Chapter 10

Beautiful embodiment: The shaping of aesthetic preference by personal experience

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Dance is the only art of which we ourselves are the stuff of which it is made.
—*Ted Shawn, American Modern Dance Pioneer*

10.1 Introduction

Imagine the following situation: you arrive at the train station bright and early on a Friday morning to start your usual commute into the office. As you cross the main concourse, the train platform departure announcements fade out and are suddenly replaced by the opening lyrics to the Isley Brothers 1959 classic song "Shout." At the same time, a lone figure square in the middle of the concourse bursts into energetic dance. A moment later, a woman behind him casts aside her shopping bags and joins in, just as two middle-aged men in dark suits with briefcases kick up their heels and join as well. Within seconds, it appears the entire concourse has come alive with normal, everyday commuters dancing with incredible energy, precision, and joy as they spin, kick, twist, and jazz-hand their way through a mash-up of decades' worth of popular songs. You and the seemingly dwindling crowd of those whose bodies are unfamiliar with this captivating choreography watch in amazement, as the faces of all the "ordinary" commuters light up with delight to be surrounded by this spontaneous injection of song and dance into a public place.

For those of us who were not present at London's Liverpool Street Station on 15 January 2009, this flashmob, filmed as an advertisement for T-Mobile, can be witnessed on YouTube (see <https://www.youtube.com/watch?v=VQ3d3KigPQM>). For those who were there, as well as the rest of us who watch online, witnessing a dancing flashmob is something that most people find thrilling. A flashmob is defined as "a spontaneous public performance, usually a dance, that appears seemingly out of nowhere with just one person, grows to hundreds of people, then quickly disappears" (<http://www.flashmobamerica.com>). The Liverpool Street Station example is one of many; from dance performances of "Do Re Mi" in the Antwerp train station to "Gangnam Style" in a Jakarta fountain to

"Loveshack" on Bondi Beach, the flashmob is gaining momentum as a much-loved, often-reproduced way to bring excitement, levity, and even a little bit of art into people's lives where they might least expect it. As I explore in this chapter, one possible explanation for the flashmob's success and appeal is that it transforms seemingly normal pedestrians to extraordinary performers through dance.

Throughout history, dance has maintained a critical presence across human cultures, defying barriers of class, race, and status (Dils and Albright 2001). The co-evolution of dance with the human race has fuelled a rich debate on the function of art and aesthetic experience, engaging numerous artists, philosophers, and scientists. While dance shares features with other art forms, one unique attribute is that it is expressed (only) with the human body. Because of this, social scientists and neuroscientists are turning to dance to help answer questions of how the brain coordinates the body to perform complex, precise, and beautiful movements. For example, when we watch a ballet dancer leap into the air in a perfect split or a breakdancer perform five consecutive head spins, how might our own dance abilities (or lack thereof) influence how we perceive performers who excite and impress us? In this chapter, I explore how research with dancers and dance-learning paradigms can help illuminate issues related to artistic creation and aesthetic preferences, and also consider more fundamental questions concerning the relationship between action and perception. I begin with a section that briefly summarizes the development of a multidisciplinary field whose aim is to explore how action production informs action perception, with a special emphasis on how studies with dancers have informed this line of inquiry. Next, I focus on a specific conceptualization of the inverse of this relationship; namely, how simple observation of actions can profoundly influence an observers' motor repertoire. Here again, pioneering work using dance underscores how powerful visual experience can be in shaping our motor abilities. While the first two sections mainly use dance as a means for exploring fundamental links between action and perception, the final two sections explore the utility of dance as an art form to inform our understanding of an observer's aesthetic experience of watching another body in motion. After a cursory introduction of issues of concern when studying the aesthetics of action in the penultimate section, I finally turn my attention to the relationship between observers' experience and the dancers they behold, in an attempt to establish connections between the two (and in so doing, perhaps help us to understand why we might derive so much pleasure from being caught up in a flashmob in person or watching one on the Internet).

10.2 The shaping of perception by action

While we are inclined to take it for granted, our ability to use perceptual information about other people's movements to inform our subsequent actions is essential for successful interactions with the environment, and thus, for survival. Consequently, it is no surprise that inquiry into how the human brain negotiates the path between action execution and perception has intrigued venerable thinkers throughout the millennia, including

Aristotle, Descartes, and William James. Until the mid-nineteenth century, thinking about this relationship was dominated by the Cartesian sensorimotor view, which advanced the idea of independence between action perception and action production (Descartes writing in 1664, as discussed by Prinz 1997). As knowledge about the capabilities of the human brain continued to accrue, pioneering scholars began to explore the idea that perceptual processes might indeed converge or overlap to some extent with motor performance (James 1890). Empirical investigation into the brain's ability to use perceptual information to shape movement began in the mid-twentieth century, when information processing explanations proposing complex transformations from perception to the organization and execution of action gathered momentum (Massaro and Friedman 1990; Mountcastle et al. 1975; Mountcastle 1975; Sanders 1967, 1983; Welford 1968).

In the mid-1970s, Mountcastle and colleagues began the first investigations into putative neurophysiological mechanisms linking action and perception (Mountcastle et al. 1975; Mountcastle 1975; Yin and Mountcastle 1977). In these seminal studies, Mountcastle and colleagues used single-unit recording techniques to track the activity of neurons within the superior parietal lobule and posterior parietal areas of the macaque cerebral cortex while the animals performed simple behavioral acts in response to sensory stimuli. In one such study, Mountcastle and colleagues investigated the specific properties of neurons in the posterior parietal association cortex, and determined that these neurons respond to visual stimulation to encode the meaning of an action, such as the goal of the perceived movement (Mountcastle et al. 1975). These researchers concluded that this region of the parietal cortex is a likely candidate for cross-modal convergence of perception and action, and established the foundation for the next several decades of further inquiry into how these modalities interact (Andersen et al. 2004).

