The Feeling of Motion: Camera Movements and Motor Cognition

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Abstract

Camera movements are considered a key element for the intersubjective relation between viewer and screen; nonetheless, their concrete effect on spectators' experience still lacks the attention it deserves. This paper promotes an embodied approach to the study of camera movements, aiming to better understand the role of motor cognition during the film experience by analyzing the effects of camera movements on viewers' motor cortex activation. We present an empirical high-density EEG neuroscientific study on camera movements, investigating viewers' brain motor responses to different techniques like zooming, and the use of a dolly and steadicam. This is triggered by the idea that each movement implies a particular form of physical relation between the audience and the movie. Indeed the experiment showed that the Steadicam determined the strongest activation in viewers' motor cortex, providing first empirical ground to the notion of the capacity of the camera to simulate the virtual presence of the viewer inside the movie. This study shows how cognitive neuroscience can contribute to a better understanding of film style and techniques. Finally, this research demonstrates how film technique can be useful to cognitive neuroscience, by enabling the simulation of observers' movements and, in so doing, allowing a novel approach to the study of action-perception links.

Camera as Fonteyn, operator as Nureyev would be ideal –
a dance partnership capable of any vector of graceful motion
within the range of the operator's hands, arms, and legs.
Garrett Brown[1]

Introduction

Most of the papers and books in the humanities in which we find studies inspired by a neuroscientific approach use cognitive neuroscience as a tool to confirm, re-

[1] Quoted in Serena Ferrara, *Steadicam: Techniques and Aesthetics*, Focal Press, Oxford 2011, p. 7.

fine, or sometimes reject theories shaped up in other domains. During the last two decades, cognitive neuroscience has shown us that human experience should be thought of as a natural form of relational experience: we live in relation with other people, objects, landscapes that are present in our real world, but we also live in relation with people, objects, landscapes that come to us within the imaginary worlds displayed by the arts.[2] Both kinds of relationship are rooted in our brain-body system, and if we aim to grasp the basis of the complexity and the multimodality these relationships imply, we have to go back to our own brain and body.

Cognitive neuroscience can enter theoretical debates on mediated experience, bodily engagement in aesthetic experience, new theories of enactment and simulation. In this case, we find that such an approach allows scholars, in diverse fields, to probe one of the artist's fundamental questions: how to involve the public? This approach could be christened as "theoretical/archaeological," and its usefulness is to bridge results from neuroscientific experiments planned and executed elsewhere with old and new questions raised within the humanities.

A second approach considers these experiments not only as a tool for implementing theories, but also as an analytic instrument capable of refining stylistic analyses, as several studies on contemporary art, literature, acting, music, and partly cinema have already demonstrated. Style is basically what strengthens our relationship with a work of art, what allows us to orient (or lose) ourselves within the imaginary worlds of fiction. Style is a way to manipulate the mediation, to establish a peculiar intersubjective relation between us and the work of art. Film style, for instance, is a matter of technology and techniques: filmmakers are compelled to use what they can afford from a technological point of view, and their film techniques depend on those technologies.[3] Once they understand how to handle the medium, they can experiment different ways to involve the viewer, to let him/her enter the story. To study film style, hence, we should have a precise idea of the technological context and we should wonder how a specific technique depending on a specific technology could embody or re-embody our experience in new interactive ways. As we see it, this approach is a very concrete one – we could describe it as "pragmatic," – and its goal is to create a real convergence between issues from film studies and neuroscientific methodologies.

However, we cannot think of cognitive neuroscience as a panacea for film studies or, more broadly, for the humanities. We are fully aware that cognitive neuroscience cannot provide all the keys for the secret doors of our aesthetic experience: cognitive neuroscience has to be thought of as a "cognitive archaeology" capable of clarifying determinate aspects of our experience, for example the relevance of motor cognition in our social behavior and aesthetic experience. It can also revolutionize our conceptions of terms like "action" and "simula-

[2] Among the huge literature, see Barbara Maria Stafford, "Crystal and Smoke: Putting Image Back in Mind," in Barbara Maria Stafford (ed.), *A Field Guide to a New Meta-Field: Bridging the Humanities-Neuroscience Divide*, University of Chicago Press, Chicago 2011, pp. 1-63.
[3] See Barry Salt, *Film Style and Technology*, Starword, London 1993.

