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HOW THE BODY NARROWS THE INTERACTION WITH THE ENVIRONMENT

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Introduction

Embodiment matters to perception and action. Beyond the triviality that, under normal circumstances, we need a body in order to perceive the world and act in it, our particular embodiment, *right here, right now*, both enables and constrains our perception of possibilities for action. In this chapter, we provide empirical support for the idea that the structural and morphological features of the body can narrow the set of our possible interactions with the environment by shaping the way we perceive the possibilities for action provided. We argue that this narrowing holds true in the perception of what we call *strongly embodied affordances*, that is, relevant micro-affordances that have a genuinely demanding characteristic, as well as in the perception of actions performed by others. In particular, we show that perceptual contents are shaped by fine-grained morphological features of the body, such as specific hand-shapes, and that they change according to our possibility to act upon them with *this* body, in *this* situation, at *this* moment. We argue that these considerations provide insight into distinguishing a variety of experienced affordance relations that can aid us in better understanding the relevance of embodiment for perception and experience.

Perceiving objects

The notion of affordance, introduced by Gibson (1979), is a conceptual tool to help explain how the environment has the power to furnish creatures with suites of possible actions. Gibson held that affordances were properties of the environment that creatures with the right kind of perceptual apparatus could latch on to and make use of. Indeed he held that our entire worlds, our "ecological niches" are just the sets of these affordances that we are sensitive to (Gibson, 1979). Affordances

are usually understood as not just any physical properties that are present in the environment, but rather as the properties that provide action opportunities to any individual who is able to perceive and use them. A horizontal surface may be stand-on-able or sit-on-able, a vertical surface may be climbable, and an object such as an apple may afford a whole range of motor acts: it may be grasped, thrown, pressed, bitten, kicked, and so on.

While many authors have emphasised the mutuality of organism and environment as well as the role of action in defining affordances (Michaels et al., 2001; Shaw et al., 1982; Turvey, 1992; Turvey et al., 1981), it has been Chemero (2001, 2003, 2009) who has perhaps done the most to explain how affordances can best be understood as relations. Chemero's model of affordances takes them to be relations between features of a situation and abilities of an individual. "Features of a situation" refers not to a property that is present in the environment regardless of whether any individual exists that can interact with it (i.e., in the way that trees exist or rabbits exist). Rather, the "situation" is the situation in which the individual finds themselves in the environment, that is to say, the interacting individual is *included as part of* the situation. The "features" of this situation are, to use Chemero's own example, more like raininess when it is raining than dentiness when there is a dent in your car. As he explains,

> [t]o see this, consider that the "it" in "it is raining" is never the same thing; it refers to a situation (what's going on right here, right now) that will never appear again. We can ask what is dented, but we cannot ask what is raining.
> *(Chemero, 2009, p. 140)*

Similarly "abilities" are, for Chemero, not to be conceived as dispositions, which (1) would exist independently of any environmental trigger and (2) can never fail (if something has the disposition of being soluble then, if it is put in water, it must dissolve). Affordances are *possibilities* for action and not forced causes. Chemero's concept of "abilities" allows for this as he conceives them as being functions. And, just as the function of a heart is to pump blood whether or not it manages to instantiate blood-pumping in this moment, an ability is a capacity that has evolved in an individual to respond to certain features of the environment.

We take this definition of affordances as a relation between a situational feature and the bodily abilities of an individual and apply it also to micro-affordances (Ambrosini et al., 2014; Ambrosini and Costantini, 2013; Ambrosini et al., 2012a; Cardellicchio et al., 2011; Cardellicchio et al., 2013; Costantini et al., 2011a; Costantini et al., 2011; Costantini et al., 2010; Costantini et al., 2011c; Costantini and Sinigaglia, 2012; Ellis and Tucker, 2000). Micro-affordances are finer-grained possibilities for action than affordances. While an object may afford grasping, a grasping action can be manifested in a number of ways not all of which would be appropriate. Micro-affordances are the "potentiated components" of a grasping response (Ellis & Tucker, 2000), which is to say, those parts of the observer's response that, if put into action, would enable, for example, grasping the object

from a particular direction, with a particular hand, and with a particular hand-shape (for example, power grip or precision grip). Note that Ellis and Tucker use the term "micro-affordance" to refer to the "dispositional states of the viewer's nervous system" (Ellis & Tucker, 2000, p. 451) that give rise to the components of a particular response, such as the precision grippiness of a grasping response. This situates the affordance *in* the observer rather than in the relation between the observer and the object and obscures the distinction between affordances and effectivities (or, if we are following Chemero, between affordances and abilities). We here generalise their term and use it to refer to those affordance relations where the situated features typically suggest particular ways of responding to action involving object-centered interactions (e.g., hand- or mouth-grasping, manipulating, tearing, pulling, pressing, biting, kicking, etc.).

