CHAPTER 26

DANCE, CHOREOGRAPHY, AND THE BRAIN

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YouTube, the videosharing site where users can upload, view, and share video clips, is one of the latest internet success stories. It is also a cultural phenomenon and an online laboratory for social experiments. As I'm writing this the video accompanying the song 'Here it goes again' by American band OK Go, in which the four band members can be seen dancing on treadmills, has been viewed more than 40 million times. As a matter of fact, OK Go rose to fame because of another video posted on YouTube, in which the band members were dancing in a small backyard. It is a fun video and it spawned numerous imitations, which led the band to organize a competition for viewers to post their own version of the video on YouTube.

The fact that a video has been viewed one million times does not mean that one million people have seen it, nor does it mean that those who have seen it, have watched it in its entirety. Still, these numbers are significant, also because there are other clips with far less views. We can surmise that many people who watch the video clip by OK Go on YouTube are sufficiently internet-savvy to also be able to find a recording of the song, perhaps even with better audio quality. Yet the video has been viewed more than 40 million times, suggesting that it is the *video* that people want to see and not just the song they want to hear. The band members look like ordinary guys and the video is basically a recording of the dance. In the absence of any other factors that might explain the video's popularity, we are left with the conclusion that people enjoy watching the dance.

Dance is a universal cultural phenomenon. In many societies it is an important aspect of religious ceremonies and celebrations commemorating weddings, victories, inaugurations, and rites of passage. In some cultures, such as India, Cambodia, and Bali, the dances performed as part of religious ceremonies have reached great refinement. Additionally, dance may fulfil various military (McNeill 1997) and social functions as part of courtship rituals (Brown et al. 2005) and as a means to self-expression and entertainment. Throughout history dance has been part of theatre, but it wasn't until the nineteenth century that dance emerged as an independent artform. The second half of the twentieth century saw a tremendous proliferation of dance styles and a rapid catching up of dance with modernist and avant-garde movements in the other arts.

The fact that dance videos that play in a small window on a computer screen receive millions of views provides some statistical evidence for the hypothesis that watching dance can be interesting in its own right. But why are all these people glued to their computer screens? Why do people pay to watch some strangers move about on a stage? The question of how dance can give rise to thoughts and emotions has intrigued me ever since I first saw a dance performance. In searching for an answer to this question I have found it useful to study the psychological and cognitive neuroscience literature on perception and emotion. People find something interesting, boring, thrilling, or moving because of what happens, as a consequence, in their brain. This is hardly an original or controversial observation. Experimental psychology and cognitive neuroscience may tell us more about the underlying mechanisms and processes that make human capacities such as thinking, perceiving, and feeling possible. Elsewhere I have argued that for this reason psychology and cognitive neuroscience can be said to have a critical dimension (Hagendoorn 2004a). Like structuralism and post-structuralism, they reveal some of the processes that underlie human behaviour and the cultural artefacts it produces.

As a philosopher I am aware of the limitations of cognitive neuroscience. Functional neuroimaging studies only reveal that a certain brain region or network is activated in an experimental task, but this doesn't say anything yet about the contribution of this region to execution of the task and the underlying causal relationship. The relationship between functional magnetic resonance imaging (fMRI) signals and neural activity is also far from resolved (Heeger and Ress 2002). Neuropsychological studies may show that damage to a particular brain region impairs execution of certain tasks, but the extent of the damage can be difficult to determine. If a certain brain region is activated when healthy individuals perform a task and if damage to that region impairs performance at the same task, we may conclude that this region is an essential component of the network subserving this task, but we still don't know exactly what it contributes. These are but some of the methodological problems that one should be aware of when extrapolating findings from cognitive neuroscience to other fields such as the arts. If we piece together findings from different studies, a picture may emerge of what goes on inside the brain, when people perform a wide-ranging task such as watching a dance performance and of how this affects and constrains perception, emotion, and judgement.

Some videos on YouTube, especially illegal recordings of dance performances filmed with a mobile phone from the rear of a theatre, are heavily pixelated and yet we have no difficulty discerning the dancers and may even take pleasure in their movements. It is quite remarkable how little information is needed to detect a human body and a human body in motion. From an evolutionary point of view it makes sense to be able to quickly detect a moving body and recognize conspecifics. It is therefore not surprising that recent experiments have pointed towards the existence of at least two areas in the human brain that are selective for the visual presentation of human bodies (Peelen and Downing 2007).

