DANCE PERCEPTION AND THE BRAIN

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In: McKechnie, S. & Grove, R. (2005), *Thinking in Four Dimensions*, Melbourne University Publishing

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Final Draft 17.06.04

An Oblique Effect in Aesthetics?

Some years ago experimental psychologists showed that humans appear to have an aesthetic preference for horizontal and vertical over oblique lines (Latto *et al*. 2000). It had already been known for over a century that the human visual system exhibits a greater sensitivity to horizontal and vertical than to oblique lines, a phenomenon referred to as the oblique effect. The effect shows both in a quicker response to and a better ability at discriminating lines along the cardinal axes. Making clever use of the fact that some of Mondrian's paintings have oblique frames, the researchers were able to show that having to select one orientation from a set of four, the majority of people also *prefer* the one in which the lines are vertical and horizontal. Outside of the laboratory a similar preference can be recognized in the common inclination to straighten slightly tilted frames. In a second experiment based on the catalogue of an exhibition of 20th century painting, which aimed to "fully reflect the art of the 20th century and its main trends comprehensively", Latto and Russell-Duff (2002) showed that artists have a preference for horizontal and vertical lines in the composition of their work, whether abstract paintings and readymades or paintings of the human figure, portraits or landscapes. Both findings suggest what the authors call "an oblique effect in aesthetics".

Of course the predominance of horizontal and vertical lines in art may simply reflect the predominance of horizontal and visual contours in our visual environment in general, as a recent study by Coppola *et al*. (1998) demonstrated. In the experiment, which almost reads like an artistic project, two persons were asked to walk around the campus of Duke University, in both indoor, outdoor and natural environments, and to take a picture of the scene in front of them every time an electrical tone device gave off a sound.[1] The images that were thus collected were subsequently analysed for the direction of oriented contours. The results showed a prevalence of horizontal and vertical lines relative to oblique lines in all three environments, the 'fractal geometry of nature' notwithstanding, although the result was less pronounced in natural scenes. To correct for a possible geographical bias in the selection of natural scenes, images from two other geographic regions were also analysed, but the results did not differ from the ones obtained at Duke University.

The fact that horizontal and vertical lines prevail in both natural and man made surroundings may be explained by the laws of gravity and mechanics. This however does not yet explain why the human brain would be better at detecting them. At present the most likely

[1] The camera was mounted on a tripod so as to ensure that it was aligned with the horizon.

hypothesis is that more orientation detectors in the primary visual cortex are selective for horizontal and vertical than for oblique lines (see Coppola *et al*. 1998 for references).

Horizontal and vertical lines are not the only visual features, which have privileged access to the visual system. The perception of faces, the human body and what has been called biological motion, the motion characteristics of humans and animals, also appears to be superior to that of other shapes. A possible explanation for these findings may be found in human evolution. The visual system has evolved to represent the visual environment as efficiently as possible. It pays to instantly see whether it is just some grass and bushes waving in the wind or an animal moving, to recognize whether it is an animal or a human body and to tell from a distance whether he or she is a friend or a foe or indeed a he or a she.

On the basis of these findings Latto and Russell-Duff (2002) suggest that artists tend to favour those shapes, figures and orientations, which the visual system is good at recognizing, or perhaps we should say *their* visual system, to allow for individual differences and to acknowledge the brain's plasticity. To understand why there is a case for this conjecture, which is sometimes referred to as the perceptual fluency hypothesis, we have to realize that artists also observe their work during the process of creating a work. Most painters do not randomly apply paint to a canvas, nor do choreographers randomly select and create movements and spatiotemporal configurations, although some may choose to do so.[2] To write, paint or choreograph is a dynamic process whereby sentences, colors, lines, sounds or movements are composed, evaluated, changed, re-evaluated, deleted and inserted. This process is set against the backdrop of the brain mechanisms involved in analysing perceptual and emotional stimuli. In the somewhat caricatural case of a horizontal line on a canvas we can imagine a painter stepping back to see whether the line is really straight. Indeed, Mondrian reportedly could spend weeks contemplating the precise positioning of lines and blocks of colour.