The dynamic change in people's sensitivity to micro-affordances has been shown by taking advantage of the spatial alignment effect (Bub and Masson, 2010), also known as the stimulus-response compatibility (SRC) effect. This effect refers to a decrease in reaction time when a subject executes a motor act that is congruent with that afforded by a seen object. For example, when I see a handled cup, there are particular movements that are suggested (or even demanded) by it for my reaching for its handle and likewise for my forming the grip adequate for grasping it in order to take a drink (Tucker and Ellis, 1998, 2001, 2004; Vainio et al., 2008; Vainio et al., 2007). These motor acts that are appropriate in this way are the ones considered "congruent." In their study, Tucker and Ellis (1998) presented images of everyday graspable objects with handles (e.g., cups) in which the objects appeared either right-side up or upside-down, with the handles randomly oriented either to the left or the right side of space. The question of interest was whether the movements afforded by the picture of the handle potentiated any form of action. Participants provided left- or right-hand responses to indicate whether the target object was right-side up or upside-down. Tucker and Ellis found a significant compatibility/spatial alignment effect based on whether the affording handle appeared on the same side as (i.e., congruent with) the responding hand, for example, left responses were faster when the handle appeared on the left side of space.

These important studies by Rob Ellis and his group clearly suggest that looking at graspable objects potentiates specific motor acts that are best suited for manipulating and interacting with the target object even when those motor acts are (i) not going to be instantiated and (ii) are task-irrelevant. This gives us good reason to think (in accordance with Gibson) that when we perceive objects upon which it is possible for us to act, we are perceiving action possibilities themselves. Furthermore, it suggests that when we perceive these finer-grained components of affordances, "micro-affordances," what is perceived is not mere abstract possibilities for action (i.e., "grasp-ableness") but rather (in accordance with Chemero) concrete possibilities for action related to the perceiver's embodied abilities to potentiate a motor act *right here*, *in this situation*, *with this body*.

We suggest these studies support viewing micro-affordances as relations between a feature of a situation (e.g., a particular kind of grasp-ableness) and an embodied

ability (e.g., the observer's ability to follow through, unreflectively and with minimum effort, with an action congruent with the morphology of their body). However, they leave unanswered just how tight the relation between situational features and current embodied abilities needs to be to perceive micro-affordances. That is, how important is it that the situation encompasses a body that has the ability to respond to the possibilities for action *right now* rather than having to change the situation into one that is act-on-able? In order to investigate this, we (Costantini et al., 2010) investigated whether and to what extent micro-affordances are space-dependent, that is to say, how strongly they are dependent on where they are in space relative to the observer. We used three-dimensional (3D) stimuli, which allowed us to give the participants the illusions of objects being located at two different regions of space. Participants were instructed to replicate a grasping movement as soon as a task-irrelevant go signal appeared. The go signal was a 3D scene in which a mug, placed on a table, had the handle oriented toward the left or right, thus being congruent or incongruent with the executed grasping action. In a first experiment, the mug was located either within the observer's peripersonal (30 cm) or extrapersonal space (150 cm) (see figure 10.1). The results showed that the spatial alignment effect (compatibility effect) occurred only when the mug was presented within the observer's peripersonal space.

Peripersonal space is usually defined as the space that encompasses the objects within reach – in contrast to extrapersonal space, which is described as the space including objects that are beyond our immediate reach and that one can get close to enough only by locomotion. According to this definition, peripersonal space can be construed in two different ways, by putting the emphasis either on the nearness of the object, that is, on its mere distance from the agent, or on the actual *reachability* of the object.