In the early 1970s, following in the footsteps of the nineteenth-century French scientist and pioneer of photography and cinematography, Étienne-Jules Marey, the Swedish psychologist Gunnar Johansson filmed an actor as he walked about in a darkened room with lightbulbs attached to some key joints. Still frames from the resulting video show nothing but a random collection of dots, but when the video is played, the moving actor instantly pops out from the screen. Johansson's experiment has since been reproduced in a wide range of settings, with the actor performing all kinds of actions, the markers placed on other parts of the body, and with animals instead of a human actor (Blake and Shiffrar 2007).

In *Biped* (1999), a ballet by Merce Cunningham with visual décor by multimedia artists Paul Kaiser and Shelley Eshkar, a similar technique is deployed to great artistic effect. At the time of the rehearsals some movement phrases were recorded using motion-capture, a technique whereby sensors track reflective markers placed on the body. Using motion graphics software the data files were transformed into dot figures, stick figures, and blurred pencil-drawn figures. As Paul Kaiser explains:

> we took care never to lose the underlying perception of real and plausible human movement. When our stick figure leaped, its various lines were flung upward in the air, then gathered back together again on landing. While no human body could do this, you could still feel the human motion underlying the abstraction.
>
> (Kaiser 2001)

During the performance the final animation sequences were projected on a transparent scrim covering the entire front of the stage, with the dancers performing behind it. The visual effect is breathtaking, as real and virtual dancers blend together in one visual image (Fig. 26.1).[1]

Neuroimaging studies have implicated one particular region, the posterior part of the superior temporal sulcus (STS), in the perception of what has been termed biological motion. Neuropsychological studies report the case of patients with damage to brain regions involved in motion perception, but intact STS, who have difficulty recognizing motion, yet are still able to perceive biological motion (Vaina et al. 2000). In another experiment, temporarily disrupting cortical activity in the posterior STS

[1] The production is part of the repertory of the Merce Cunningham Dance Company and is regularly performed on tour. A video recording is available on DVD from French label MK2, http://www.mk2.com.

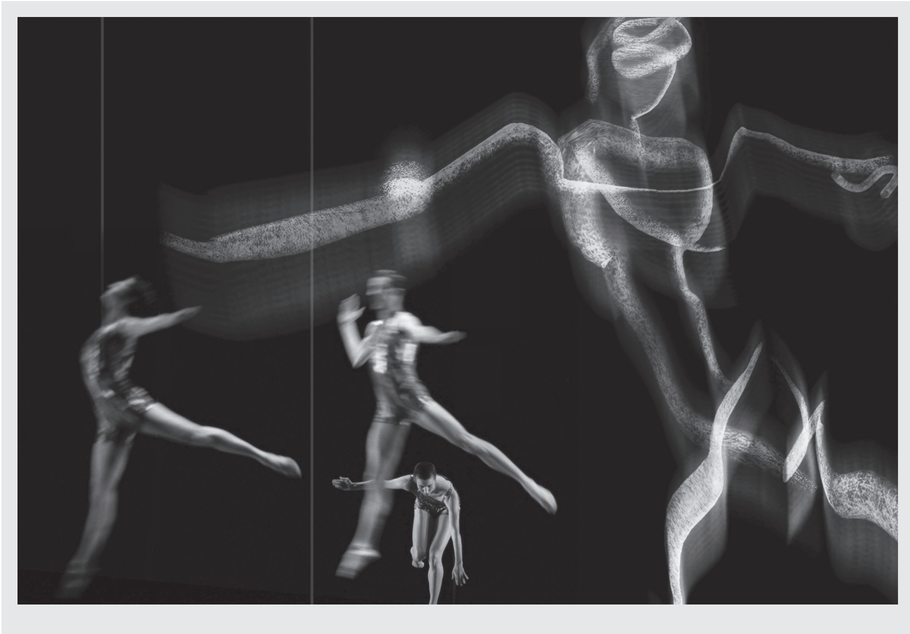

Fig. 26.1 Merce Cunningham, *Biped* (1999). Projected onto a scrim pencil-drawn figure of a dancer.

