks were constant across instances of all three types of action, then we could infer that some motor representations capture something more abstract than joint displacements and bodily configurations. But we do have marks by which motor representations can be identified: motor representations can be identified from patterns of neuronal discharge, from motor-evoked potentials, from where blood flows in motor areas of the brain, from behavioural performance profiles and in other ways besides. And we do have evidence that such marks are constant across instances of all three types of action which realise a particular grasping outcome (Rizzolatti et al. 1988, 2001; Hamilton & Grafton 2008; Cattaneo et al. 2010). So we can infer that some motor representations do not represent joint displacements and bodily configurations only.

To infer, further, that some motor representations represent outcomes such as the grasping of a pen we need to consider what happens when, conversely, we hold joint displacements and bodily configurations constant while varying to which outcome an action is directed. Take an action which realises the grasping of a pen and compare it with a second action which is as similar as possible to the first with respect to its kinematic features but differs with respect to which outcome it is directed to because the object is manifestly too large or too small to grasp or because the object is manifestly absent (so the action is not plausibly directed to grasping anything). There are marks of motor representations which distinguish these actions (Umiltà et al. 2001; Villiger et al. 2010; Koch et al. 2010). This together with the constancy of some motor representations across variations in the joint displacements and bodily configurations that might realise a goal-directed action is evidence that some motor representations carry information about the kind of outcomes that are sometimes identified in thought as the goals of actions, outcomes such as the grasping of a pen.

Can we say anything more general about about the types of outcomes that motor representations carry information about? While there is no comparably direct evidence for cases other than object-directed hand actions, it is sometimes plausibly implied that among the outcomes motor representations carry information about are things such as the articulation of a phoneme (Fadiga et al. 2002), the playing of a chord (Buccino et al. 2004), the hitting of a ball with a bat (Shimada 2009) and the production of a dance step (Calvo-Merino et al. 2005). Further, just as motor representations carry information not only about reaching, grasping and transporting outcomes but also about sequences of such outcomes (Fogassi et al. 2005), it is possible that motor representations carry information not only about individual phonemes, chords, hittings or dance steps but also sequences of these. These are all outcomes which specify actions involving complex coordinated movements and last for seconds rather than minutes or hours.

That a representation carries information about an outcome does not imply that it represents the outcome, of course. But information about outcomes has a functional role in performing and—crucially for our purposes—monitoring actions. For motor representations carrying information about outcomes trigger processes which, in effect, compute means by which the outcomes could be realised; and they generate expectations concerning sensory consequences of the outcome's occurrence (Miall & Wolpert 1996; Wolpert et al. 2003). We can infer two things. First, motor representations not only carry information about outcomes: since this information is appropriately related to their functional roles, we can infer that they represent outcomes.[5] Second, it is not just that some motor representations represent outcomes which could be identified in thought as goals of actions; rather, such representations are essential for monitoring how an action unfolds.

How does all this bear on how motor representations influence thoughts? In the previous section we saw that motor representation occurs in observation and, further, that motor representations concerning particular observed actions sometimes influence thoughts about the goals of those actions. We have just seen that some motor representations concerning actions are representations of outcomes to which they are directed, outcomes such as reaching, grasping, transporting and placing; and that such representations are essential for monitoring how such actions unfold. Putting these two things together, we can conclude that where motor representations influence a thought about an action being directed to a particular outcome, there is normally a motor representation of this outcome, or of a matching[6] outcome.

This conclusion, to which we are all but forced by the evidence just sampled, leads to a puzzle. The puzzle arises because the conclusion entails that motor representations have content-respecting influences on thoughts. It is the fact that one outcome rather than another is represented motorically which explains, at least in part, why the observer takes this outcome (or a matching one) to be an outcome to which the observed action is directed. But how could motor representations have content-respecting influences on thoughts? One familiar way to explain content-respecting influences is to appeal to inferential relations. To illustrate, it is no mystery that your beliefs have content-respecting influences on your intentions, for the two are connected by processes of practical reasoning. But motor representation, unlike belief and intention, does not feature in practical reasoning. Indeed, thought is inferentially isolated from it. How then could any motor representations

[5] More detailed arguments for the same conclusion are provided by Prinz (1997, pp. 143–6), Pacherie (2008) and Butterfill & Sinigaglia (2014).