The results from our first experiment did not allow us to disentangle these two notions of peripersonal space. So, to investigate whether the space-dependence of the affordance relation is just matter of distance or whether it has to do with the actual readiness-to-hand of the affording feature, we carried out a second experiment in which we divided the surrounding space of the participants into reachable and nonreachable subspaces by presenting the task-irrelevant handled mug in front of (reachable) or behind (nonreachable) a transparent panel presented in near space (see Figure 10.1). The results showed that the spatial alignment effect occurred only when the mug was actually reachable by the participants.

These studies show that the spatial alignment effect really is keying in to an affordance relation that is importantly situated and embodied. In all of the tasks described above, the handles on the mugs could be seen by the experimental participants. Furthermore, it was always the case that these handles were *in principle* graspable (although they were not always graspable in practice due to being placed too far away or behind a transparent panel). And yet reaction times were only reduced when the stimuli were *reachable* even though the participants were never asked to *actually reach-to-grasp* the mugs. Note that conceiving of affordances as relations in the way described at the beginning of this section does not distinguish

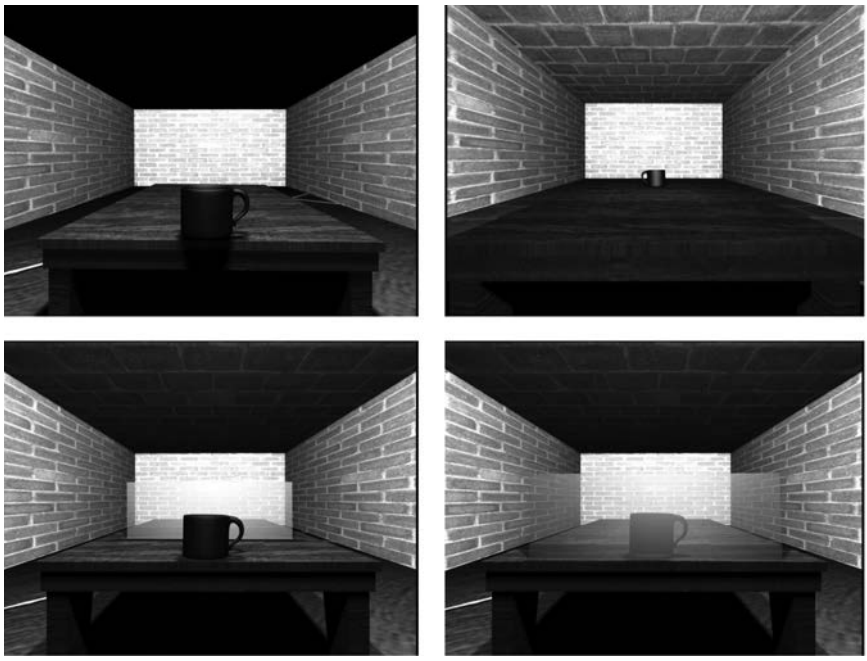

FIGURE 10.1 Exemplar of 3D stimuli used in Costantini et al 2010. Participants were instructed to perform a reach-to-grasp movement as soon as the go stimulus appeared. A spatial alignment effect was observed only when the object represented in the go stimulus was located in the reachable space of the participants.

Source: Costantini et al. (2010).

between (1) relations between features and abilities that are potentially exercisable and (2) relations between features and abilities that are actually exercisable right here, right now. That is to say, according to Chemero, an affordance is present as long as there is at least one individual that can perceive the relation between a relevant situational feature and their own motor abilities, regardless of whether that individual is actually in a position to do so (see Chemero, 2009, p. 193). Moreover, his proposal that abilities are functions also implies that these are not solely occurrent processes (after all if they were they could not "malfunction"). If this is right, then there *is* an affordance relation between the participant and the mugs that are out of reach/behind the transparent panel, and it is therefore not the affordance relation that is being latched onto by the spatial alignment paradigms. We might call the affordance instantiated here a "potential affordance," but that would imply that it is in fact not a real affordance. Rietveld and Kiverstein (2014) have suggested that we distinguish between affordances and affordances that are placing some active demand upon us, that are relevant to our current concerns. Following Dreyfus and Kelly (2007), they call these relevant affordances that have demand characteristics "solicitations," short for "soliciting affordances."