(Photograph: Stephanie Berger.)

using a technique called transcranial magnetic stimulation,[2] resulted in impaired recognition of biological motion displays (Grossman et al. 2005). Interestingly, another study demonstrated that the posterior STS is also activated when people listen to footsteps (Bidet-Caulet et al. 2005). These findings suggest that the STS plays a central, cross-modal role in the perception of human motion.[3]

Some years ago, the neuroscientist Vilayanur Ramachandran and philosopher William Hirstein advanced eight principles of aesthetic experience derived from Gestalt psychology and various properties of the visual system (Ramachandran and Hirstein 1999). The main principle is what they refer to as a peak shift effect, a phenomenon known from studies of animal behaviour, according to which the response to exaggerated features is stronger than to average features. This hypothesis can be illustrated with reference to caricatures and representations of women in Indian art and popular culture. In an interview, Ramachandran speculated that motion capture displays of biological motion would serve as a hyper-optimal stimulus for brain

[2] Transcranial magnetic stimulation, often abbreviated as TMS, is a technique whereby a brief but strong electric pulse is applied through a coil placed on the head, creating a magnetic field, which temporarily disrupts local neural activity.

[3] It should be noted that the STS has also been associated with the perception of facial expression and eye gaze (e.g. Engell and Haxby 2007).

regions involved in human motion perception and, as such, would generate a stronger response (Ramachandran 2001). It is interesting to observe that the stimuli used in neuroimaging studies are usually presented in isolation in highly controlled settings and that the reported activity may therefore already represent a peak shift effect. In the case of biological motion studies, though, the original idea was to show how *little* information is needed to still observe motion. Biological motion displays therefore do not present a hyper-stimulus but a hypo-stimulus. As I would argue, dance in itself already constitutes a peak-shift effect in human motion perception.[4]

In the remaining part of this essay, I will juxtapose some aspects of dance and choreography and some insights from cognitive neuroscience and psychology. I will show how each may illuminate the other, whereby the emphasis will be on how cognitive neuroscience may add to our understanding of dance. I will take the perspective of a choreographer creating a dance performance. I will deconstruct the creative process into various decision moments and will show how they can be related to various brain processes. For budgetary and artistic reasons, but also to keep things simple, I will assume that we will create a solo.

We will start from scratch. At this moment anything is possible. For this reason I will not concern myself here with a definition of dance. In much contemporary dance there is nothing perceptible to differentiate dance movements from everyday movements. What's more, dance performances need not involve any movement at all. In 1957 the American choreographer Paul Taylor performed a piece called *Duet*, in which he and another dancer stood and sat still for four minutes.[5] The dance critic Louis Horst responded with a review in the *Dance Observer*, which consisted of four square inches of blank space with the initials 'L.H.' at the bottom (Reynolds and McCormick 2003, p. 383).

Let us suppose that our performance is taking place at a theatre. Even though performing at alternative locations may be interesting, there are good reasons for our choice. Theatres have all the necessary facilities to stage a performance. They are like an empty canvas. Although in some theatres you can hear cars or the underground passing by, theatres are relatively closed off from the outside world, thus limiting whatever may distract the audience from watching the performance.

Most of the people who attend the performance will have paid to see it. They may have seen a flyer or have heard about it from friends. Some may be interested in dance, others may have been dragged along by their partner, and some may be paid to write a review. All of this influences how people perceive and will remember the performance. Experimental psychologists use a technique called priming to study how prior information in general, and unconscious attitudes in particular, bias people's perception

[4] I should add that, as I have argued elsewhere (Hagendoorn 2005), this line of reasoning extends to other goals. A choreographer wishing to confuse the audience would have to organize his or her material to this effect. Actual dance performances, however, are always a mixture of different goals and principles, whether implicit or explicit.

[5] The piece is reminiscent of John Cage's 4'33" (1952), in which the performer sits behind his/her piano without touching a single key for the duration of the piece, and Robert Rauschenberg's series of white paintings, which he painted in 1951.

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and judgement. This knowledge can be put to creative use and I would like to contend that, unconsciously, this is what many artists do.