tion," which have been long discussed within Western philosophy. That said, it should be clear that if we wish to understand something new about film by means of cognitive neuroscience, we must question the movies according to the limits and potentialities of the neuroscientific approach. In a previous paper, we showed how to blend the theoretical/archaeological approach and the pragmatic one, starting from film theory, then formulating hypotheses about a new concrete approach to the history of film style, and finally to programmatically promote a third step, the "experimental" one, inspired by previous theories and capable of offering new insights on film.[4]

To put it even more clearly, we want to pose some questions: how important is it to evaluate our embodied relationship with film technology? At which level and by which means can we study and understand this kind of embodiment? Does such a perspective contribute to a fuller comprehension of our film cognition? Does it add something to the traditional and shared knowledge on film? Could we consider the degree of embodiment as a sign of the salience of a scene with respect to a multilayered form of viewers' involvement? Could an embodied approach to film have relevance also from a historical point of view?

The viewer's ability to move inside a virtual spatio-temporal dimension like that of the screen is tightly connected to these issues, and matters like bodily engagement in film viewing or film subjectivity should cope with the embodied approach to film techniques. As Jacinto Lageira wrote, referring to previous proposals like those put forward by Erich Feldmann in the 1950s, viewers' subjectivity can simultaneously locate itself aesthetically in the film while obviously remaining itself in the real world.[5] This is the very mission of film, and this is the field on which cinema has been challenged by other media, like videogames or VR, which shape up their virtual space-time often referring to simulation techniques previously elaborated within film practices. Though in this first phase cognitive neuroscience can primarily provide quantitative data to the study of film experience, as emphasized by Hasson and colleagues in their seminal work,[6] we will show that some analyses could not only contribute to clarify stylistic issues, but also to focus on theoretical issues that have been long considered out of reach because of the difficulties in providing solid empirical bases to their discussion.

We present here a recent empirical neuroscientific study we performed on camera movements by means of high-density EEG, which we believe could be a good starting point to show how cognitive neuroscience can tell us something new on a quite neglected topic in film studies. This study allows us to talk of

[4] Vittorio Gallese, Michele Guerra, "Embodying Movies: Embodied Simulation and Film Studies," in *Cinema: Journal of Philosophy and the Moving Image*, no. 3, 2012, pp. 183-210.
[5] Jacinto Lageira, "Imaginary Subject," in Dominique Chateau (ed.), *Subjectivity: Filmic Representation and the Spectator Experience*, Amsterdam University Press, Amsterdam 2011, p. 150. See also Erich Feldmann, "Considérations sur la situation du spectateur au cinéma," in *Revue Internationale de Filmologie*, no. 26, 1956, p. 83.
[6] Uri Hasson *et al.*, "Neurocinematics: the Neuroscience of Film," in *Projections. The Journal for Mind and Movie*, no. 1, 2008, p. 21.

mediated experience, embodied techniques, spatial cognition at the movies, and most of all to talk of the crucial role that motor cognition plays at a pre-reflexive level in making us empathize with the moving pictures.

Film and camera movements

As Vivian Sobchack pointed out, there are four basic kinds of movement in moving pictures. The first is the movement of the human beings or even the objects within the frame; the second is the movement between the images, that is, the editing; the third is the optical movement of the camera lens from a fixed position, that is, the zoom; the fourth is the camera movement: "the bodily motion of the camera itself."[7] Since the very beginning, the relevance of what Don Ihde would call "motile experience" to provide a stronger form of simulation,[8] was perfectly present to the mind of film operators and technicians. While the still camera can provide a strong impression of reality, but it does not reduce the distance between the viewer and the screen, the moving camera not only implements our experience by adding kinesthetic, bodily, tactile cues as well as the sense of balance and gravity, but also gives the impression that the movie is to some extent *live*, that there is an intentionality which endows it with peculiar bodily functions and subjectivity.