Using this conceptual distinction, we can see that the spatial alignment and compatibility tasks are latching onto *solicitations* rather than affordances in general; they are revealing the relation between an ability and features of situations that the participants could actually do something with *now* – that *demand* that they do something with *now*. Not only does this suggest that the soliciting affordance is related to an individual's current concerns (following Rietveld and Kiverstein, 2014), but it also goes some way to explaining what underpins the demand characteristic of solicitations. Fleshing the notion of solicitations out in this way shows that they are more strongly embodied than is implied by their merely being relations between situational features and motor abilities. That is to say, we propose that micro-affordances are not only "embodied" because the ability that is brought into play in exercising the affordance is a motor ability. Rather, when we perceive that an affordance is affording, namely, that it is a solicitation, one must – bodily – be in a situation where this ability could (right here, right now) be exercised. We will expand on this inherently bodily character of soliciting affordances in the next sections.

Actual reachability versus perceived reachability

So far, so good. We perceive an object as graspable (right here, right now, in a particular way, and that it demands this of us) provided that it falls within our reachable space. However, in order to understand how deeply the possibility of acting upon a given object, namely, its reachability, shapes our perception of the object one must take into account that a distinction exists between perceived reachability (i.e., what is judged by the observer to be reachable) and actual reachability. A relatively common finding among studies of perceived estimates versus actual movement is the observation of an overestimation bias in reachability at midline positions (Mark et al., 1997; Martin, 2000). What this means is that individuals exhibit a general tendency to perceive that they can reach objects that are, in fact, out of grasp. Explanations for this overestimation bias in perceived reachability have focussed on two possibilities, both based on a misconception of one's own action capabilities during the motor simulation involved in the reachability estimates. According to the whole body engagement hypothesis (Rochat and Wraga, 1997), the overestimation bias arises because the participants engage in a simulated reach that includes all degrees of freedom (just as they are used to doing in their everyday experience of reaching), whereas they are generally tested in situations that prevent natural bodily movements. Alternatively, the postural stability hypothesis (Carello et al., 1989) proposes that participants naturally tend to overestimate their reaching range as long as – in reaching to that (overestimated) range – their body's centre of mass would be safely supported during the simulated movements required to contact the object. To date, however, the consensus is that neither of these hypotheses can fully account for the pattern of results in reachability judgments (Delevoye-Turrell et al., 2010; Martin, 2000).

This distinction between perceived reaching space and actual reaching space can give us some insight into another distinction: experienced perception of affordances and nonexperienced perception of affordances. While at least one stream of the philosophical literature on affordances tends to focus on them as instigating unreflective action (see, for example, Dreyfus, 2002; Rietveld, 2008; Rietveld et al., 2013), it seems to be generally assumed that conscious (or at least reportable) perceptions of affordances are a guide to the presence of their demand characteristic (i.e., their status as a solicitation). To see how important this distinction is consider a metaphor that de Haan and colleagues give, drawing on the affordance/solicitation distinction discussed earlier (Dreyfus, 2002; Dreyfus and Kelly, 2007; Rietveld and Kiverstein, 2014). In their phenomenological analysis of individuals who suffer from psychopathologies, they nicely distinguish between a *landscape of affordances* and a *field of affordances* (de Haan et al., 2013); see also (Bruineberg and Rietveld, 2014). A *landscape of affordances* is the collection of all affordances that are available to what they call, following Wittgenstein, a "form of life," that is to say, a particular kind of creature. A *field of affordances*, on the other hand, is the collection of affordances that one is responsive to right here, right now; the field is made up of the solicitations acting on you as a specific individual.

In de Haan et al.'s (2013) analysis of the phenomenology of deep brain stimulation for psychopathologies such as obsessive compulsive disorder (OCD), the authors propose understanding the field of affordances as having three dimensions: "width," corresponding to the scope of affordances perceived; "depth," corresponding to the temporal nature of the affordances perceived; and "height" corresponding to the strength of soliciting pull. This proposal very nicely allows us to visualise the differences in phenomenology between individuals who do not suffer from psychopathologies, individuals with depression, and individuals with OCD. Contrasted with neurotypical individuals, those with depression can be described as having a field with less width (fewer affordances presented) and less – and monotonous – height (the affordances that are presented have little soliciting pull and little to differentiate each from the other, either in the moment or in the future). The field for those with OCD however looks quite different; the field for the present consists of one (i.e., single width), very strongly soliciting (very high) affordance that towers over (and thus for the most part obscures) any future affordances that might otherwise be visible (see de Haan et al., fig. 10.1).

