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Embodied Viewing and Degas's *Little Dancer Aged Fourteen*: a multi-disciplinary experiment in eye-tracking and motion capture

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Abstract:

This paper presents a cross-disciplinary project based on an experiment in eye- tracking and motion capture (Sainsbury's Centre for Visual Arts), which aimed to study viewers' movements around an iconic sculpture: Edgar Degas's Little Dancer Aged Fourteen. The experiment studies how viewers respond to this three-dimensional artwork not only by looking at it but also through their own bodily reactions to it, such as by unconsciously mimicking a represented attitude or gesture. We compared two groups of viewers: classically trained dancers and non-dancers. Our hypothesis was that the skills and embodied experiences of the dancers would alter the ways in which they engage bodily with the work compared to the non-dancers. Our underlying research question was: how are vision and the body interlinked in aesthetic and kinaesthetic experience? This paper does not give results, which are forthcoming. It focuses on methodology and provides a commentary on the design and development of the interdisciplinary collaboration behind the project. It explores an interdisciplinary collaborations that bridges the humanities and experimental sciences and asks how being confronted with unfamiliar methodologies forces researchers in a given field to critically self-examine the limits and presuppositions of their practices.

What determines a viewers' movements around a three dimensional work of art? How do viewers respond to it not only by looking at it but also through their own bodily reactions, such as by unconsciously mimicking a represented attitude or gesture? How are vision and the body interlinked in aesthetic and kinaesthetic experience? How, and through what interdisciplinary collaborations, can this be studied? In July 2017 the authors of this paper conducted an experiment at the Sainsbury's

Centre for Visual Arts that aimed to address the above questions in relation to Edgar Degas's iconic sculpture *Little Dancer Aged Fourteen,* first exhibited at the impressionist exhibition of 1881.[1] We set out to test the hypothesis that the work itself contains an invitation for the viewer to become mobile. We wanted to find out if it leads viewers through certain patterns of movement and if so, how? The experiment involved a collaboration between researchers with an art and humanities background and others using empirical and experimental methodologies. We were brought together by the international Network, "Evaluating Methods of Aesthetic Enquiry across Disciplines,"[2] whose own aim was to examine how different disciplines approach aesthetics and engage with other disciplines, whether distant or close.[3] Accordingly, our experiment was also concerned with what researchers from different disciplines can learn from each other and with the ways in which being confronted with unfamiliar methodologies forces researchers in a given field to critically self-examine the limits and presuppositions of their practices. One might describe such an approach as Cross-disciplinary Empirical Aesthetics, in as much as it seeks to closely embed empirical approaches with research questions from art history, aesthetics, visual culture, philosophy, etc. [4]

Our group consists of: two researchers with an expertise in biomechanics and the clinical study of human movement in the context of ageing and neurodegenerative disorders such as Parkinson's disease (Lisa Alcock and Claudia Mazzà) and two biomedical researchers with expertise in data processing and analysis (Eloise Briggs and Sarah Poyntz). It also included: two humanities scholars: one with a background in visual culture studies and art history (Boris Wiseman) and another in philosophy, in particular the phenomenology of technology (Annamaria Carusi). Finally, a psychologist trained in the methods of empirical aesthetics (Matthew Pelowski) completed the international team. Given the broad research questions outlined above, our first challenge was to design an experiment that allowed us to address them, one of the most creative and difficult aspects of the process. We decided to compare two groups of viewers: classically trained dancers and non-dancers. Our hypothesis was that the skills and embodied experiences of the dancers would alter the ways in which they engage bodily with the work compared to the non-dancers. We wanted to use trained dancers because of their experience in visually detecting motion cues, their enhanced visual-spatial processing, their aesthetic appreciation and kinesthetic sensitivity to posture and motion. Dancers served as the perfect candidates for addressing the core research questions about embodied viewing outlined above. We then aimed to isolate the effect of training and prior experience by comparing the data gathered from dancers with that from a control group.

We made innovative use of a series of recording technologies in order to try and grasp the differences between these two groups empirically, while at the same time drawing on our cross-disciplinary discussions to reflect on how we were using these technologies, which ones to use, how to deploy them and adjust them according to the specific context. Addressing questions about the design of the experiment involved technical expertise but it was a creative process too.

The volume and complexity of the data collected are such that the results of this pilot experiment have not yet been fully analysed. This paper will not give results. It will focus on methodology and will provide a commentary on the design and development of this interdisciplinary collaboration. Its rationale is to present the innovative approach to the analysis of aesthetics experience that we adopted, to shed light on the different disciplinary perspectives that the experiment opened up and to discuss the implications of collaborating across disciplines as we tried to do, including when this confronted us with the difficulties involved in such a collaboration. The results will be presented in a separate paper.

The place of technology

We used a mobile monocular infrared eye-tracker (Dikablis, Ergoneers, GmbH, Germany) to measure gaze behaviour from participants as they navigated the gallery space and observed the statue. It was a surprise to the humanities scholars taking part in the project to discover that most existing eye-tracking studies of viewers looking at 3D objects in fact use 2D images of the object presented on a computer screen. There are relatively few museum-based studies for sculpture and installations (Pelowski et al., 2017) although Pelowski et al. (2018) used eye-tracking with installation art. Despite this scarcity, other kinds of approaches remain relevant to what we undertook, including the study by Orlandi et (2017) in which videos of performances were used to show that dance expertise modulates visual sensitivity to complex biological movements. Also worthy of note are the studies of viewers looking at 2-D works in a museum setting that use mobile eye-trackers such as Walker et al. (2017) which was conducted in the Vincent Van Gogh Museum and looked at how so-called top-down and bottom-up attentional processes affect the viewing behavior of adults and children.