In the 1990s, research into the intersection of action perception and production experienced an extraordinary surge in interest that was due in large part to the discovery of so-called mirror neurons in the ventral premotor cortex of the monkey. These neurons were found to discharge in a similar manner both when a monkey performed an action as well as when it observed another monkey or human perform the same action (di Pellegrino et al. 1992; Gallese et al. 1996; Rizzolatti et al. 1996). As such, these specialized neurons have prompted these researchers and others to propose that action perception and production processes form a bi-directional, interactive loop within the primate brain, and that action understanding might be explained by the observer's brain simulating the observed movements of another individual (Fadiga et al. 1995; Fadiga et al. 1999; Grafton et al. 1996; Rizzolatti et al. 2001).

This hypothesis has sparked hundreds of studies and an ongoing lively debate among researchers regarding the specific parameters, scope, and limitations of such an action simulation system within the human brain (Gallese et al. 2011; Gallese and Sinigaglia 2011). While an exhaustive review of the past decade and a half of research undertaken in this domain is beyond the scope of this chapter (the interested reader is directed to several outstanding overviews of this work, such as those by Grosbras et al. 2012; Molenberghs et al. 2012; Rizzolatti and Sinigaglia 2010), what a burgeoning corpus of research demonstrates

is that neural tissue found within parietal and premotor cortices of the human brain is engaged when actions are performed or when they are observed. This work has given rise to the notion of a human mirror system, which comprises multiple cortical regions and shows evidence for behaving in a similar manner to individual mirror neurons found within non-human primate brains (Molenberghs et al. 2012). In our laboratory, however, our research focus is on what we term the "action observation network" (AON; Cross et al. 2009; Grafton 2009). The AON comprises those brain regions implicated in the human mirror system (and shown to contain mirror neurons in monkeys), as well as broader swathes of premotor and occipitotemporal cortices (Figure 10.1). The interest I have in this network and its role in motor learning and performance is perhaps best summed up by Scott T. Grafton, who said "[w]hat is striking about this network is that a perceptual stimulus can lead to such a large-scale recruitment of the brain with a complete disregard of textbook divisions between sensory and motor portions of the cortex" (Grafton 2009, p. 100).

The bulk of research conducted on the neural correspondence between action and perception, across human and non-human primates, has focused on small, constrained movements of the hands and fingers (cf. Grosbras et al. 2012; Rizzolatti and Sinigaglia 2010). However, my colleagues and I have devoted a considerable amount of attention to investigating the neural underpinnings of dance performance and perception which at first might appear to be rather far removed from simple hand and finger actions. However, we use dance to study the AON for three main reasons. First, for most of us, daily life requires the efficient coordination of the entire body, not just the fingers and hands. Thus, dance provides a variety of ideal paradigms for studying whole-body coordination. Secondly, dance is generally not object-directed, and thus enables the study of "movement for movement's sake," where the goal of an action is the action itself (rather than opening a bottle, tying a shoelace, etc.). Finally, by studying a motor behavior that is much more complex and requires the coordination of multiple effectors, we are better placed for understanding a broader range of motor behaviors, from the simple to complex. Such an understanding should, in turn, engender greater understanding of failures of the sensory and motor systems, such as those caused by neurological injury.

Thus, we turn to dance as a useful means of exploring the impact of action experience on perception. The first paper to report this was a seminal study by Beatriz Calvo-Merino and colleagues, which investigated how highly specialized physical training in one dance style (classical ballet or capoeira) influenced perception of the familiar dance style compared to the unfamiliar dance style (Calvo-Merino et al. 2005; see also Chapter 11, this volume). The authors reported that when trained ballet dancers watched ballet, or when trained capoeira dancers watched capoeira, greater activity was seen throughout the AON, compared to when ballet dancers watched capoeira or capoeira dancers watched ballet. The authors took this finding as evidence that years of physical practice shape the action resonance processes that occur within sensorimotor cortices active during action perception and action production, such that they are finer-tuned to respond to movement that is familiar due to extensive physical practice.

As this study by Calvo-Merino and colleagues (2005) was underway, my colleagues and I were addressing a similar question, with additional interest in whether it is possible to track the emergence of motor expertise in something closer to real time with expert dancers (Cross et al. 2006). In our study, we followed an ensemble of expert contemporary dancers as they learned Laura Dean's 25-minute piece entitled *Skylight* (Dean 1982) across an eight-week rehearsal period. We invited the dancers into the laboratory for six consecutive weeks to scan their brains with functional magnetic resonance imaging (fMRI) as they watched and imagined themselves performing short segments of choreography from *Skylight*, as well as kinematically similar dance movements that were never seen or rehearsed in the studio. Across the rehearsal period, dancers unsurprisingly became more adept at physically performing the choreography they rehearsed in the studio each day. However, the most interesting finding to emerge from this longitudinal study is that as dancers became more adept performers, activity within two core regions of the AON, left inferior parietal lobule and left ventral premotor cortex, showed increased activity the better a dancer was at performing a particular sequence. We took this evidence to suggest that the better one is at performing an action, the more one embodies it, as evidenced by increased parietal/premotor activity tracking with increased performance ability (Cross et al. 2006; although see also Cross et al. (2012) for an updated account of the relationship between the magnitude of AON response and motor familiarity).