The resonance effect provided by the camera movement would suggest that the impression of "being there," and exploring the film space and measuring its time, largely relies on a shared motor code. As Maurice Merleau-Ponty wrote in his notes for the "Cours au Collège de France" of 1953 – where cinema plays a role and the influence of French filmology is quite well detectable – "on perçoit donc mouvement, son sens, son allure characteristique, par possibilité motrices du corps propre."[9] As we have already showed in our abovementioned paper, this view was widely shared by many "film physiologists" between the 1910s and 1920s, and partly by some film theorists like for instance Léon Moussinac or Sergej Eisenstein, but it would be enough to read some interviews given by Hollywood directors to have an idea of how deep this conception of camera movement was.[10]

[7] Vivian Sobchack, "Toward Inhabited Space: the Semiotic Structure of Camera Movement in the Cinema," in *Semiotica*, no. 1-4, 1982, p. 317.

[8] "In the trajectory that began with monosensory simulations and then increased its complexity of those dimensions, adding audiovisual to visual, and ultimately kinesthetic-tactile to audiovisual, one could see a trajectory toward, although not reaching whole body, motile experience." Don Ihde, *Experimental Phenomenology 2nd Edition*, SUNY Press, Albany 2012, p. 142.

[9] Maurice Merleau-Ponty, *Le monde sensible et le monde de l'expression. Cours au Collège de France. Notes 1953*, texte établi et annoté par Emmanuel de Saint-Aubert et Stefan Kristensen, MetisPresses, Genève 2011, p. 119.

[10] To refer just to some of Bogdanovich's interviewees (Peter Bogdanovich, *Who the Devil Made It*, Knopf, New York 1997), Allan Dwan talks of the first time he decided to move the camera in 1915 movie *David Harum*, saying that viewers thought *they* were moving, while Fritz Lang, talking of the reasons of each camera movement, admits he never loved the zoom because it looks "unnatural."

The reasons that bring a director to move the camera are multiple: of course, the profilmic implicit 3D experience will gain intensity through movement, but also the kinetic, psychological and dramatic effects of the movie will be enhanced by these techniques, sometimes consisting of a complex combination of different camera movements. That said, we could sum up the very meaning of camera movement by borrowing Garrett Brown's statement: "In the movies, when the camera begins to move, we are suddenly given the missing information as to shape and layout and size. We are there."[11]

Though camera movement has even become a "moral issue," as notoriously French critics and filmmakers like Rivette, Moullet, and Godard saw it, such a technique was originally conceived as a means for strengthening cinematic intersubjectivity and to emphasize the relational nature of film style. Its importance was not well grasped by film theorists, and if we tried to look for essays or books on camera movements we would be disappointed. During the first phase of film history, camera movements were discussed and analyzed only in magazines devoted to the craft of cinematography, like for instance *American Cinematographer*.[12] In the following years, we do not find any thorough analysis, as such when David Bordwell decided to focus on camera movement in two 1970s essays, he observed that this issue had been considered as too elusive to be analyzable for long.[13]

Bordwell, who is more interested in the visual perception of camera movements than in their motor implications, focuses immediately on their anthropomorphism, saying that they would represent

> *a basis for the orthodox comparison between the camera and the human body. The head may rotate, that is, pan or tilt, or the entire organism may displace itself, may "locomote," by tracking or craning.*[14]

Bordwell goes on pointing out that we can hardly resist reading the effect provided by camera movements as a "persuasive surrogate for our subjective movement through an objective space,"[15] properly referring to our anthropomorphic conception of camera movement. Bordwell's assumptions have been basically shared both by film phenomenologists like Sobchack – who approaches camera movements from an embodied perspective, understanding them as natural as our bodily movements in space,[16] – or Voss – who put forward the idea of the

[11] Garrett Brown, "The Moving Camera. Part I," http://www.garrettcam.com/movingcamera/article1.htm, last visit 7 January 2014.
[12] A historical and theoretical survey on camera movements is Jakob Isak Nielsen, *Camera Movement in Narrative Cinema: Toward a Taxonomy of Functions*, Ph.D. dissertation, Department of Information and Media Studies, Faculty of Arts, University of Aarhus, 2007.
[13] David Bordwell, "Camera Movement and Cinematic Space," in *Ciné-Tracts*, no. 2, Summer 1977, pp. 19-25 and the prior "Camera Movement, the Coming of Sound, and the Classical Hollywood Style," now in Paul Kerr (ed.), *The Hollywood Film Industry*, Routledge, London 1984, pp. 148-153.
[14] David Bordwell, "Camera Movement and Cinematic Space," cit., p. 20.
[15] *Ivi*, p. 23.
[16] Vivian Sobchack, "Toward Inhabited Space: the Semiotic Structure of Camera Movement in the

viewer's body as a "surrogate body," which "loans" a three-dimensional body to the screen.[17] More obviously, such a position has been also shared by ecological/cognitive film theorists like Anderson – who says that through camera movements we feel as if we moved inside the diegetic space of film, and who was the first to claim an empirical study of dollies and zooms.[18]