In a performance setting almost everything can be controlled and that means that almost everything involves a decision. Before the audience take their seats, we already have to make a decision. We could have the performer take the stage before the doors open, so that, upon entering, the audience has a sense they have to hurry so as not to miss something. This is how the American choreographer William Forsythe begins many of his performances. Let us assume that for our piece the lights in the audience are on and that the stage is closed off from the audience by a black curtain.

When the audience has entered and taken their seats, at some point the lights in the audience are dimmed. This signals to the audience that they should stop their conversations and switch off their cell phones, because the performance is about to begin. Dimming the lights in the audience also removes some more potentially distracting elements in the form of the visible shape of other people in the audience and emphasizes the division between audience and stage, between the real and the imaginary. Some choreographers like to confound the audience's expectations by keeping the lights on until well into the performance[6] or by transgressing the imaginary boundary between stage and audience, for example by having the performers mingle with the audience. But we will refrain from such experiments.

With the lights in the audience dimmed we can, overtly or covertly, open the curtains. Now we face another decision. We could switch on the stage lights to reveal the dancer, who can be either just standing there or already dancing, in which case the audience again would feel as if it has dropped in on a conversation, or we could keep the stage empty. This is what we will do for our present piece. The audience will be waiting, curious as to what is going to happen. They will be on high alert. In neural terms the baseline activity of neurons in visual, auditory, and somatosensory cortices will be raised (Voisin et al. 2006).

When at some point, not surprisingly but still unexpectedly, the dancer walks on stage, all eyes will be focused on him or her. The moment the dancer takes the stage the audience will notice whether the dancer is male or female. We could postpone this moment and put it to creative use by obscuring the dancer's body and unveiling it later. Let's assume that our dancer is female and that she is simply wearing a non-obtrusive pair of jeans and a plain tank top. There is a reason the costumes in dance tend to be simple. The lavish costumes in classical ballet notwithstanding, anything too sumptuous may distract from the movements.

Now that the dancer is on stage and has captured the audience's attention something has to happen. We could have our dancer stand there for a few minutes and then walk off stage again.[7] We could call this short conceptual piece *Breathing*. Never mind that Paul Taylor has done something similar. Most people in the audience won't know.

[6] A famous example is *Steptext* (1984) by William Forsythe.

[7] The German theatre director Einar Schleef (1944–2001) began his production of Oscar Wilde's *Salome* (1997) with a tableau vivant of the entire cast facing the audience for about 15 minutes in utter silence, interrupted only by the protests of some people in the audience and the sounds of people coughing, laughing, and leaving.

However, it is a bit cheap and we should be able to do better than this. With more dancers we could continue having dancers enter the stage until the space is full, which might actually be fun,[8] but with only one dancer at our disposal, if we don't want to just let her stand there, we have to come up with something different. If we don't allow our dancer to talk, she will have to do something, that is, she will have to move in such a way as to keep the audience's attention fixed on her body. This is the hard part and there are no easy answers as to how to proceed, for we are now at the heart of dance and choreography as an artform. In a way, every solo performance can be seen as an attempt to answer the question of how a single body can capture and hold the audience's attention. Here, again, expectations are important, since each new piece fits in or deviates from an existing repertoire of previous choreographies.

In the work of choreographers such as William Forsythe and Merce Cunningham, at any moment there is a lot of concurrent activity on stage. Dancers perform in seemingly random groupings and orderings at different locations on stage. There is no main action, which dominates the stage. It is impossible to keep track of everything at once. The audience has to choose where to look and is constantly challenged to shift its attention (Fig 26.2). This observation has a parallel in various scientific experiments, which show that there is a task-dependent upper limit to the number of objects people can track simultaneously (Cavanagh and Alvarez 2005; Alvarez and Franconeri 2007).

Attention is the process of selectively concentrating on one object, feature, or event, while relaying everything else to the background. It can be modulated both by top-down and bottom-up signals. Trying to focus on one particular dancer because one knows that s/he is a famous performer is an example of top-down attentional control. On the other hand, the fact that other events may automatically grab our attention shows that attention can also be driven by sensory cues. In the absence of both top-down control and salient stimuli, attention drifts and the mind wanders. Some people may therefore experience performances in which not much happens, as in *butoh*, a dance form which originated in post-Second World War Japan in which stillness plays an important role, as boring. They can also be a revelation, *because* the mind is free to wander or because one is invited to pay close attention to more subtle changes, a slight tilting of the head or a tiny movement of a finger, which can make all the difference.