Since these two early studies investigating the brains of expert dancers, a number of research teams have combined dancers with brain imaging techniques (Brown et al. 2006; Orgs et al. 2008) and behavioral paradigms (Calvo-Merino et al. 2009; Jola et al. 2011; Stevens et al. 2010) in innovative ways to illuminate further how highly skilled movement repertoires influence perception of others (for a comprehensive overview, the interested reader is referred to Bläsing et al. 2012). However, from the earliest conceptualizations of action–perception coupling, it has been asserted that not only does action influence perception (as we have seen with the expert dance studies in this section), but perception also influences action (Prinz 1990). The following section thus examines how dance paradigms help illustrate the impact of perception on action.

10.3 The shaping of action by perception

While it is an indisputable fact that one's prior motor experience influences how one sees the world (Prinz 2006), how we see others moving around us also shapes our own interactions with the environment. In particular, we rely heavily upon our visual system to help us learn new actions. One of the hallmark ways in which we learn new skills in life, from baking a cake to dancing the tango, is by watching others (Flynn and Whiten 2010). Behavioral research on action learning suggests that simultaneously observing and reproducing the correct pattern of movements results in the quickest and most accurate learning (e.g. Badets et al. 2006; Bandura 1977, 1986; Blandin et al. 1999; Blandin and Proteau 2000; Schmidt 1975; Sheffield 1961). Nevertheless, the ability to learn a new skill or improve an existing one by observation alone, without concurrent practice, is also a powerful capacity in humans (Mattar and Gribble 2005; Torriero et al. 2007).

Early behavioral investigations of observational learning by Sheffield (1961) led to the proposal that observation of a motor sequence improved learning by providing a "perceptual blueprint," or standard of reference for how the task should be performed. Behavioral studies comparing observational and physical learning support the value of a perceptual blueprint (Blandin and Proteau 2000; Carroll and Bandura 1990; Doody et al. 1985; Lee et al. 1990; Zelaznik and Spring 1976). While the bulk of observational learning research has focused on learning from an expert human model (see Hodges et al. 2007 for a review), the use of a human actor performing the target behavior is not a requirement for forming a perceptual blueprint. A more inclusive conceptualization of observational learning encompasses encoding any instruction, whether physical or symbolic, that can provide a sufficient model of the actions to be performed (e.g. Cisek and Kalaska 2004). The key distinction of what defines observational learning is the subject not performing concurrent physical practice at the time instructions are provided.

In a study using psychophysical and electromyographic (EMG) measures with human participants, Mattar and Gribble (2005) demonstrated that participants' learning of a novel, complex motor task was facilitated if they previously observed another individual learning to perform that same task, compared to watching another individual perform the task without learning or learning to perform a different task. This established the specificity of a perceptual blueprint formed during the observational period on subsequent physical practice. What emerges from these studies and others (Barzouka et al. 2007; Bouquet et al. 2007; Ferrari 1996; McCullagh et al. 1989; Schmidt and Lee 2005) is the hypothesis that observation of movement sequences and physical rehearsal share common cognitive mechanisms, and training of this circuit by either means improves novel motor-skill learning.

Evidence from non-human primate neurophysiology as well as psychophysical and EMG work with humans suggest that physical and observational learning might share common neural substrates, at least in terms of mental rehearsal (Cisek and Kalaska 2004; Frey and Gerry 2006; Mattar and Gribble 2005; Wiggett et al. 2012). In one such study, Cisek and Kalaska (2004) recorded extracellular spike activity from single neurons within the dorsal premotor cortex (PMd) of monkeys while they observed the sensory events associated with accurate performance of a saccadic motor task. They reported that when the monkeys passively observed a symbolic representation of accurate task performance, PMd neurons responded in a similar manner as when the monkeys physically performed the task. These authors were thus the first to measure mental rehearsal of a to-be-learned task occurring at the single-neuron level.

The studies discussed previously provide a foundation for exploring areas of overlap and divergence between observational and physical learning in the human brain. However, important questions remain concerning how physical practice compared to observational practice affect brain and behavior. To begin addressing such questions, my colleagues and I again turned to dance to determine how brain and behavior are influenced by only watching a new dance sequence, compared to physically practising it (Cross et al. 2009). In this study, we incorporated the dance video-game "StepMania" (<http://www.stepmania.com>;

a freeware programme similar to the popular video game "Dance Dance Revolution™" (Konami Digital Entertainment, Redwood City, CA)) into our paradigm. To play this game, participants must attend to scrolling arrow cues on a computer screen that correspond to particular foot positions on a dance mat attached to the computer. When the steps are performed in quick succession with music, this approximates dancing (to some). Importantly, however, the video-game context is fun, engaging, and ideal for studying motor learning, as participants receive real-time feedback about the accuracy of each movement via points scored. In this study, we recruited 17 young adults with no formal dance training and asked them to practise six different dance sequences for one week, to observe only six different dance sequences, and a further six sequences were untrained in any way. We collected scans of participants' brains with fMRI as they watched and listened to all 18 sequences before and after a one-week training period. Following all training and scanning procedures, participants returned to the laboratory to attempt to perform all 18 dance sequences.