Insofar as vertical and horizontal lines are concerned there is an obvious parallel between these findings and classical ballet. Much of ballet technique is based on alignment, from the five positions of the feet to the three basic arm positions, the four basic *arabesques* and of course the *arabesque penchée*, whereby a dancer bends forward lifting one leg as high as possible. Every ballet dancer will instantly point out that there are good anatomical reasons for a proper alignment. So in the case of ballet practical and aesthetic considerations may go hand in hand. Of course these are positions and not yet movements, but it is interesting to observe that within a ballet some positions are often not only the goal or end point of a movement, but are also held onto for a very brief moment to provide a momentary still point. Not surprisingly these positions are also clear favorites among photographers and the postcard buying public. Even though ballet, as well as the work of Merce Cunningham and Jiri Kylián, to name but two other examples, provides some evidence for an oblique effect in dance, the more interesting question would be whether other, similar regularities can be identified in choreographed dance performances and if so, whether they correlate with known properties of the visual system. Again we can find some inspiration in the analysis of visual art.

Implicit Principles

Instead of looking at forms such as lines, faces or the human body we can also try and find some common abstract qualities in paintings, photos, sculptures and installations. In their much discussed paper *The science of art: A neurological theory of aesthetic experience*

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[2] Note that Merce Cunningham works with a pre-defined set of movements that form the basis for his chance operations, which is why a piece by Merce Cunningham is instantly recognizable as such.

Ramachandran and Hirstein (1999) propose eight such qualities, which they call laws of aesthetic experience. These laws include: the enhancement of features that deviate from average, which Ramachandran and Hirstein refer to as a peak-shift effect, grouping of related features, isolation of a particular visual clue, contrasting of segregated features, metaphor and symmetry. Elsewhere I have shown how these principles may apply to dance (Hagendoorn 2003a, 2004). The perfect synchronization of the movements of a group of dancers for example, creates a peak-shift effect in the grouping of related features, while having another dancer perform different movements elsewhere on stage creates a contrast between group and individual. I have also proposed that, given the fact that part of the brain will automatically form a prediction of the next event in a series, the interplay between these implicit expectations and their rupture or resolution, can be seen as a principle specific to dance, music and cinema. One of the simplest examples is that of someone playing scales and suddenly striking a different key. Another example is the global narrative structure of thrillers and detective stories. In dance, suddenly accelerating a limb, breaking off a movement, 'going against the logic of the movement', as one dancer once described one of my improvisation techniques (Hagendoorn 2003b) or introducing a new element in a sequence of recurring movements, draw the observer's attention and raise overall awareness by differing from the movement's anticipated continuation as built up by preceding movements.

I should add that the use of words such as 'law' or 'principle' in the present context is a bit misleading and has led to much misguided criticism. It suggests that artists follow, in the sense of adhering to, these laws when they create a work of art, the way a poet might adhere to the principles for writing a sonnet. Properly speaking there are no principles in the brain either. What are referred to here as 'laws' or 'principles' are regularities deduced from how the brain operates in certain tasks. But as such they can be said to be 'principles'. They are *implicit* in the manifold ways by which the brain constructs a percept from sensory input and in the reverse process by which a percept is materialized in the form of a work of art.[3]

Destabilizing Perception

The fact that the human visual system is better at discriminating horizontal and vertical lines does not mean that it is *poor* at discriminating oblique lines and curves. And granted that, when forced to choose, we prefer the scene in which the picture is straight to the one in which it is crooked, it cannot be the whole story, for what about the work of artists like Kandinsky, Malevich, Jackson Pollock and Frank Gehry? As Latto (*in press*) concedes, visual artists make ample use of oblique lines, perhaps *because* we are less good at seeing them. The oblique brush strokes in Monet's *Springtime Through the Branches* (1878) vividly capture the image of leaves moving in the wind and the sensuous curves in the work of Frank Gehry seduce visitors across the world. While these examples may reveal another principle, that of a preference for fluid curves, which one also finds in dance, and the fact that repetitive patterns on a plane create the impression of depth and motion, an artist can also deliberately choose to as it were 'upset' the visual system and the principles that normally guide perception and recognition. The British artist Anish Kapoor for instance, frequently uses dark pigments to create the illusion of deep voids, which seem to expand far into space, whereas in other works shapes or tonal differences appear to be painted on but are in fact cut away from the material. It is precisely *because* the brain cannot form an adequate representation of the images that fall on the retina or *because* the object appears out of context, that it summons a chain of

[3] I am alluding here to the notion of a work of art as a compound of percepts and affects, coined by Deleuze and Guattari (1994).

associations. This is also why abstract art gives way to the wildest and most arbitrary interpretations: if the brain is free to roam it will. The same can be said of dance in general.