[6] One outcome *matches* another in a particular context just if, in that context, the occurrence of an outcome of the first type would normally constitute or cause, at least partially, an occurrence of an outcome of the second type, or vice versa.

have content-respecting influences on thoughts?

Broadly, our proposal will be that content-respecting influences of motor representations on thoughts go via experience. Motor representations sometimes influence our experiences when we observe actions, and these experiences in turn provide their subjects with reasons for thoughts about the actions. Further, which reasons an experience provides depends in part on the contents of the motor representations influencing it. (To save words, let us say that a representation *shapes* an experience to mean that the representation influences the experience in such a way that which reasons the experience provides depends in part or whole on what the representation represents.) It is thus experience that ties thought to motor representation. This, anyway, is the proposal we shall elaborate and defend in the rest of this paper.

4. Motor Representations Sometimes Shape Experiences

The puzzle is how motor representations could have content-respecting influences on thoughts despite not being inferentially integrated with them. Our proposal will hinge on experience. Even in advance of any details, invoking experience may seem, far from resolving the puzzle, only to make things worse. Suppose we were to ask how visual representations can have content-respecting influences on thoughts despite thoughts being inferentially isolated from them. One view is that visual representations influence thoughts by shaping experiences: that is, they provide their subjects with reasons for certain thoughts, and which reasons an experience provides depends in part on the contents of the visual representations that give rise to it. Our proposal is, in effect, that something analogous holds for motor representations.[7] This may appear implausible because whereas visual representations give rise to visual experiences, it is unclear both what sort of experiences motor representations might influence and how they might influence these experiences—if indeed they have any influence at all. In this section we take a first step towards developing and defending our proposal by arguing that motor representations sometimes shape experiences.

What kind of evidence could there be for this claim? Ideally we would have a pair of cases which are as similar as possible except for differences in

[7] In making this analogy we do not intend to propose that there are motor experiences of actions in the sense that there are visual experiences of shape and colour (say). Our proposal is much less ambitious: motor representations influence experiences of some or other kinds, and do so in such a way that, sometimes, which thoughts the experience provides its subject with reasons for depends on what these influencing motor representations represent.

what is represented motorically. Any difference in experience between the two cases would then plausibly be a consequence of the difference in motor representation.

One way to find such cases is to compare experts with non-experts. (As noted earlier, 3, some forms of expertise affect how things are represented motorically.) Repp and Knoblich (2007) asked expert and non-expert pianists to press two keys in sequence, where the first key was sometimes to the left, and sometimes to the right, of the second key. The key presses produced an *ambiguous tone pair*, that is, a pair with the property that the first tone is sometimes perceived as lower in pitch than the second whereas at other times it is perceived as higher in pitch (Deutsch et al. 1987). The tones always occurred in the same order regardless of which key was pressed first. By asking subjects to report how they perceived the relative pitches of the tones, Repp and Knoblich found that, for the expert pianists, the direction of the key presses influenced the perceived direction of the change in pitch. Could what influences experience in this case be not a motor representation but merely the occurrence of a movement, or perhaps even the perception of a movement of the subject's own fingers? Against these possibilities, note that the effect was not observed in non-expert pianists: for them the direction of movement did not measurably influence the perceived pitches. Since the direction of movement was the same for both groups, if the influence were due to movement only we would expect it to occur irrespective of piano-playing expertise. Instead it seems likely that differences in expertise between the two groups of subjects affected how the movements they performed were represented motorically, and that these differences in motor representation are in turn what explains their perceptions of relative pitches.