Salient stimuli tend to grab our attention. A female dancer will stand out among a group of men, she will stand out even more if she is dressed differently and even more if she is wearing a colourful floral dress and the men wear plain trousers and shirts. The dress will stand out at a perceptual level, but it will also emphasize her femininity. In many dance performances we can observe such a doubling of contrast. Women in the work of German choreographer Pina Bausch always wear dresses. The example I just gave is, in fact, taken from a scene in *Masurca Fogo* (1998). In the work of choreographer and pioneer of contemporary ballet George Balanchine (1904–1983) women often wear white pants and black tops, whereas men wear black pants and white t-shirts. This relates to what is known in cognitive neuroscience as grouping by features

[8] *Glass Pieces* (1983) by the American choreographer Jerome Robbins opens with a seemingly endless stream of dancers crisscrossing the stage from all directions.

Fig. 26.2 William Forsythe, *The Second Detail* (1991). Dancers: Ballet de L'Opéra de Lyon.

(Photograph: Vincent Jeannot.)

and 'object-based' (global) attention, in which all stimuli sharing a similar feature are selected.

It is important to note that salient sensory stimuli only grab our attention when they are relevant to the task we engage in, are known to be of behavioural significance, or when we diffusely attend to a broad spatial region, as in our opening scene just before the dancer entered. Various experiments have demonstrated that, when focusing on a particular task or when attending to a particular object, people may fail to notice another salient and distinctive object or event, a phenomenon known as inattentional blindness. In one experiment, people had to watch a video of a group playing a ball-game and to count the number of passes (Simons and Chabris 1999). At some point a person in a gorilla costume walked through the scene. After the experiment about half of the participants reported not having seen anything unusual. Dance performances offer many illustrations of this phenomenon. When our attention is focused on one dancer, we may fail to notice the entrance of another dancer in the periphery of our visual field, a change in the lighting, or the fact that a television on stage has started playing.

Motion and novelty are two features that tend to guide the deployment of attention. Both are, of course, related, since motion can be seen as a change of the position of the body as a whole or as a change in the configuration of the body, that is, a change in the position of the limbs relative to each other. Now, if we add motion and novelty, we see that to keep attention focused on the dancer, she would have to move and, more than that, she would have to diversify her movements. If she were to repeat the same movement over and over again, attention would again wane.

A simple technique for bringing variation into a movement sequence is this: start with a random limb and then keep moving a different limb or part of the body, left arm, right leg, head, left shoulder, etc., one limb at a time. To add some more variation the number of body parts being moved can be alternated, as can the time span between movements and the speed with which they are performed. This is similar to musical compositions in which a theme is repeated with different instruments and changes in tempo. We can also imagine drawing figures with the hand, foot, head, elbow, or shoulder, or imagine avoiding and stepping over imaginary obstacles. We can also define a vocabulary of ten or more movements, which we can then deconstruct and perform in different constellations (Hagendoorn 2003). If you practise these techniques yourself, you will notice that what you are doing resembles dance.

There is a risk that after a few minutes the audience will lose interest. They may wonder what the fuss is all about. All they may see is a person moving about on a stage, twisting and turning and swinging her arms. They may admire the dancer's virtuosity and bodily agility, but it may leave them unmoved. To keep the audience interested, we don't just need variation and differentiation we also need structure. As William Forsythe once commented, 'if there isn't a directing mind, it looks like a can of worms'.[9] This may be fascinating to look at for a little while, but not for a full hour.