When we first thought about an experiment on the viewer's brain motor responses to camera movement, we started from the idea that each movement implied a particular form of physical relation, and that a motor approach to its meaning would add to what Brown calls the "camera's putative presence and behavior."[19]

Moving mirrors: Motor Cognition and camera movements

For quite a long time the cortical motor system was considered as the mere neural controller of elementary physical features of movement such as force, direction and amplitude. This picture was revolutionized by the discovery that many cortical motor neurons do not discharge during the execution of elementary movements, but are active before and during motor acts – movements executed to accomplish a specific motor goal. Furthermore, it was discovered that the cortical motor system is endowed with sensory properties, perceptually responding to visual, auditory and somatosensory inputs.[20] Particularly revealing, in this respect, was the discovery of mirror neurons.[21] Mirror neurons, originally discovered in macaques and later on also revealed in the human brain, are motor neurons that not only respond to the execution of movements and actions, but also during their perception when executed by others. It has been proposed that the mirror mechanism instantiated by mirror neurons enables a direct form of action understanding: the relational character of behavior as mapped by the cortical motor system would enable the appreciation of purpose without relying on explicit inference. Altogether, these findings led

Cinema", cit., p. 317.

[17] Christiane Voss, "Film Experience and the Formation of Illusion: the Spectator as 'Surrogate Body' for the Cinema," in *Cinema Journal*, no. 4, Summer 2011, pp. 136-150.

[18] Joseph D. Anderson, "Moving Through the Diegetic World of the Motion Picture," in Lennard Højbjerg, Peter Schepelern (eds.), *Film Style and Story: a Tribute to Torben Grodal*, Museum Tusculanum Press, Copenhagen 2003, pp. 11-21.

[19] Garrett Brown, "The Moving Camera. Part II," http://www.garrettcam.com/movingcamera/article2.htm, last visit 7 January 2014.

[20] For reviews, see Giacomo Rizzolatti, Vittorio Gallese, "From action to meaning," in Jean-Luc Petit (ed.), *Les Neurosciences et la Philosophie de l'Action*, Vrin, Paris 1997, pp. 217-229; Vittorio Gallese, "The inner sense of action: agency and motor representations," in *Journal of Consciousness Studies*, no. 7, 2000, pp. 23-40.

[21] Vittorio Gallese, Luciano Fadiga, Leonardo Fogassi, Giacomo Rizzolatti, "Action recognition in the premotor cortex," in *Brain*, no. 119, 1996, pp. 593-609; Vittorio Gallese, Christian Keysers, Giacomo Rizzolatti, "A unifying view of the basis of social cognition," in *Trends in Cognitive Sciences*, no. 8, 2004, pp. 396-403.

to formulate the "Motor Cognition" hypothesis[22] as a leading element for the emergence of social cognition. According to this hypothesis, cognitive abilities like the hierarchical representation of action with respect to a distal goal, the detection of motor goals in others' behavior and action anticipation are possible because of the peculiar functional architecture of the motor system, organized in terms of goal-directed motor acts.

It should be added that a limiting factor of most experiments carried out so far to study the mirror mechanism in humans consisted of their avoidance of real social interactions, like movements of the observer towards or away from the observed agent. In a recent study we tried to fill this gap by devising a more ecological approach. We used a combined behavioral and high density EEG experiment to determine whether various types of camera movements, more or less simulating an observer's own movement toward the observed acting agent, might modulate observers' mirror mechanism.[23] Stimuli were short videos showing an agent performing goal-related hand actions, like grasping an object from a table and looking at it. We studied observers' motor cortex activation by measuring Event Related Desynchronization and Resynchronization (ERD/ERS) of the mu rhythm, a standard marker of "motor resonance," that is, of the activation of the mirror mechanism in observers' brains. Previous studies showed that voluntary action execution and observation correlate with ERD in upper alpha bands as well as in lower beta bands recorded over sensorimotor areas. Building on the design normally employed to investigate the hand action mirror mechanism, we focused on two questions: 1) whether the mirror mechanism responds differently to the observation of the same hand action filmed by a static camera in comparison with a moving camera approaching the scene; 2) whether the mirror mechanism activation is modulated by different ways a camera can be used to approach the scene. More precisely, we investigated whether the mirror mechanism is differently modulated by camera movements such as: a) zooming in on the scene; b) real camera movement towards the scene realized by using a dolly (camera mounted on fixed tracks); c) real camera movement towards the scene obtained by using a steadicam (camera fixed to the body of the cameraman, walking towards the scene).[24] We also investigated whether differences among viewing conditions (still, zoom, dolly, steadicam) could be related to participants' subjective