De Haan et al.'s analysis is a phenomenological one, based on interviews of the patients. While it may be the case that the interviewing technique and subsequent analysis of this data may be able to reveal affordances that are not occurrently phenomenologically conspicuous (what we here refer to as nonexperienced), the research on overestimation bias discussed above suggests that we may not have phenomenological access to which affordances are (i) experienced as solicitations but are merely "perceived" as demanding and (ii) those experienced as solicitations and that are *actually* demanding, that is, affordances whose demand characteristic is revealed in the activation of the motor components specific to the relevant micro-affordances. That is to say, the individual with OCD may experience that

there is just one very strongly soliciting affordance that obscures the more temporally distal and less demanding affordances in their field, but do we have good reason to suppose that this phenomenology actually reveals something about the embodied demand characteristics of their affordances?

We suggest that this is not the case. To see this, consider a further series of experiments that took advantage of the spatial alignment effect in order to investigate whether the affordance relation mainly depends on the individual's perceived reaching space or his/her actual reaching (Ambrosini and Costantini, 2013; Ambrosini et al., 2012a). We asked participants to replicate a reach-to-grasp movement with either the right or the left hand as soon as a go stimulus appeared (Ambrosini and Costantini, 2013). We recorded reaction times of the onset of the movement. During the experimental sessions, participants wore liquid-crystal shutter glasses, which can rapidly change from a transparent to an opaque state, allowing vision to be efficiently suppressed. At the beginning of each trial, when the shutter glasses turned opaque, the experimenter placed the mug at one of four different distances, with its handle oriented either to the right or to the left. These distances varied for each participant according to both her personal-actual and perceived-maximum reaching range: The first distance (near reaching space) and second distance (actual reaching space) were computed as 90% and 100% of the participant's actual reaching range, respectively; the third (perceived – but not actual – reaching space) and fourth (nonreaching space) distances were computed as 100% and 110% of the participant's perceived reaching range, respectively (recall that 100% of perceived reaching range is in fact greater than 100% of actual reaching range). We found that the spatial alignment effect occurred only for objects presented within the near reaching space and actual reaching space and not for the perceived reaching space and nonreaching space. Borrowing de Haan et al.'s terminology, these results demonstrate that the field of affordances is composed of at least two subfields: a subfield of actually demanding soliciting affordances and a subfield of affordances that are perceived as soliciting but do not actually have the demanding characteristic (because demandingness does not reduce to the experience of demandingness but rather can be characterised in terms of the potentiation of the components of the specific motor abilities). Our field of affordances, the set of those affordances that we experience as solicitations, is therefore not isomorphic to the field of actually demanding solicitations.

If we can perceive something as affording action now (i.e., perceive it as being a soliciting affordance) without it being an actually demanding solicitation as the overestimation bias experiments show, then could the converse not also be the case; may there not also be affordances that have a demand characteristic but that we do not experience as soliciting affordances? This idea would seem to be anticipated in Gibson where he argues that perception, as the pick-up of information, "can sometimes occur without the accompaniment of sense impressions" (cited in Scarantino, 2003, 953; Cowey and Stoerig, 1991). The recent work of Graydon et al. (2012) would suggest exactly this. They show that by inducing anxiety in participants, subjects become more conservative in their judgements about their

capacities for action in near space. These manipulations of the experience of soliciting affordances suggest, contra de Haan, Rietveld, and colleagues, that it may be better to not limit the concept of solicitations to affordances that are phenomenally experienced as demanding but rather use the term to track the demandingness of affordances (whether or not this demandingness is experienced). Under such a reconception then, we can distinguish affordances that are experienced as soliciting from those that are not. Furthermore, we can distinguish experienced affordances that are experienced as soliciting and actually are (i.e., have the actual demand characteristic of embodied affordances) from affordances that are experienced as soliciting but are merely "perceived" (or rather *mis*perceived) as solicitations (i.e., that do not have the actual demand characteristic of embodied affordances but are only experienced as demanding/soliciting).