It is not only in performing action that motor representation can influence experience: the same can occur in observing action. Thus in another experiment, Repp and Knoblich (2009) compared observing someone else perform a sequence of key presses with performing the same sequence oneself. They found the same effect on experiences of an ambiguous tone pair in expert pianists regardless of whether they were observing or performing the action. Sometimes, which judgement about pitch an experience provides a reason for depends on what is represented motorically; and this dependence is systematic, of course, for it reflects how pianos work. These studies, and others like them,[8] provide relatively direct evidence that motor representation can shape experience.

Our overall concern is with evidence for the double life of motor representation, and in particular its influence on thoughts about the goals of observed actions. So far we have been discussing thoughts about pitches.

[8] See also Zwickel et al. (2010) who investigate effects of action on visual experience of motion, and Schütz-Bosbach & Prinz (2007) for a review.

We cannot take for granted that what applies to pitches will also apply to goals: whereas pitches are plausibly among the admissible contents of experience, goals such as reaching and grasping may not be. What grounds could there be to hold that motor representations might also shape the sort of experiences that provide their subjects with reasons for thoughts about goals?

5. Experiences Revelatory of Action

Thoughts about actions sometimes involve *experiences revelatory of action*, that is, experiences which provide the subject of experience with reasons for thoughts about the goals of actions someone, herself or another, is performing. Where an experience provides its subject with reasons for thinking that a particular action is directed to a certain goal, we shall say that the experience *reveals* that goal.[9] Suppose, for instance, that you are observing a stranger you have never communicated with. You may be able to judge on the basis of observation that the stranger is exercising a dog or catching a ball. You are able to make such judgements about the stranger's actions because your experiences provide you with reasons for them. The same is true of thoughts about your own actions. Suppose you intend to perform a downwards dog. How do you know whether you have already acted on this intention? Sometimes experiences provide you with reasons to judge that you have acted to this end.

In this section we aim to show that some experiences revelatory of action depend on motor representations of outcomes, and in such a way that which goals the experiences reveal is determined, at least in part, by which outcomes are represented motorically. Ideally we want to identify pairs of cases with these features: in each case there is an experience revelatory of action; the two cases differ regarding what is represented motorically, but are otherwise as similar as possible; and which goal is revealed in each case matches what is represented motorically.

One source of such cases is research on anosognosia for hemiplegia. Patients with anosognosia for hemiplegia will sometimes deny, and appear in some ways unaware of, a severe paralysis of one or more limbs on one side of their bodies. Some such patients lack concurrent awareness of failures to move their plegic limbs but do not suffer from severe sensory deficits or

[9] Note that experiences revelatory of action are not necessarily experiences of actions. For comparison, consider two kinds of experience that can be revelatory of fire. One is an experience of fire itself, the other is an experience of smoke. Somewhat similarly experiencing the effects of an action might, given the right background knowledge, provide you with reasons for a thought about which goal it is directed to. Here we are neutral throughout on whether any experiences revelatory of action are experiences of action.

neglect, and cannot move their hemiplegic limbs at all. For our purposes it is useful to focus only on these patients.[10] On the leading, best supported explanation, in these cases anosognosia for hemiplegia arises from deficiencies in monitoring action (Berti et al. 2005, 2008). To illustrate, consider a patient who was asked to brush her hair holding a brush in her paralysed hand. Although she was unable to move the hand, she proceeded to move her head as if her hair was being brushed and then reported having successfully brushed her hair (Berti et al. 2008, pp. 173–4). How could a deficit in monitoring action explain this? When a subject with anosognosia for hemiplegia is asked to perform an action involving her hemiparetic limb, motor representations occur as they might do in ordinary subjects (Berti et al. 2005; Garbarini et al. 2012). However, in ordinary subjects monitoring processes reliably ensure that any failures to act are detected; motor representations adjust accordingly (Haggard 2005). By contrast, in these cases of anosognosia for hemiplegia, there is damage to the monitoring processes or to capacities underlying them. A consequence is that motor representations are isolated from information relevant to failures to act. This is why some patients with anosognosia for hemiplegia sometimes act as if their hemiparetic limbs were actually moving.