[22] Vittorio Gallese, Magali Rochat, Giuseppe Cossu, Corrado Sinigaglia, "Motor cognition and its role in the phylogeny and ontogeny of action understanding," in *Developmental Psychology*, no. 45, 2009, pp. 103-113.

[23] Katrin Heimann, Maria Alessandra Umiltà, Michele Guerra, Vittorio Gallese, "Moving mirrors: a high density EEG study investigating the effects of camera movements on motor cortex activation during action observation," in *Journal of Cognitive Neuroscience*, no. 9, 2014, pp. 2087-2101.

[24] Video clips were recorded in a professional film studio, enabling us to film the same scene 4 times under highly controlled conditions. The camera starting position was always 260 cm far from the filmed agent, the end position (in case of movement) was 80 cm from it. The camera movement speed as well as its height from the ground were kept identical in the three different movement conditions, so that the only difference among them consisted of the type of movement/approach to the scene: zoom, dolly and steadicam, respectively.

reports regarding the feeling of involvement and the experienced naturalness or artificiality of the camera movement used. At the end of the EEG recording session participants were again shown the same video clips and for each of them they were asked the following six different questions: 1) How much did you feel involved in the scene? 2) How much did you feel like the actor? 3) How much did you feel as if you yourself would approach the scene? 4) How comfortable did you feel watching the scene? 5) How realistic did you find the camera movement? 6) How much did you feel the camera movement resembled a person's movement when approaching the scene? Questions 3, 5 and 6, of course were not asked for still camera video clips.

The results of our study demonstrated that reducing the distance between spectators and observed agent, realized by moving the camera towards the scene, evoked stronger ERD of the mu rhythm during the observation of goal-directed hand actions. This difference reached significance only when the camera movement was realized by using the steadicam. Videos in which the zoom was applied reliably demonstrated a weaker activation of the motor cortex, as demonstrated by a stronger resynchronization. Results of control recordings from electrodes located over occipital visual areas, which were not affected by the different film styles, demonstrate that the observed different responses of the motor cortex to different film techniques are not due to mere increased attention evoked by the observation of these specific ways of filming actions.

The behavioral rating task showed that the steadicam was most able to produce a visual experience close to the one of a human approaching the scene. Indeed, participants perceived the movements of the steadicam as being the most natural and most resembling the movements of an approaching observer, thus eliciting the feeling that the observer him/herself would walk towards the scene.

These results suggest that film technique predicts time-course specifics of ERD/ERS during action observation, with only videos simulating the natural vision of a walking human observer eliciting a stronger ERD than videos filmed from a fixed position. Among videos dynamically reducing the distance between the observer and the observed agent, only those simulating the "natural" vision of a human observer approaching an agent do elicit a significantly stronger "motor resonance" in comparison to videos showing the same scene from a fixed distance. Furthermore, the artificiality of other ways of simulating the dynamic distance reduction (such as those obtained by filming the same scenes with the zoom or the dolly) appears to be reflected by differences in the time course of the resynchronization phase of the mu rhythm. The time-course of observers' motor cortex activation is modulated by the resemblance between the effect of camera movements and ordinary human vision. Familiarity with the visual experience provided by the video predicts the time course of the mu rhythm ERD/ERS.