In recent years, psychologists have begun to study what makes people interested in something. One theory proposes that interest depends on an appraisal of novelty and/or complexity on the one hand and an appraisal of comprehensibility on the other (Silvia 2005). Various experiments using both experimental artefacts, pieces of modern art, and contemporary poems have provided evidence for this hypothesis. Participants in the experiments tended to spend most time with a picture when it was complex and, in the case of modern art and poetry, when they felt able to understand it.[10] These results may sound obvious, since they confirm what we may have guessed ourselves. They explain why minimal and conceptual dance can be boring at a perceptual level, but intellectually interesting, compared with musicals and classical ballet. They also explain why the opinion of experts, such as critics, and the general public, may differ, and why, over the course of a career, the work of many artists becomes more complex and subtle, as is evident in the work of choreographers such as Merce Cunningham, William Forsythe, Sasha Waltz, and Jiří Kylián. Whereas the audience will usually only see a performance once or twice, the choreographer is, of course, totally familiar with his or her own work. A choreographer's benchmark for appraising the novelty and or complexity of his or her own work is therefore likely to

[9] William Forsythe interviewed on BBC Radio 3 by John Tusa, 2 February 2003. The interviewer refers to another unnamed source. http://www.bbc.co.uk/radio3/johntusainterview/forsythe_transcript.shtml

[10] These findings provide some experimental evidence for the MAYA, Most Advanced Yet Acceptable, principle coined by the American industrial designer Raymond Loewy.

increase over time. Similarly critics, whose job it is to watch and critically evaluate dance performances, are likely to have a different benchmark than the average person in the audience.

Structure can be narrative, as in the work of Pina Bausch and Sasha Waltz, or purely spatiotemporal, as in the work of Merce Cunningham and Lucinda Childs. The techniques introduced earlier to bring variation into a movement sequence can also be used to add structure. We can also invent some new rules and techniques. We could alternate between performing at a point in space and along a line. We can divide the stage into left and right and front and back and perform different movements in different regions. By thus emphasizing geometrical relations and the 'spatiality' of space, the audience's awareness of space may be heightened.

With the help of these techniques we may have succeeded in bringing some structure into the dancing, but that doesn't necessarily make it interesting. What we need is judgement. Up until now I have assumed that our dancer entered the stage unprepared and that she is just dancing around or 'improvising' as this is called in dance and theatre. We can also put ourselves into the seat of the audience and rehearse the piece. We can try out different beginnings and endings and different movement sequences, which we can fine-tune to the desired effect, judging every subsequent rehearsal in an ongoing trial-and-error process. As I would argue, this is how most choreographers and dancers work, whether the breakdancer wishing to impress his friends at their next meeting or the poledancer who uploads a video of herself on YouTube to show off her skills.

Journalists always like to know where an artist gets his or her inspiration from and most likely it is something audiences like to know as well, since it is a question I am often asked in one form or another. My own work is not an illustration of my research and I don't take any direct inspiration from what I've read and learned. This may sound odd. Of course I carry it with me, but there is so much that I carry with me. Inspiration may come from anywhere and may strike at any time. When I start work on a new dance production I may have some ideas, but the actual work is created in the studio, not in my mind. I totally concur with the American choreographer William Forsythe, who once said in an interview that on day one he usually tells his dancers he has absolutely no idea what he is doing because he has never made this ballet before.[11]

In a recent review of a performance by the New York City Ballet of Balanchine's *Agon* (1957), one of the greatest ballets of the twentieth century, Clement Crisp, dance critic for the *Financial Times*, wrote that 'after half a century it remains an innovative marvel, questioning and discovering, time-travelling still, and still light-giving' (Crisp 2008). In an article for the *New York Times*, dance critic Anna Kisselgoff once wrote of Merce Cunningham, that 'his idea that any movement can follow any other symbolizes the discontinuity of our time' (Kisselgoff 1992). When I read such statements I am often reminded of a remark by Susan Sontag: 'interpretation is the revenge of the intellect upon art' (Sontag 1966). Leaving aside the question whether our time is discontinuous, how can dance symbolize it? And how can dance be questioning, discovering and

[11] William Forsythe interviewed on BBC Radio 3 by John Tusa, 2 February 2003. http://www.bbc.co.uk/radio3/johntusainterview/forsythe_transcript.shtml

light-giving? How can a dancer by 'writing with her body (. . .) suggest things which the written word could express only in several paragraphs of dialogue or descriptive prose' as the French poet Stéphane Mallarmé wrote? (Mallarmé 1886/1983).