Normally, if we see someone make a move we can infer the movement's intention and sometimes even the state of mind of the person making the movement, for instance whether he or she is angry or nervous. If the person sitting in front of us is reaching for her glass, we infer that she is going to drink from it. If instead of bringing the glass to her mouth we notice in a fraction of a second that she is moving her arm towards us, we instantly duck for cover.[4] On an empty stage outside of a social context a movement's meaning and intention are more difficult to detect than in everyday life. What is the fuss all about? Why the raised legs? Why the frantic arm movements? Even walking can be ambiguous. Obviously the stage setting itself provides a context, which may impart a perceptual framework and objectives on the movements. Thus a ballet critic may write of a piece by William Forsythe for the Royal Ballet that it is not 'proper' ballet.

If we adopt the language of dynamical systems, a neural representation can be seen as the temporary formation of a pattern of activity within a network of neurons. Each such pattern can be said to form an attractor, like a basin in a landscape, to which the system converges after it has been perturbed (Skarda and Freeman 1987). At rest neurons fire randomly, representing a stationary but chaotic state of low metabolic activity. Upon presentation of a familiar stimulus the system goes through a limited number of cycles before it settles upon an attractor, like a marble on a roulette wheel. In the case of novel or ambiguous stimuli the system may fail to reach a new equilibrium and turn to a chaotic state of ongoing oscillations as if the marble keeps jumping from one pocket to another. The famous drawings of the duck/rabbit and the old woman/young girl can be seen as examples of the brain rapidly switching between two attractors. Learning in this view consists in the formation of a new attractor following the repeated exposure to the same stimulus.

Within this conceptual framework works of art which destabilize perception push the perceptual system to what physicists call the 'edge of chaos' (Bak, Tang and Wiesenfeld 1987), a state where new connections, associations, meanings and levels of understanding can emerge. It may happen that almost instantly a new attractor is formed, the work categorized, its power to affect neutralized. It may also happen that we feel as if we suddenly see the world with new eyes, in which case the attractor landscape itself can be said to have been transformed. "Music and dance can inhabit separate planes!" (Merce Cunningham). "Any movement can be dance!" (Trisha Brown, Yvonne Rainer, William Forsythe).

Even though a work can be unsettling independent of the artist's intentions, due to the lighting conditions for instance, an artist wishing to disturb the perceptual system will, just as the artist finetuning a work to its properties, try to perfect the 'stimulus'. The same is true of the artist wishing to free his work from any perceptual or emotional biases. One reason Mondrian sometimes spent weeks rearranging lines and blocks and worked for several years on his *Boogie Woogie* paintings, may lie in the fact that there is no perceptual ground which favours one composition over another. When watching dance, seeing 'just' the movements stripped of the goals and contexts, which normally guide action, we are at once free to focus on their inherent qualities and at a loss to make sense of what is happening in front of our eyes. We constantly swing between looking only at the movements and searching for meaning, accustomed as we are to the fact that movements tend to have a goal and a meaning. And so the dance critic who could not make sense of the performance will write that it lacked dramaturgy, unless he realizes that may have been its objective. Neutrality can be a quality.

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[4] Thankfully the glass was half-empty.

An Evolutionary Perspective

It is an undeniable fact that some songs, paintings and ballets are more popular than others. In dance we can think of *Riverdance*, musicals such as *West Side Story* and *Chicago* and ballets like *Swanlake* and William Forsythe's *In the middle somewhat elevated*. But why is this so? Why aren't preferences uniformly distributed? It is also interesting to observe that in dance certain configurations seem to have a cross cultural appeal. Synchronized rhythmical group scenes are found from classical ballet to African and Australian aboriginal tribal dances, musicals, the dances of North-American indian tribes, music videos and Pina Bausch's *The Rite of Spring*. Similarly virtuoso solos have universal acclaim. Following an impressive solo and regardless of whether it is ballet or capoeira, audiences across the world have the unstoppable urge to give way to their enthusiasm and interrupt the performance with a spontaneous applause. Their apparent universality suggests these phenomena, like other capacities of the human brain, are products of evolution and adaptation. To account for these observations a different approach, rooted in evolutionary psychology, may therefore provide useful insights.