Camera movements, the brain and film theory: closing the gap

The literature on film shows converging evidence on the centrality of camera movement for, on the one hand, building a concrete spatiality within film space[25] and, on the other, for inventing a film technique capable of approaching human vision. One of the most relevant characteristics of the steadicam, as explicitly stated by its inventor Garrett Brown, is precisely to simulate human vision.[26] According to the operator Larry McConkey, by means of the steadicam, the "camera becomes like another person and the audience becomes connected through that person to the other actors. The audience becomes more empathetic, more involved."[27] According to McConkey, what steadicam basically does is to convey the viewer's point of view inside the cinematic space-time, giving this point of view the immanence of a virtual body capable of moving in a very natural manner together with the film characters. Martin Scorsese used steadicam this way in very famous shots like the "Copacabana shot" in *Goodfellas* (Martin Scorsese, 1990) and the "Counting room shot" in *Casino* (Martin Scorsese, 1995). In both scenes the camera/viewer not only follows the characters, but also explores the profilmic space by turning its "head" and by focusing on details or accomplishing movements both related and unrelated to the characters' behavior. The sense of immersion is of course provided by the fluidity of the movement that conveys a very ecological approach to the scene without the overexcitement caused by the handheld camera, but it is provided as well by the motor engagement of the viewer, which has the impression to move freely inside the shot, following both the characters and his own curiosity.

In other words, the feeling of motion triggered by the steadicam seems to suggest a sort of independent movement of the viewer inside the shot, heightened by a stronger motor resonance, as we demonstrated for the first time with our study. This effect is quite well detectable in some shots of Stanley Kubrick's *The Shining* (1980), when the camera follows Danny's tricycle in the hallways or the kitchen of the hotel. When the kid exits the shot, Kubrick does not cut, but leaves the camera walking again for some seconds in the empty space, giving on the one hand the physical impression that a phantasmatic entity is actually following and threatening Danny, and on the other hand that the feeling of motion is to some extent independent from the character's action and intentions.

Even if sometimes the steadicam – as any other stylistic technique – can be used in a less embodied way, our experiment is more in line with Sobchack's ideas about steadicam than with Geuens' ones, according to which steadicam would leave behind the force and subjectivity of personal enunciation and would basically disembody vision.[28]

[25] John Belton, "The Bionic Eye: Zoom Esthetics," in *Cineaste*, no. 1, Winter 1980-81, pp. 20-27.
[26] Serena Ferrara, *Steadicam: Techniques and Aesthetics*, cit., p. 104.
[27] *Ivi*, pp. 123-24.
[28] Jean-Pierre Geuens, "Visuality and Power: the Work of the Steadicam," in *Film Quarterly*, no.

Our experiment clarifies widely shared ideas among film directors on the nature of camera movements. The zoom is usually considered as a fake movement or, at least, an abstract one, while the camera movement is the only way to elicit the audience's sense of presence. David Cronenberg stated:

> *One tool I never use is the zoom lens, because it doesn't correspond to my idea of filmmaking. The zoom is just an optical gadget; it's purely practical. And I will always prefer moving the camera, because I find that it physically projects you inside the film's space. And zooming doesn't achieve that. It keeps you outside.*[29]

Similarly, Bernardo Bertolucci said: "I hardly ever use a zoom. I don't know why, but I find that there's something fake about its movement."[30] As our experiment shows, the relationship between viewers' motor and empathic involvement and camera movements is best obtained with steadicam. Considering that, as Geuens notes, it is not so easy to distinguish a steadicam shot from others using traditional techniques, the results of our experiment emphasize the skill of the motor brain to recognize a different kind of camera's motor behavior.

By the same vein, these data allow us to say that film's intentionality and subjectivity are also grounded on viewers' embodied simulation of camera movements, suggesting that the immanence of cinematic subjectivity largely relies on the bodily nature and understanding of film. Our experiment provides strong empirical neuroscientific evidence supporting what Dominique Chateau wrote about subjectivity: "If film has something to do with subjectivity, it is to the extent that its moving form bears the imprint of a subjectivity."[31] In conclusion, the relational nature of film style and cinematic intersubjectivity can be usefully investigated by focusing on viewers' motor cognition implied by film techniques.

2, Winter 1993-1994, pp. 15-16.

[29] David Cronenberg in Laurent Tirard (ed.), *Moviemakers' Master Class*, Faber and Faber, New York 2002, p. 108.

[30] *Ivi*, p. 53.

[31] Dominique Chateau (ed.), *Subjectivity: Filmic Representation and the Spectator Experience*, cit., p. 166.