Changing the body changes affordances

There is converging evidence from neurophysiological, neuropsychological, and behavioural studies that active tool use deeply impacts agents' space representation, extending their own reaching space according to the range of tools being used. In their seminal studies, Iriki and colleagues (Iriki et al., 1996; Ishibashi et al., 2000) showed that the visual receptive fields of monkey's parietal neurons can be modified by actions involving tool use. They trained monkeys to retrieve pieces of food with a small rake and found that, when the instrument was used repeatedly, the visual receptive fields (vRFs) anchored to the hand expanded to encompass the space around both the hand and the rake. If the animal continued to hold the rake but stopped using it, the vRFs shrank back to their normal extension. The dynamic mapping of peripersonal space has also been demonstrated at the behavioural level in both healthy (Maravita et al., 2002; Serino et al., 2007) and brain damaged humans. Patients with hemispatial neglect for near or far space often show displacement errors in bisection tasks of a line located in near and space, respectively (Berti and Frassinetti, 2000; Halligan and Marshall, 1991). In this task patients are required to indicate the centre of a horizontal line. Interestingly, if asked to use a tool the displacement errors are reduced or increased according to the status of the line to be bisected (near or far) in relation to tool use (Ackroyd et al., 2002; Berti and Frassinetti, 2000; Costantini et al., 2014; Neppi-Mòdona et al., 2007; Pegna et al., 2001). Similar results have been found in patients with visuotactile extinction. Extinction is a neurological disorder that impairs the ability to perceive multiple stimuli when they are simultaneously presented in the same portion of space (i.e., both near to the body or both far from the body) (Bueti et al., 2004; Costantini et al., 2007; Farnè et al., 2000; Ladavas et al., 1998; Ladavas and Farne, 2004). Several studies have shown that this spatial boundary can be modified by tool use (Farnè et al., 2005; Farnè and Ladavas, 2000; Maravita et al., 2001). For instance, a patient might fail to detect a tactile stimulus delivered on the left hand when simultaneously presented with a visual stimulus near the right hand. That is, the visual stimulus extinguishes the tactile stimulus. This behaviour

is not observed if the visual stimulus is presented far from the right hand. However, if the patient is asked to use a tool for several minutes both the near and the far visual stimuli are effective in extinguishing the tactile stimulus.

Drawing from this evidence, we investigated how deeply the perceiver's body (and thus her actual action possibilities) impact the perception of objectual affording features (micro-affordances) (Costantini et al., 2011). Using a spatial alignment paradigm that was very similar to those described in the previous sections, participants were instructed to replicate a reach-to-grasp movement as soon as a task-irrelevant go signal was presented (e.g., a mug was presented as located either within or outside the participants' reachable space and with the handle orientation either congruent or incongruent with the grasping hand). The experimental task was performed both before and after a training session in which participants were requested to actively use a grasping tool such as a garbage clamp (Experiment 1, see Figure 10.2). Results showed an interesting deviation from the spatial alignment effect previously observed. After being trained in the use of a garbage clamp, participants became sensitive to the micro-affording feature of an object (the oriented handle of a mug) not only when it was in their actual reaching space but also when it was presented far from them (but still within what would have been the actual reaching space of their arm + the garbage clamp). This sensitivity strongly suggests that training in active tool use deeply impacts an agent's representation of their own reaching space (Cardinali et al., 2009a; Cardinali et al., 2009b; Brozzoli et al., 2012; Maravita and Iriki, 2004) and consequently their sensitivity to affordances, thus making outside-reach objects actually "reachable."

To return to the previous metaphor, what seems to be happening here is that, after being trained to use a tool to expand one's actual reaching space, the field of soliciting affordances remains for some time in this expanded state, even after the tool is relinquished, so that the agent perceives affordances as soliciting an ability

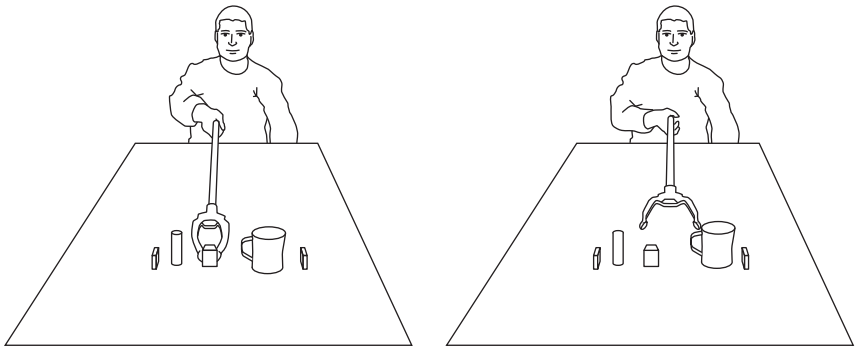

FIGURE 10.2 Schematic representation of the training phase used in testing spatial alignment effect.