Based on the wealth of behavioral data showing evidence for learning by observation, we hypothesized that participants' ability to perform the sequences from the observation condition would be better than their performance for the untrained sequences. This is indeed what our post-training follow-up dance test revealed (Cross et al. 2009). Of greater interest was how the brain was affected by physical compared to observational experience with the previously novel dance sequences. Importantly, in this study, participants were not instructed to try and learn during the observation blocks of the training period: instead, they were told to just rest and watch several music videos of dance sequences they had not trained on while their heart rates recovered. Thus, they were surprised when they were asked to perform the sequences they had observed throughout the training week (as well as the untrained sequences, which were experienced only during scanning). The fMRI data revealed that physical and observational learning appeared to affect brain regions in a similar manner. Put another way, responses within the left inferior parietal lobule and right premotor cortex were quantifiably more similar when observing danced and watched sequences compared to untrained sequences. Thus, observational training, even when one might not explicitly be trying to learn, shapes responses within the AON in a similar manner to physical practice. This was among the first brain-based evidence to suggest that mere observation of an action has the potential to build a similar neural representation of that action as physical practice (Cross et al. 2009), which added to prior behavioral support (e.g. Badets et al. 2006; Bandura 1986; Hodges et al. 2007) for a common neurocognitive representation of performed and perceived actions.

Of course, this is not to say that observational learning is so powerful that physical practice is unnecessary for learning new motor skills. However, it does suggest that the parts of our brains that are active during physical training might be active in a similar manner when we observe, and this activity appears to be related to the efficacy of learning by observation. As with the studies discussed in the first section, when examining how observation shapes action, studies using dance (as well as other highly skilled full-body actions, such as

gymnastics and contortion) have advanced our understanding of how observation affects motor regions of the brain (e.g. Calvo-Merino et al. 2006; Cross et al. 2010; Cross et al. 2013; Jola et al. 2012). While some evidence suggests that visual experience alone is not enough to affect motor regions within the brain (Calvo-Merino et al. 2006), other research suggests that even when an individual observes movements that he or she could not possibly physically perform, extensive visual experience with these actions is associated with the emergence of neural representations within sensorimotor regions (Cross et al. 2013; Jola et al. 2012). Thus, while the influence of perception on action might not be as strong as the inverse, evidence continues to accumulate to support the notion that how we see others move influences how we ourselves act. In the next section, the focus on action perception is broadened to include how we *feel* when we watch an action; a natural segue way into the aesthetics of action.

10.4 Aesthetics of action

When watching an attractive stranger dancing in a club, a solo ballerina pirouetting with ease on stage, or a street performer's breathtaking breakdancing moves, motor resonance processes are engaged. Another major factor that guides and holds our attention on the mover is how much we *enjoy* watching them move. When considering the aesthetics of action at either the brain or behavioral level, two key issues warrant discussion. The first is what, precisely, is meant by aesthetics, and the second is what kinds of entities or experiences should be "eligible" for aesthetic evaluation. In a forward-thinking piece on the future and utility of neuroaesthetics as a field, Brown and Dissanayake (2009) present a strong case for broadening the focus of aesthetics to include any perceptual phenomenon that "promotes selective attention and positive emotional responses" (p. 44; see also Orians 2001). Consequently, they challenge the nascent field of neuroaesthetics to develop and evaluate a broader, more general conception of aesthetic responses in the brain, rather than focusing exclusively (and narrowly) on Eurocentric conceptions of "art," which has typically comprised works created for a wealthy elite in the classical/fine art traditions (Brown and Dissanayake 2009; see also Brown et al. 2011; Ramachandran and Hirstein 1999).

One of the most prominent theoretical conceptualizations of neuroaesthetics was put forth by Freedberg and Gallese (2007). These authors argue that an important factor in shaping an observer's affective (or aesthetic) experience is the simulation of actions, emotions, and bodily sensations visible or implied in a work of art. In this theory, Freedberg and Gallese (2007) focus almost exclusively on static works of visual art in the form of paintings and sculpture, and suggest that an observer can experience "embodied resonance" when viewing a piece of art based on the content of the work itself or via the visible traces of the artistic medium. While a compelling case can be built to support these ideas when beholding paintings or sculpture, in many ways it seems just as intuitive and valuable to extend this concept beyond classical conceptions of visual art. Without a broader evidence base for considering aesthetic experiences, we risk under-appreciating

the breadth and depth of aesthetic appreciation of all manner of experiences in the real world. Thus, by accepting Brown and Dissanayake's challenge that the study of (neuro) aesthetics should include a wide range of phenomena and experiences beyond classical paintings and sculpture, we are free to explore affective responses to all manner of objects and experiences around us, from street dance and folk music to product design and culinary creations.

Along these lines, it is instructive to consider an elegant study by Hayes and colleagues that looked at aesthetic appraisals of performing or observing simple actions directed toward common, everyday objects (Hayes et al. 2008). The study of such simple actions can provide a useful template to build toward understanding affective appraisals of more complex behavior, such as dance. In a set of three experiments, Hayes and colleagues examined how perceptual or motor fluency in terms of how an object is grasped influences participants' liking of that object. In one experiment, participants were asked to perform a fluid reaching action to grasp an object (such as a salt-shaker), or they were asked to grab the same salt-shaker, but the only possible way to grab it was by performing a more awkward grasp so as to avoid an obstacle. Hayes and colleagues report that participants rated the objects with which they interacted fluidly as more likeable. In a follow-up experiment, Hayes and colleagues showed participants video clips of an actor interacting fluently or awkwardly with a number of different everyday objects. They asked participants to rate how likeable they found the objects based on viewing these interactions. Here again, simply the perception of a fluent grasp toward an object significantly increased participants' liking ratings.