Natural selection is the process by which organisms best adapted to the environment survive. But as Darwin (1859) already observed, natural selection cannot be the full story, since it does not account for the within species differences between male and female and because some traits, the peacock's tail being a prime example, have little survival value. Darwin (1859, 1871) therefore proposed a second mechanism, sexual selection, the competition within one sex for mates, to explain the evolution of secondary sexual characteristics such as bird song, colouring, plumage and behaviours such as courtship dancing, like that of cranes.[5] Now colourful patterns not only attract the opposite sex, they also attract predators. Similarly the peacock's tail makes it more vulnerable. This is why many biologists today refer to these and other secondary sexual features as fitness indicators (Zahavi and Zahavi 1997). A peacock with a large tail and deer with large antlers send out the message "look at me, I'm strong and healthy, mate with me". As Miller (2000) writes, "Applied to human art, this suggests that beauty equals difficulty and high cost. We find attractive those things that could have been produced only by people with attractive, high-fitness qualities such as health, energy, endurance, hand-eye coordination, fine motor control, intelligence, creativity, access to rare materials, the ability to learn difficult skills, and lots of free time". This theory could therefore provide a rationale as to why audiences rejoice at virtuoso solos. But avant-garde choreographers who cannot dance need not despair, it's not just about high jumps and virtuoso solos. Unintelligible works may indicate high sophistication and intellect on the part of the maker and for that reason inspire admiration.

Walter Freeman has proposed that dance functions as the "biotechnology of group formation" by offering a means to bridge the gap between self and other. As Freeman writes "To dance is to engage in rhythmic movements that invite corresponding movements by others. The reciprocity fosters transcendence over the boundaries of self in physical and emotional communion" (Freeman 1995, p. 153). Freeman does not consider dance as a performance art, which may have emerged when it was discovered that instead of joining in, it can be equally satisfying to watch others dance and that watching together also creates a sense of community. Movements were finetuned to please the observer and the implicit rules that govern communal dances abandonned. At a later stage in a reflexive move the assumptions that shape dance were questioned. But while these developments took place over

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[5] Of particular interest in this respect are bowerbirds, so called because the males build intricate bower like structures decorated with colourful objects, which are not used for breeding purposes but solely to attract females during courtship.

the course of years or centuries, the human brain has not changed significantly since the beginning of the Holocene, some 10,000 years ago. And so we still get excited when we see a large group of dancers move in sync. Of course accounts like these are highly speculative and I am not saying that this is the final word.[6] But even if it is in the wrong direction, it is a first step.

Conclusion: Unspoken Knowledges

Every work of art is the product of a series of choices. In making these choices artists are *implicitly* guided by the properties of the neural mechanisms associated with perception, attention and emotion and by the legacy of the likes and dislikes with which evolution has equipped us. A work of art can therefore be said to express these mechanisms and the knowledge the artist has acquired about their workings.

A neuroaesthetic analysis of dance and choreography does not deny the cultural context within which specific dance forms emerge, but acknowledges that neural mechanisms are the same in all human beings. It reveals the implicit choices choreographers make when they create a piece and in so doing may tell us more about the workings of the brain. It does not claim that some dance performances are better than others. It does not disqualify any response, but studies different responses and tries to explain where they come from.

An individual person's experience at any moment in time is not just based on data provided by the senses, it is shaped by memories, desires, and intentions, conditioned by expectations, coloured by emotions and contingent on the physical state of the body. The reasons why a certain piece may be meaningful to someone, lie beyond scientific investigation and philosophical speculation and even beyond each person's own understanding. What we can do is observe regularities in what choreographers do and how audiences respond.

Two recent neuroimaging studies show one possible route a neuroaesthetic analysis of choreography might take to move beyond the present preliminary considerations. The first study used functional magnetic resonance imaging (fMRI) to compare the brain activity of a skilled artist and an ordinary person as they drew a series of faces (Solso 2001). Activity in the area associated with processing faces was higher in the non-artist than in the artist, suggesting that the latter may process faces more efficiently. Interestingly the right prefrontal cortex (see below) of the skilled artist was significantly more activated than in the non-artist. Taken together these results suggest that the non-artist relies more on processing facial information while drawing a face, perhaps so as to ensure that the drawing represents a face, whereas a skilled artist is less engaged with individual features and more with their composition.