Source: Costantini et al. (2011).

which in fact cannot be exercised. Note that this differs in important respects to the way that the field of affordances was described as being expanded earlier. The case just discussed is not a case in which the field of affordances is expanded by including affordances that are experienced as soliciting but are nevertheless only perceived (but not-actual) solicitations. The experiment just discussed shows rather that the subfield of *actually demanding solicitations*, namely, those that are underpinned by a specific motor response, can be expanded (at least temporarily) to include the strongly embodied aspects of affordances (the components of specific motor response that underpin the demand characteristic of solicitations) without standing in a genuine relation to an affording feature of a situation right here, right now.

Looking at action

We have so far been considering how the genuine possibility of acting impacts the instantiation of the affordance relation. However, such possibilities to act also seem to affect the way we perceive others' actions.

Manipulating objects requires specific goal-related saccadic eye movements (Hayhoe and Ballard, 2005; Land, 2006, 2009). These eye movements have been demonstrated to be proactive in nature, seeking out the information needed by the motor system in planning and monitoring the execution of a given action (Johansson et al., 2001). In grasping actions, for instance, the eyes of the actor typically shift towards objects that will be eventually picked up, whereas they rarely saccade towards objects that are irrelevant to action (Rothkopf et al., 2007). In a seminal study, Flanagan and Johansson (2003) showed that when people observe object-related manual actions (e.g., block-stacking actions), the coordination between their gaze and the actor's hand is highly similar to the gaze-hand coordination when they perform those actions themselves. In both cases, people proactively shift their gaze to the target sites, thus anticipating the outcome of the actions without attending to the visual unfolding of the action itself.

In a series of studies, we replicated these important findings and extended the paradigm, showing that one's body state and the possibility of one's own action impact on the way we perceive other's actions (Ambrosini et al., 2011, 2012b, 2013; Costantini et al., 2012a–b). We recorded eye movements while participants observed an actor reaching for and grasping one of two objects requiring two different kinds of grip to be picked up (i.e., precision grip or whole hand prehension). In a control condition, the actor merely reached for and touched one of the two objects without preshaping his hand according to the target. We found that eye-gaze proactively landed on the correct objects more frequently when participants observed an actually grasping hand than when they observed a mere touching hand that was devoid of any target-related preshaping. In a further study (Costantini et al., 2012a), we replicated the previous experiment; however, in this study, participants performed the task with their right hand either freely resting on the table (Free Hand session) or holding a large or small object using a suitable grip (Whole Hand prehension session or Pincer prehension session, respectively).

In the Whole Hand and Pincer sessions, the grasping action that the participants observed was either compatible or incompatible with the grip that the participants had to execute. That is to say, the grip shape (either whole hand or pincer) that the participant made with her hand was either of the same kind as the one made by the hand they were observing as it made a grasping action (compatible condition), or it was not of the same kind (incompatible condition). The results showed that when participants freely rested their right hand on the table, the proactivity of their gaze behaviour was significantly higher while observing a preshaping hand grasping the target than while observing a closed fist merely touching it. However, the proactivity of their gaze behaviour was selectively affected when participants observed a grasping action while their own right hand held an object with a grip incompatible with that shaped by the actor's hand. In other words, participants' gaze behaviour was less proactive both when they observed a grasping action performed with whole hand prehension while holding a small object with a pincer prehension and when they observed a grasping action performed with a pincer prehension while holding a large object with a whole hand prehension. A subsequent study further supported this finding (Ambrosini et al., 2012b). Just as in the experiment described above, we recorded proactive eye movements while participants observed an actor grasping objects. This time, however, participants' hands were either freely resting on the table or tied behind their back. We found that when the participants' hands were tied behind their back the proactivity of their gaze behaviour was dramatically impaired when observing others' actions.