Suppose we want to render the idea of futility in dance. The archetype of futility is perhaps Sisyphus, who was forced to roll a rock up a mountain slope. But every time he neared the top it would roll down again. With this in mind we could have a dancer try and then try again, without ever succeeding. But try what? Since we have restricted ourselves to movements, we could choreograph a movement sequence and have the dancer perform it several times in a row. After each attempt she stands still, her head slightly tilted sideways, visibly breathing, as if reviewing her movements. She walks back to the starting position. Once or twice she may break off the sequence in-between, as if realizing that she did something wrong. Perfection in dance is unattainable. It may be what, in ballet, dancers strive for, but the perfect arabesque, *épaulement*, or attitude does not exist. It is an idea.

Let's review what we have just proposed. We started with a familiar scenario, which we made more abstract. We then added some familiar poses. Throughout our life we witness countless events; some are regular, others singular. We know of many events how they unfold and we understand the emotional impact if there is one, even if we ourselves have never experienced it. Through experience we acquire habits and knowledge of the world around us. When watching an action movie we know that the hero will eventually prevail. When we brush our teeth and get dressed, we do so in more or less the same order every day. All of this is laid down deep inside our memory in the form of templates, action scripts, and scenarios.

We also instantly recognize emotional body postures expressing fear, joy, aggression, anger, or sadness (de Gelder 2006). One consequence is that if we *don't* want the audience to get emotionally involved we should take great care to avoid familiar gestures. This is why Merce Cunningham frequently uses random procedures to determine the order of movements. One of the classic experiments in experimental psychology, in which the participants watched an animation movie featuring some geometrical figures, showed that people even attribute intentions, desires, and fears to inanimate objects (Heider and Simmel 1944). So we can surmise that they will do so, too, when watching people perform more or less abstract movements outside of the context of everyday life. This is one reason why the work of Merce Cunningham can still have great expressive power.

As you're reading this you may have formed an image of the scenes I have described thus far. If you didn't, you will when I tell you to do so. Picture an empty stage. After a few seconds the dancer reappears from the back end of the stage and walks in a straight line to the front of the stage, where she stops. She stands facing the audience, crosses her arms in front of her body and slowly begins to pull up her shirt, baring the upper half of her body. When you picture the stage or the dancer you will form a visual representation in your mind. When you picture a movement you form a motor representation. Neuroimaging studies have shown that mentally rehearsing a movement and reading action verbs such as walking or throwing activate motor regions in the brain. So, what about watching movement?

In an intriguing neuroimaging study researchers compared the brain activity of ballet dancers and capoeira dancers as they watched short videos of each others' movements (Calvo-Merino et al. 2005). They found greater activity in parts of the premotor and parietal cortex when dancers watched movements in their own style. In a follow-up study the authors compared the brain activity of male and female ballet dancers as they watched short clips of gender-specific movements (Calvo-Merino et al. 2006). The idea behind the experiment was that both male and female dancers are equally visually familiar with all movements, because they take class together, but they don't perform all movements. The authors found greater activity in parts of the premotor and parietal cortex and the cerebellum when dancers watched their own gender-specific movements. They concluded that 'observing an action can activate the corresponding motor representation'. But what if there are multiple dancers in your field of view (Fig 26.2)? Is there really a motor representation for each movement? I doubt it.

In recent years, so-called motor theories of cognition have become increasingly popular in cognitive neuroscience. According to one version of this theory we understand others by simulating their actions (Blakemore and Decety 2001). With reference to Freud's book on jokes, the French neuroscientist Marc Jeannerod gives the example of watching a clown:

> pretending to make an enormous effort to lift an apparently heavy object and then falling on his back. We laugh because we have created within ourselves an expectation by simulating the effort of the clown, and we see something that is very different from the expectation. The effect we see is at discrepancy with respect to our internal model, and this is the source of comedy. The simulation of the action we observe does not meet the expectation.
>
> (Gallagher and Jeannerod 2002)

The discovery of mirror neurons, a class of neurons in the ventral premotor cortex of the monkey brain that respond both when the monkey performs and observes a goal-directed action such as grasping a raisin, added considerably to the popularity of simulation theory (Gallese et al. 1996). Various neuroimaging experiments have since provided tentative evidence for the existence of a similar mirror system in the human brain (for a review, see Rizzolatti and Craighero 2004; Iacoboni 2005). As yet there is little hard evidence to support the claim that the mirror system contributes to our understanding of the meaning and intention of observed actions (Dinstein et al. 2008). Some caution in interpreting these findings is therefore warranted (Jakob and Jeannerod 2005).