In the second study participants watched a 30-minute excerpt from *The Good, the Bad and the Ugly* as they were lying in the scanner. Statistical analysis of the data revealed that on average about 30% of brain activity of one individual corresponded with that of another person (Hasson *et al*. 2004). Interestingly the regions showing intersubject correlation extended beyond the primary visual and auditory cortices, which process basic perceptual features such as shape and pitch, towards 'higher' association cortices. The experimental set-up also allowed the researchers to relate the fMRI signals to segments of the movie. Part of the correlation was explained by similar responses to highly salient scenes, such as gunshots and surprising scene changes. Of equal importance as the finding that part of the activation

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[6] As Miller (2001) writes it should be emphasized that the biological function of art should not be confused with individual motivations for creating art, which may range from making money to social criticism, deep felt anger and commenting on other works of art.

patterns were shared among different individuals, is the fact that another part was not. The areas which showed no intersubject correlation included the parietal cortex and in particular the prefrontal cortex. The latter region receives its input from other brain areas and is associated with the integration of sensory and memory information and the representation and control of action (Wood and Grafman 2003; Miller *et al*. 2002; Damasio 1994). A recent study found that some regions of the prefrontal cortex are also involved in the reappraisal and cognitive regulation of emotions (Ochsner *et al*. 2002). Thus, while the primary perceptual and emotional responses are the same across different brains, the associations they elicit and the appraisal of these responses differ. This might explain why an audience responds identically to the same events yet afterwards evaluates it in different terms.

We can thus imagine recording the brain activity of a choreographer as he watches a video of a short dance phrase he has just choreographed and subsequently ask his comments. This process can be repeated until the choreographer says the phrase is ready to be performed. We can also imagine recording and comparing the brain activity of one person watching the first and the same or another person watching the final version. What should we expect from such an experiment and does it matter in any way what happens where inside the brain? For one thing once a mechanism or locus of activation has been identified its properties can be analyzed. How does it function? Under what conditions? What are its thresholds? What are its limits? Effectively this is what choreographers and artists in general also investigate, varying a stimulus' intensity, the context in which it occurs, its duration, quality etc. With a better understanding of how implicit brain mechanisms shape the act of creating a choreography and the audience's thoughts and feelings, we might appreciate more what it is choreographers do and replace blind admiration or heedless criticism with more informed judgement.

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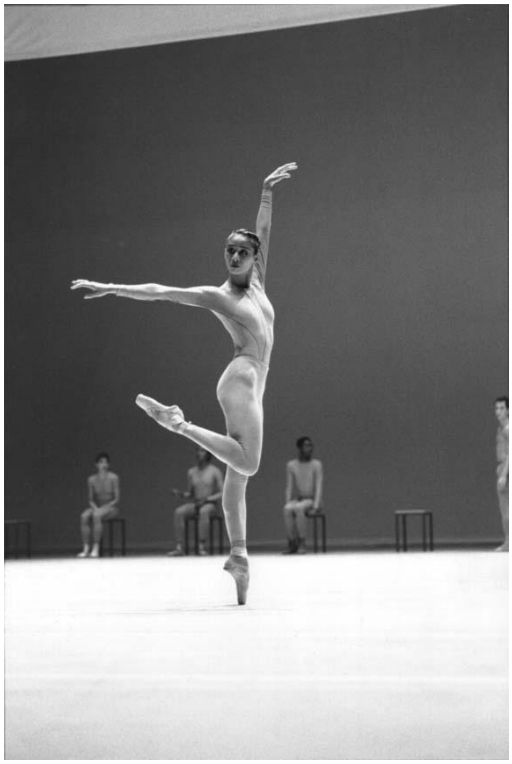

William Forsythe, Second Detail (1991). Ballett Frankfurt. Dancer: Nora Kimball. Photo © Dominik Mentzos.

Set to Steve Reich's energetic Drumming, performed live on stage, Jiri Kylián's Falling Angels, a group work for 8 women, is at once an example of perceptual principles such as grouping, symmetry and contrast through the opposition of group and individual, as an example of the power of synchronized group works danced to a rhythmical score. Lynette Halewood, dance critic for Ballet.co Magazine wrote of this piece that "There's an elemental force about it that at times evokes some primitive ritual." (Ballet.co Magazine, July 1999).

Jiri Kylián, Falling Angels (1989). Dancers: Netherlands Dance Theatre 1. Photo © Joris-Jan Bos courtesy of Netherlands Dance Theatre.