One way of interpreting these findings is in light of the affordance relations discussed earlier. The studies reviewed here indicate that perception of affordances is disrupted both when the participant has an incompatible grip to that which would be needed to interact with the relevant object and when they are unable to make any grip at all. In both of these cases, it seems right to say that they no longer have the possibility to act (i.e., exercise their ability) to grasp the object and therefore do not genuinely have that ability (in the here and now) after all. Recall that the definition of affordance that we have been using (following Chemero) is that an affordance is a relation between a situational feature and an ability. If, as is the case in these experiments, the participants do not have the relevant ability, then the micro-affordance relation is not instantiated in this instance, that is, it is not a genuinely soliciting affordance for the individual. Viewed through this lens, it therefore makes sense that this affordance is not perceived – and thus that the kind of (goal-related) gaze behaviour that is instantiated when affordance relations do obtain does not occur. But why would the perception of someone else's soliciting affordance be disrupted? Why is it the case that participants view actions differently if they are not in a currently instantiated soliciting affordance relation to the object of action themselves? The result that our current action capacities even affects our ability to perceive soliciting affordances for others suggests that our bodies effectively narrow our interactions with the world to such an extent that we even view others through the eyes of our own personal niche of solicitations, despite having knowledge that they have abilities that are not available to us in the moment.

Concluding remarks

In this chapter, we have argued that affordances are strongly embodied. Affordances, (in accordance with Chemero) are of course trivially "embodied" as they relate situational features to *bodily abilities*. Here we have given evidence to support the claim that they are embodied in a much deeper way and that this embodiment constrains the range of our experience of those possibilities for action that are available to us right here, right now. Whether a soliciting affordance relation obtains crucially depends on the bodily capacity for undergoing that action in respect to (1) the components of the specific motor response that realise the micro-affordances, for example, being able to shape one's hand into a pincer grip and (2) how far that body can reach. This seems to hold, not only for the perception of soliciting affordances available to oneself, but also for the perception of those affordances that solicit others. That is to say, the kinds of interaction that our own bodies are capable of having with the environment constrain not only our own perceptions but also what we perceive others as capable of (Twedt et al., 2014).

We have considered what this evidence tells us about the conception of affordances understood as a relation between situational features and abilities (Chemero, 2001, 2003; Chemero, 2009; Costantini and Sinigaglia, 2012) and argued that in the light of these results not only must a distinction be made between affordances and solicitations (Dreyfus, 2002; Dreyfus and Kelly, 2007; Rietveld and Kiverstein, 2014) but that the metaphor of a landscape and a field of affordances (Bruineberg and Rietveld, 2014; de Haan et al., 2013) must be extended. While this metaphor, as it stands, is useful for visualising phenomenological differences in affordance relations, the research that we have surveyed suggests that for a deeper understanding of affordance relations we should rather think in terms of a *variety of affordance fields* within the landscape: The field of perceived solicitations is not isomorphic to the field of solicitations that actually obtain. Moreover, the field of actually demanding solicitations must be further divided into the field of actual ability-related possibilities for action and the field of represented, but not-actual possibilities for action (i.e., those which the body responds to but which do not actually stand in relation to a situational feature).

In closing, we would like to draw the reader's attention to what is for us a particular area of interest: the role that the internal body plays in perception and cognition. The evidence that we have related in this paper has, for the most part, focussed on the effect of bodily morphology on the instantiation of the affordance relation. Yet it is clear that internal changes have a significant effect on our affordances. The phenomenological analysis that de Haan and colleagues (2013) have produced in relation to their work with individuals undergoing deep brain stimulation for psychopathologies such as obsessive compulsive disorder indicates**,** for example, that our perception of affordances (at least in so far as the solicitations are experienced) does not solely depend upon morphological bodily differences. And, the research by Graydon et al. (2012), which shows an underestimation bias in affordance perception in individuals induced with anxiety, gives us good reason to think that

internal bodily differences may play a significant role in our perception of the world around us and thus what possibilities for action are available to be perceived by us. Work on internal (rather than morphological) bodily differences has, to date, been significantly neglected in the embodied cognition paradigm. To our knowledge, work that has been done in this regard (like that cited above) has predominantly focussed on gross emotional or mood differences but has failed to address the particular bodily mechanisms, such as changes in the endocrine and immune systems, that may partially constitute these phenomenological and behavioural differences. We propose that a full investigation into how the body both enables and constrains our interaction with the environment must incorporate these affective and internal bodily constraints. This is the goal of our future research.

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