The authors conclude that fluent interactions with objects, defined in this situation by smooth, efficient movement, engender positive affect toward those objects (Hayes et al. 2008). Moreover, it does not matter whether fluent movements are performed or simply observed for the effect to be present. Hayes and colleagues suggest that these findings are consistent with models of hedonic fluency, which posit that when a stimulus is easily processed, it is liked more (Winkielman and Cacioppo 2001; see also Berlyne's (1974) account of perceptual fluency). What Hayes and colleagues (2008) added to earlier models was evidence that movement itself adheres to these same principals. In other words, objects participants attempted to grasp or watched an actor grasp with an awkward or fluid movement are susceptible to being liked more or less depending on the movement directed toward them.

This evidence reported by Hayes and colleagues (2008) fits well with Freedberg and Gallese's (2007) embodied simulation notion of aesthetic processing. Perhaps unsurprisingly, since Freedberg and Gallese's (2007) theoretical proposal and the behavioral work performed with simple grasping actions, a small number of research labs have begun the empirical evaluation of aesthetic responses in the human brain when watching dance (Calvo-Merino et al. 2008; Cross et al. 2011; Cross and Ticini 2012; Kirsch et al. in press). In particular, my colleagues and I have been interested in exploring the relationship between the observer's own experience and how much they enjoy watching a dancer perform.

10.5 How action experience shapes preferences in dance spectators

The motivation for the first empirical study my colleagues and I performed that investigated neuroaesthetic responses to watching dance came from a number of sources. The first was the "Skylight" study that showed greater activity within the AON when (dance-experienced) participants watched movements they were highly skilled at performing (Cross et al. 2006). The second was Friedberg and Gallese's (2007) embodied simulation account of neuroaesthetics, suggesting that we use our sensorimotor cortices when making aesthetic evaluations of artworks. The third and most significant motivation behind our investigation was the first study that investigated aesthetic responses of spectators when watching dance (Calvo-Merino et al. 2008). In this study, six dance-naïve spectators watched 24 movements performed by an expert ballet dancer or an expert capoeira dancer whilst undergoing fMRI. Approximately one year later, the investigators invited these six participants back to the laboratory to watch the same 24 movements. For this testing session, participants simply watched the videos on a computer screen and responded to simple questions designed to query their aesthetic experience (after Berlyne 1974). The authors then used participants' group averaged ratings to interrogate brain regions that showed neural responses of higher magnitude when watching movements that were generally liked. They reported two important findings that were relevant for the follow-up study performed by my colleagues and I: first, that bilateral medial visual cortices as well as right premotor cortex showed greater responses when viewing liked movements; and second, that participants as a group tended to like watching whole-body movements and those that involved significant displacement of the whole body across space (such as a large horizontal jump) compared to smaller or less explosive movements (Calvo-Merino et al. 2008).

The study by Calvo-Merino and colleagues (2008) offered an intriguing first glimpse into the neural underpinnings of an aesthetic response when watching dance. It also sparked many new questions concerning the relationship between sensorimotor brain regions and the pleasure derived from watching dance that were ripe for exploration. One main question concerned how individuals' online ratings of aesthetic value relate to brain function. In Calvo-Merino and colleagues' (2008) paradigm, all six participants' aesthetic ratings were averaged into one value for each dance movement, and aesthetic ratings were collated in a later testing session outside the fMRI scanner. Thus, this paradigm did not allow the authors to address individual differences in aesthetic preferences the first time the movements were watched. In our study, we wished to address these specific issues of individual differences in aesthetic preferences, as well as how an observer's physical ability to perform a movement interacts with their enjoyment of watching a movement (Cross et al. 2011).

In our experiment, participants' main task was to rate 64 3-second video clips of dance movements performed by either a male or female professional ballet dancer. When we were filming the two dancers to construct the stimuli, we asked them to perform a range of

movements from both classical ballet and contemporary dance vocabularies, and to vary the size, intensity, and complexity of the movements, so that we ended up with the widest possible range of different movements. We then piloted nearly 100 possible video clips on several dozen participants (who did not take part in the main experiment), whom we asked to rate each movement on how difficult they thought it would be to reproduce each movement, as well as how much they liked watching each movement. From these pilot ratings, we selected the 64 dance clips that elicited the broadest range of ratings in terms of both liking and reproducibility.

For the main experiment, we recruited a study sample of 22 dance-naïve participants who underwent fMRI scanning while watching the dance video stimuli and answering one question after each video clip. The question was either "how much did you enjoying watching the previous video?" or "how well do you think you could reproduce the previous movement?". Participants responded to each question according to a 1 to 4 response scale, with 1 corresponding to "liked it a lot" or "could perfectly reproduce the movement" and 4 corresponding to "did not like it at all" or "could not reproduce the movement at all." To understand the relationship between embodiment and aesthetics within our study design, we assessed what the behavioral data revealed in terms of the relationship between liking and reproducibility ratings, as well as what the brain imaging data revealed about how the action observation network responded to movements that could be physically reproduced compared to those that were pleasing to watch. If our data support dominant theories of the AON, which state these brain regions respond most to movements that a participant can perform or are present in their action repertoire (e.g. Calvo-Merino et al. 2005; Cross et al. 2006), then we would predict most AON activation when watching the movements that participants rated as easily reproducible, independent of aesthetic value. However, if the embodied simulation theory of aesthetics more accurately explains how our brains respond to aesthetically pleasing stimuli (Freedberg and Gallese 2007), then we would predict strongest AON activity when watching movements that participants ranked as most pleasing, independent of how possible it is to reproduce them.