How is anosognosia for hemiplegia relevant to our concern with experiences revelatory of action? Consider an anosognosic patient like those just mentioned and a patient with hemiplegia but no anosognosia. Suppose each is asked to draw simultaneously with both hands, where the unaffected hand was supposed to continuously draw a vertical line and the paralysed hand to continuously draw a circle. There will be a difference in their experiences. The anosognosic patient will sometimes judge that she is performing a bimanual action; this indicates that she has an experience which reveals the goal of drawing both lines and circles. By contrast, the non-anosognosic patient with hemiplegia will report performing a unimanual action and not the bimanual action, of course; this confirms that, as expected, she has no experience revealing the goal of drawing both lines and circles. What could explain this difference in experience between the two patients? The sensory information available to each patient should be the same: after all, hemiplegic individuals can of course only actually move one hand, and the patients we are concerned with do not have relevant sensory deficits. But there is a difference between the patients' motor representations. In the anosognosic patient, deficient monitoring means that motor representations should occur much like those that would occur were she not hemiplegic: there will

[10] On the existence of such patients, see for instance Berti et al. (2005); on variety in the extent and nature of the unawareness of paralysis in anosognosia for hemiplegia, and in the accompanying deficits, see for instance Marcel et al. (2004). Note that this paper is not concerned with a fully general explanation of anosognosia for hemiplegia, nor with issues about the unity of the disorder.

be motor representations concerning the movements of left and right hands. By contrast, in the hemiplegic but non-anosognosic patient intact monitoring ensures that these motor representations do not occur or do not persist: there will only be motor representations concerning the movements of the unaffected hand. The predicted difference in motor representation can be confirmed by measuring how straight the lines drawn are: in the anosognosic patient's case only, the attempted straight line will show interference of the sort that, ordinarily, would be expected only if the other hand were actually drawing a circle (Garbarini et al. 2012). So comparing hemiplegic patients with and without anosognosia yields a pair of cases fitting our criteria: there are differences in which goals experiences reveal, and these differences appear to be determined by differences in what is represented motorically.[11]

6. Experiences Revelatory of Others' Actions

In the previous section we considered experiences revelatory of one's own actions, but our primary concern is with others' actions. It is reasonable to suppose that claims about experiences of one's own actions will generalise to experiences of others' actions. After all, the ways motor representations are involved in observing actions are strikingly similar to the ways motor representations are involved in performing actions (as we noted in section 2). But are there also pairs of cases which support our claim that some experiences revelatory of others' actions are such that which goals they reveal is determined in part by which outcomes are represented motorically?

Suppose you are shown two pictures in short succession. These depict the start and end points of someone rotating her hand around her wrist. You will have an experience as if the hand had actually moved from one point to the other. But which direction does your experience indicate that the hand moved in? Suppose that movement of the hand clockwise would involve the shortest distance but violate biomechanical constraints, whereas movement anticlockwise would be biomechanically plausible but involve a longer distance. Where the temporal interval between presentation of the two pictures is very brief, you are you are likely to experience the biomechanically implausible movement. But if the interval between presentation of the two pictures is not too brief, your experience will be such as to indicate that the hand moved through the longer, biomechanically plausible path (Shiffrar & Freyd 1990). The latter type of experience can be revelatory of action, where

[11] Anyone who denies that illusory experiences of shape (say) could provide their subjects with reasons for thoughts about the shapes of the objects experienced is likely also to reject the claim that anosognosic patients' experiences are revelatory of action. We ignore this complication here; it could be accommodated without substantially changing the conclusions we draw.

the goal revealed is that of rotating one's hand. By contrast, an experience of the former type—one indicating that the hand moved through the shorter, biomechanically implausible path—is an experience revelatory of a different action; or, perhaps more plausibly since this is not the sort of movement that could normally feature in a goal-directed action, it may be not an experience revelatory of any action at all.