I once believed the mirror system could provide the basis for an explanation as to why dance can be fascinating to watch (Hagendoorn 2002; 2004b), but I have since become more sceptical. I wonder how the mirror system might contribute to the perception of the concurrent movements of multiple dancers, and how it could account for our understanding of the simultaneous pushing and pulling in a duet.

After another brief interval our dancer returns to the stage. This is our little trick to connect disconnected scenes and to give the audience some time to breathe (and cough). The dancer is carrying a portable music player. Music can be a means to amplify reality, to envelop the audience in moods and waves of feeling. Only few dance performances are performed in silence. I've got nothing against music, I enjoy listening to music, or some music sometimes, but as a choreographer I've always found it somewhat disconcerting that dance in itself isn't strong enough as a stimulus to capture and hold the audience's attention for say 30 or 60 minutes. That this is so can be inferred by adopting the line of reasoning popular in economics: if silent dance performances would have immense popular and critical appeal, they would abound and draw huge crowds.[12] Why isn't this so when people can be immersed in a book for hours on end? I must say that I myself rarely go to concerts, because I get bored from just watching musicians play their instruments. I mean, do something visually interesting on stage, like a dance performance! I'm afraid I don't have an answer to this question, but we can offer a conjecture on why music and dance seem like brother and sister.

One of the principal components of music is rhythm. Rhythm can be weak or strong, dense or extended, single or multilayered, regular or irregular. Across cultures people have been found to spontaneously synchronize their body movements to music with a strong regular rhythm and a beat that is neither too slow nor too fast. Neuroimaging studies have shown that the production and perception of auditory rhythms activate motor areas in the brain (Janata and Grafton 2003). Interestingly, one of these regions, the lateral premotor cortex, has also been associated with a number of sequential prediction tasks (Schubotz 2007). Earlier, we saw how at a macro-level cognitive structures, habits, and our own episodic memory create an expectation in us of how events unfold. The picture that is beginning to emerge from studies of the premotor cortex is that, at a micro-level, the premotor cortex extracts the sequential structure from a series to allow the prediction of its continuation. Watching dance accompanied by music, on this account, creates expectations in both the auditory, visual, and motor domain. This may explain why dance and music go together so well. The expectations engendered in each domain are mutually reinforcing. However, setting a step to every note in the music may be too predictable and as a result may be experienced as boring.

It is now two days before the premiere and we sense that something is still missing. It's not quite what we wanted yet. Thankfully, our dancer comes to the rescue. She's a real professional. Dancers understand when you tell them not to go through the movements, but to let the movements go through them. They know how to emphasize a movement, how to add an exclamation mark here and a question mark there. They know how to let a movement linger and how to alter its intensity. Of course all of this is metaphor and somehow it has to be translated into motor commands. An important concept in Graham technique, the movement system developed by the American choreographer Martha Graham (1894–1991), is 'contraction'. An example of a typical contraction would be to imagine holding a very large ball and to then squeeze it with the entire body. The opposite of contraction is release. Various choreographers have developed their own version of release technique. An example would be stretching your arm and then letting go off the muscles in the shoulder. Gravity will cause the arm to drop. These two examples may give some idea of how the quality of a

[12] Some dance pieces are performed in silence, but their number is negligible.

movement sequence can be modulated. The use of contractions gives movements an angular look, while release technique tends to look loose and floppy.

We have now finished choreographing our performance. Whether it will be any good is for the audience to judge and depends on whatever else they may have seen and the mood they are in when they attend the performance. All we need is a title. A title can be descriptive, *Solo*, or borrow from the title of the music that accompanies it, like *Violin Concerto*. Titles can also be used to prime the audience. A good title is ambiguous, mysterious, and open to interpretation. It raises the curiosity of the audience. Let's call the piece we just created *To be is to be better than is not.*[13] Coming soon, to a theatre or a computer screen near you.

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[13] Excerpts will be made available on my website, http://www.ivarhagendoorn.com.

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