The results yielded several interesting and surprising findings. First, we found a strong negative relationship between enjoyment and perceived ability to physically reproduce a movement (Figure 10.2a). This analysis demonstrates that in our study, liking and physical ability ratings were not independent, as participants showed a tendency to prefer those movements that they rated as extremely difficult to reproduce. As far as the fMRI data were concerned, we chose to apply a series of parametric analyses to our data, which enabled us to look at participants' individual liking and reproducibility ratings for each stimulus, and query how brain responses change as movements are rated as increasingly (or decreasingly) likeable or increasingly (or decreasingly) easy to reproduce. We found that several regions within the AON, specifically occipitotemporal cortex and the inferior parietal lobule, show increasingly strong activation the more a movement is liked. Curiously, when we asked which brain regions show greater activity the more easily a movement is reproduced, we failed to replicate the findings from our previous study with

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expert dancers (Cross et al. 2006), which demonstrated greater parietal and premotor engagement the better observers could reproduce the observed action. In our 2011 study with non-dancers, no brain regions emerged from a contrast evaluating which brain areas become more active the better an observer is at performing an observed action. When we looked at the inverse analysis, which revealed brain regions showing stronger activity the more difficult a movement appears, some activity emerged within bilateral visual cortices. Figure 10.2b illustrates the overlap between these two analyses within the occipital cortices of the brain.

The most interesting analysis in our view, however, was the one that directly compared the interaction between liking and perceived physical ability. Put another way, this analysis asked what brain regions are responding more strongly when participants watch a movement they really like, but which they also judge to be extremely difficult to reproduce. As with the simple parametric analysis of liking only, here we saw robust activation of bilateral occipitotemporal cortices, as well as the right inferior parietal lobule. Thus, it appears that the movements that leave the spectator impressed but that the spectator could not do him or herself, result in activation of some parts of the AON that are also implicated in embodiment processes (cf. Calvo-Merino et al. 2005; Cross et al. 2006).

When the behavioral and imaging findings are considered together, they appear somewhat contradictory to the findings reported by Hayes and colleagues (2008) and what might be predicted by the perceptual or hedonic fluency accounts of stimulus processing (Berlyne 1974; Winkielman and Cacioppo 2001). One reading of what these accounts would predict is that participants should find less pleasing those movements that would be extremely difficult for them to perform. However, it seems that the perception trumps action ability when dance-naïve participants watch dance movements for the first time, and seeing a dancer perform a highly complex movement with apparent ease and grace is extremely enjoyable, even if (or even especially because?) participants could not come close to achieving the same thing with their own bodies. This explanation finds much anecdotal support, of course, when considering that people pay large sums to money to see physical feats that most of us could never perform ourselves, such as the incredible precision of dancers in the Forsythe Company, the acrobats in Cirque du Soleil, the slam-dunking professional basketball players in the NBA, or the action hero who narrowly escapes death by leaping across rooftops of burning buildings and jumping to safety on a passing helicopter.

What we discuss in our paper is that watching an aesthetically pleasing movement might drive activity within certain parts of the AON because interest in the movement drives sensorimotor regions to "work harder" to try and embody the movement (Cross et al. 2011). As such, the findings we report in this study lend tentative support to Freedberg and Gallese's (2007) proposal that a perceiver's use of his or her own body to simulate what is seen in an artwork (or any stimulus) is related to his or her aesthetic experience of that work. Of course, this relationship between lack of physical ability, high aesthetic evaluation, and AON activity reflecting an increased drive to embody a movement remains

speculative at this stage, and it will require careful empirical evaluation. Moreover, this study is not without shortcomings. One major limitation to the study by Cross and co-workers (2011) is that we relied on participants' self report of physical ability to reproduce movements, instead of actually asking them to attempt to perform each movement they watched.[1]

As a next step toward understanding how physical experience is related to aesthetic evaluation, work in my laboratory is underway to test how learning to perform a dance sequence affects participants' aesthetic appraisal of it. In this experiment, we implemented a between-subjects training design with 60 dance-naïve participants. Our question is whether aesthetic ratings of a dance sequence increase or decrease as a participant learns to perform that sequence. Because actual physical ability is being assessed here, we again chose to use a video-game paradigm that evaluates dance performance in an unbiased manner. However, we have taken a step forward in the complexity of movement scoring by using the Xbox Kinect™ system in conjunction with the "Dance Central 2" video game. This system uses sophisticated whole-body motion tracking and relays real-time feedback to participants as they dance along with an avatar on the monitor. In this behavioral study, participants were split into three groups of 20. They came into the laboratory across five consecutive days for training, and took part in a pre-training rating assessment before the first training session and a post-training rating assessment after the last training session. Among the three training groups, one group physically practised several routines of hip-hop/dance-club movements choreographed to a popular song, a second group just watched the avatar dance to same sequences while also listening to the music, and a third group only listened to the music from the dance sequences in each training session.

Contrary to what we found when dance naïve participants watched professional ballet dancers perform short dance sequences, the data from a recent training study suggest that participants who physically practise a dance sequence across a week of training show significant increases in their aesthetic ratings of the dance movements on several dimensions (Kirsch et al. 2013). Notably, just watching the sequences and listening to the corresponding music, or just listening to the music alone did not correspond with an increase in enjoyment of any dimensions of the dance sequences, so we can be fairly confident that it is not a mere exposure or familiarity effect in the audio or visual domains. Rather, it appears that there is something additional that performance of these particular dance sequences contributes to aesthetic appraisals. Data from our most recent training study, which implemented the dance training procedures described for Kirsch and colleagues (2013) and added pre- and post-training fMRI measures, replicate the behavioral effects described by Kirsch and colleagues (2013). Moreover, the neuroimaging data provide evidence for a shift in neural processing from subcortical regions associated with dopaminergic reward processing when an observed movements are novel to cortical regions associated with multisensory integration and higher-level emotional processing once dance movements have been rehearsed.