Consider two individuals with bilateral congenital absence of arms, one with and one without phantom limb experiences of postures and movements. The presence of such phantom limb experiences are evidence of motor representations concerning actions involving the absent limbs (Mercier et al. 2006). What happens when these two individuals are presented with the sequence of pictures just mentioned? Their reports about the direction in which the hands move indicate that they have different experiences. The individual with phantom limb experiences appears to have experiences indicating that the hand rotates through the longer, biomechanically plausible path (providing, that is, that the interval between presentation of the two pictures is not too brief); whereas the other individual only has experiences as if the hand were moving along the shorter path, violating biomechanical constraints (Funk et al. 2005). What explains the difference between these two individual's experiences? The most plausible candidate is the difference in motor representations concerning the absent limbs. So comparing aplasic individuals with and without phantom limb experiences of postures and movements yields a second a pair of cases fitting our criteria: there are differences in which goals experiences reveal, and these differences appear to be determined by differences in what is represented motorically.

Our aim in this section was to show that some experiences revelatory of others' actions are shaped by motor representations of outcomes. We offered two considerations in favour of this view, neither decisive but jointly compelling. The first was that what goes for experiences revelatory of one's own actions probably also goes for experiences revelatory of others' actions (and, as we saw in the previous section, there is evidence that some experiences revelatory of one's own actions are shaped by motor representations). The second was a pair of cases indicating that, sometimes, the presence or absence of an experience revelatory of another's action can depend on the presence or absence of motor representations concerning the goal the experience reveals. Motor representation shapes experiences revelatory of both one's own and other's actions.

7. Conclusion

We have been examining a puzzle related to the double life of motor representation. How could motor representations have content-respecting influ-

ences on thoughts about actions given that thoughts are inferentially isolated from motor representations? The solution we have defended involves experience. Motor representations sometimes shape experiences revelatory of action, and they do so in such a way that which goals the experiences reveal depends on which outcomes are represented motorically. This indicates that, in something like the way experience may tie thoughts about seen objects to the representations involved in visual processes, so also it is experience that connects what is represented motorically to the objects of thought.

This may matter for understanding thought about action. On the face of it, the inferential isolation of thought from motor representation makes it reasonable to assume that an account of how humans think about actions would not depend on facts about motor representation at all. But the discovery that motor representations sometimes shape experiences revelatory of action justifies reconsidering this assumption. It is plausible that people sometimes have reasons for thoughts about actions, their own or others', that they would not have if it were not for their abilities to represent these actions motorically. To go beyond what we have considered here, it may even turn out that an ability to think about certain types of actions depends on an ability to represent them motorically.

One consequence of our proposal concerns how experiences of one's own actions relate to experiences of others' actions. For almost any action, performing it would typically involve receiving perceptual information quite different to that involved in observing it. This may suggest that experiences involved in performing a particular action need have nothing in common with experiences involved in observing that action. However, two facts about motor representation, its double life and the way it shapes experience, jointly indicate otherwise. For actions directed to those goals that can be revealed by experiences shaped by motor representations, there are plausibly aspects of phenomenal character common to experiences revelatory of one's own and of others' actions. In some respects, what you experience when others act is what you experience when you yourself act.

But what do we experience when our experiences revelatory of action are shaped by motor representations? One possible view is that such experiences are all experiences of bodily configurations, of joint displacements and of effects characteristic of particular actions. A more radical view is that some goal-directed actions can be experientially present in some way. Perhaps, for instance, they can be experientially present in something like the way that, it is sometimes held, some physical objects can be experientially present. The experiential presence of physical objects arguably depends on a system of object indexes which is part of a perceptual system for segmenting objects and tracking their movements (Kahneman et al. 1992); this system is not tied to a particular modality (Jordan et al. 2010) and may enable experiences of physical objects even while they are temporarily fully occluded.

Given this, one version of the more radical view is that motor representations stand to experiences of action in something like the way that the object indexes stand to experiences of objects. On this view, experiences revelatory of action are not only experiences of bodily configurations, joint displacements, sounds and the rest—they include experiences of goal-directed actions. The proposal we have developed about how motor representations influence thoughts by shaping experiences is consistent with either view about what is experienced. But our guess is that sometimes what one experiences when one performs or observes a goal-directed action is not only bodily configurations, joint displacements and the sensory effects of the action but also the action itself.[12]

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