In terms of what might explain the contradictory findings between our fMRI investigation with novice dancers watching professional ballet dancers (Cross et al. 2011) and our latest training studies with novice dancers learning to perform hip-hop/street dance moves in a video game context (Kirsch et al. 2013; in press), we suggest that there are likely to be multiple ways in which embodiment and aesthetic preferences interact. One possibility is that a U-shaped function, similar to the one we proposed in a related study on action familiarity (Cross et al. 2012), might partially explain why we derive intense pleasure from watching movement that is familiar, practised, and well within our physical capabilities, as well as movements that are so spectacular and novel and far beyond our ability to reproduce them. Returning to the flashmob example discussed at the start of the chapter, I propose that the reason these are so effective in engaging and delighting onlookers is because they satisfy both possibilities, thus resulting in maximum enjoyment. First, flashmobs feature dancers that look like all other pedestrians in the crowded public space in which they materialize, and onlookers can easily imagine dropping their own shopping bags and joining in (if only they knew the choreography). Second, dancing flash mobs elevate the common pedestrian to the exalted status of a dancer who is extremely adept at performing a sequence of movements that are often highly complex and have required hours of practice.[2] Thus, the appeal of flashmobs might lie in the fact that they are made up of individuals who look much like the onlookers, and yet move in a complex, coordinated way that invites others to dance along, even if they do not know the moves.

10.6 Next steps in using dance to explore embodiment and aesthetics

The overarching aim of this chapter has been to highlight two areas where the convergence of dance and neuroscience has the potential to further our understanding of the human brain. The first is that action perception and production share common neural substrates, and dance provides a useful means for exploring this relationship. The second is that notions of embodiment and an observer's prior sensorimotor experience might help to illuminate why certain individuals enjoy watching particular dance performances. As has now been suggested by a number of researchers with expertise that spans the dance and neuroscience domains, ongoing collaboration between the dance and scientific communities stands to benefit both disciplines (Bläsing et al. 2010, 2012; Cross 2010; Cross and Ticini 2012; Hagendoorn 2004, 2010; Jola 2010; Orgs et al. in press). While most of the work described in this chapter has used dancers as participants or dance learning/perception as a paradigm for studying full-body movement without much concern for the artistic properties of dance per se, the field of neuroaesthetics is one where science has the potential to benefit the dance world (depending, of course, on the right questions being asked). Along these lines, one platform that is encouraging collaborations between scientists and dancers from the Forsythe Company is the Dance
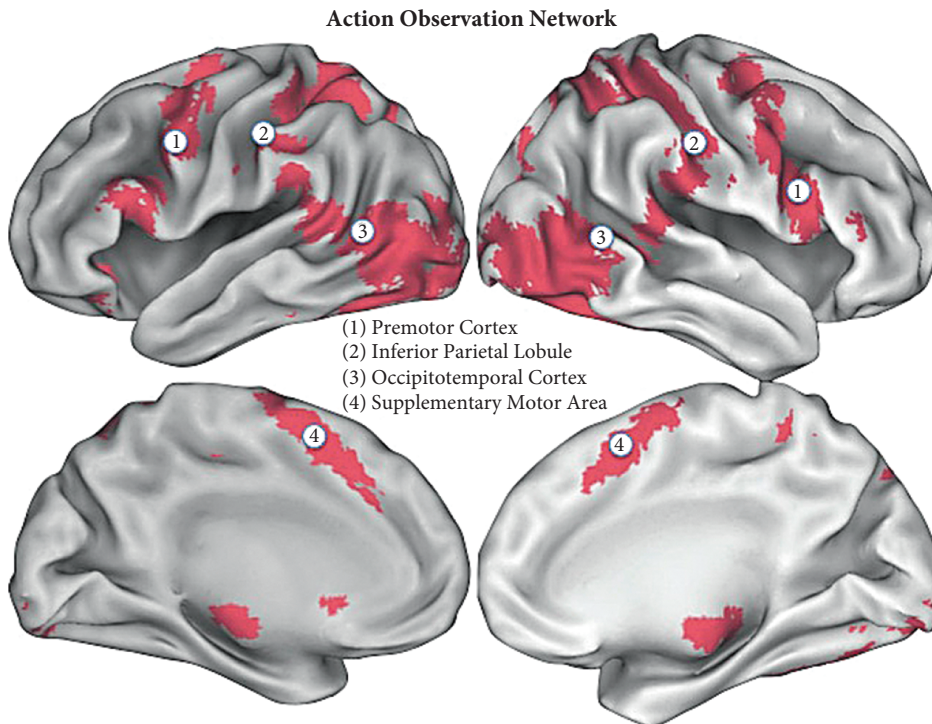
Action Observation Network

(1) Premotor Cortex
(2) Inferior Parietal Lobule
(3) Occipitotemporal Cortex
(4) Supplementary Motor Area

Figure 10.1 Schematic of the Action Observation Network.
The action observation network is distributed bilaterally and comprises brain regions active when watching other people's bodies in motion. The core regions of this network are: (1) the ventral and dorsal premotor cortices; (2) the inferior parietal lobule, often extending posteriorly along the intraparietal sulcus; (3) more anterior portions of the occipitotemporal cortex, including posterior superior temporal sulcus as well as the lateral occipital complex; and (4) the supplementary and pre-supplementary cortices located on the medial surface of each hemisphere. The particular set of brain regions illustrated here came from a contrast that compared watching dancers in motion compared to dancers standing still.
Figure as originally published in Emily S. Cross, Louise Kirsch, Luca F. Ticini, and Simone Schütz-Bosbach (2011), The impact of aesthetic evaluation and physical ability on dance perception, *Frontiers in Human Neuroscience*, 5, figure 2 doi: 10.3389/fnhum.2011.00102.

Engaging Science interdisciplinary research workshop series (<http://motionbank.org/en/research-2/>). As a consequence of this series, a number of exciting new collaborations focused on how the neuroscience of action and perception relates to movement aesthetics are being forged with equal input from dancers and scientists. While such interdisciplinary work necessarily faces myriad challenges of accommodating different vocabularies, priorities, and goals, it also sets us on a path worth exploring, and will hopefully further elucidate the links between the embodiment and enjoyment when watching or performing dance.
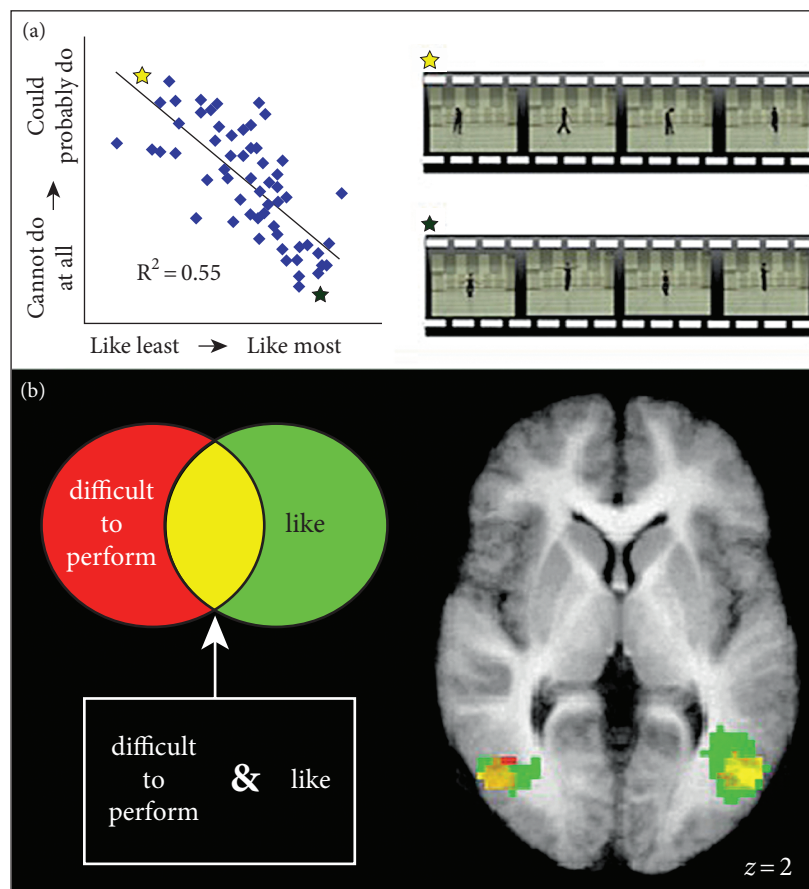
Figure 10.2 Summary of behavioral and neuroimaging findings from Cross et al. 2011.
a: Panel A illustrates the negative correlation between liking ratings and perceived physical ability ratings. The scatter plot shows how participants liked least those movements they thought they could easily reproduce, such as a dancer walking simply in a circle. The light-colored star at the top left of the plot corresponds to the movement detailed in the top video clip on the right. Participants liked most those movements that they rated as extremely difficult to reproduce. The dark-colored star at the bottom right of the scatter plot corresponds to the video clip on the bottom right of panel A. In this sequence, the dancer performs an *entrechat six*, followed by a *demi-plié* as a preparation for a double *tour en l'air* (put simply, this is a jump where the dancer performs six crossings of his pointed feet, followed by a jump with straight legs where he performs two consecutive rotations). **b:** Panel B illustrates some of the occipitotemporal brain regions that emerge from the conjunction analysis interrogating regions that increase in activation the more difficult participants rate the movements to be (in red), brain regions that become increasingly active the more participants like a movement (in green), and brain regions that increase in activity both as a movement is rated as more enjoyable to watch *and* more difficult to perform (in yellow). Figure as originally published in Emily S. Cross, Louise Kirsch, Luca F. Ticini, and Simone Schütz-Bosbach (2011), The impact of aesthetic evaluation and physical ability on dance perception, *Frontiers in Human Neuroscience*, 5, figure 2 doi: 10.3389/fnhum.2011.00102.

Acknowledgments

Notes

1   While this is a shortcoming of the study by Cross and colleagues (2011), it must be stated that we used the same physical ability ratings scale that we used in the earlier study by Cross and team (2006). We found a close correspondence between self-report ratings of physical ability and actual performance ability, but in the 2006 study, participants were expert dancers who, it could be argued, are much more sensitive to their own physical abilities and better at assessing what movements they could or could not reproduce.

2   Of course, there are undoubtedly elements of awe and respect felt by the spectators as the dancers bare their souls through movement in very close proximity to other people in public—unfortunately, addressing larger issues of performance context, audience expectations, and how they relate to the enjoyment of art is beyond the scope of this chapter.

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