Eye-tracking data allows researchers in empirical aesthetics to analyse viewers' eye movements in two ways. Eye movements may be quantified temporally, that is the timing and amplitude of eye movements can be quantified (saccades), or spatially, by extracting contextual information from where someone is foveating relative to space and time (i.e. fixation location). See Stuart et al. (2014, 2016, 2018) for more extensive presentations of this methodology. The temporal and spatial analysis of eye-tracking data is complementary and both are needed in our study. They will tell us in what order the different features of the *Little Dancer* were visually processed and how much time was spent on each. This could be relevant for understanding the relative importance of top down and bottom up visual processing, which in turn links back to the notion that the prior experience of dancers will affect movement around the work and viewing patterns. Bottom-up processing usually takes place when the object is being viewed for the first time. Eye movements are often the result of direct environmental input. Bottom-up processing is linked to attention and to ways of looking that have been modified by prior knowledge or assumptions about the visual environment. The eye-tracker obtains video footage from two head-mounted cameras, one positioned to record the movement of the viewer's left pupil (eye camera), and the other to record the visual scene the viewer perceives (field camera). Overlaying the video data from the two cameras allows us to extract fixation locations.

The fact that few eye-tracking studies take place in the gallery is in part due to technological challenges, including the difficulty of creating a controlled environment, targeting particular features or interactions that are empirically interesting, while also minimizing the conflation of the rich mix of ambient variables in the setting. How does one focus a participant on a specific piece of artwork and ignore other pieces within the gallery/ museum? How to manage the presence of other people in the testing environment? Do we need to constrain the movement path for negotiating the museum? This is coupled with the difficulty in obtaining permission to access a museum or gallery, which provides a natural environment for viewing such artwork, to conduct these studies. There are many considerations, for example; the financial implications of restricting public access to the museum during research assessments, or controlling the distractors and other environmental features, which may equally increase the ecological validity of the testing environment/paradigm. Crucially, the shifting focal plane and distance between eye and artwork also makes it difficult to code or quantify the resulting looking information. This is probably the major reason studies are not often done with museum art.

Our experiment combined this data with two further measures of viewers' embodied reactions: wireless in-shoe pressure insoles (F-Scan, Tekscan, Boston) and wearable inertial sensors, (Opal, APDM, Portland). (See Storm, Buckley and Mazza [2016] for another instance of combining these instruments for real life measurements.) Both devices provide very detailed and comprehensive measures of movement and where in relation to the statue the viewer was standing to look at the work and roughly how close they were to it (no numerical data is available for the latter). The insoles logged the plantar pressure distributions as a function of time, using force-sensing-resistor technology. Subjects wore the inertial sensors on their wrists, ankles, back (lumber spine; L5), and forehead. They are comprised of a gyroscope, which works in conjunction with a magnetometer to record angular motion events (flexing motions or turnings), and an accelerometer, which collects linear data (accelerations in a straight line). We will use the data from the inertial sensors to describe the motion of different parts of the body, such as stepping, turning the head, moving the pelvis, etc. Data from the pressure insoles will be used to extract the distribution of pressure exerted on each foot during the observation. Initial analysis of this information will allow us to understand, first, how mobile individuals were whilst looking at the *Little Dancer* and, second, whether, when they were standing still, they tended to put more weight on one foot than the other. The aim is to try and identify instances in which viewers appeared to replicate the posture and weight distribution of the *Little Dancer*.

What is unique about this approach is that it allows us to associate the movement and physical reactions of individuals to the visual stimulus that they are scrutinising at the time, i.e. to associate embodied reactions to specific features of the work of art. The technology enables measurement of the visual and motor systems and their interaction, providing an objective, quantitative measure, which may be used to compare the two groups. These measures are invaluable but nevertheless leave the interpretative act open, as it is an act that requires a leap, maybe several, beyond the horizon of data and objective measurement, one that requires researches in different fields giving meaning to the data, which in turn involves applying different criteria of validity and truthfulness depending on the disciplinary perspectives adopted.

The viewpoint from art history and visual culture studies

The nature of the experiment that we conducted is different if we consider it in terms of its relevance to art history and visual culture studies as opposed to, say, experimental psychology. In the former case what comes to the fore is what the data tells us about the particular artwork on which we decided to focus. The experiment is a way of approaching the work of art. Empirical aesthetics as informed by psychology takes a different approach. The work of art is an example that serves to advance a particular line of experimental study, that allows one to test (psychological) hypotheses. The two approaches feed into one another and may at times flip but are not the same.

In carrying out our project we wanted to ensure that we maintained the focus on the work of art as a unique object, that we didn't lose sight of Degas's sculpture. This is in part because the study was initially construed as a response to current research in Degas scholarship that argues that rendering movement was one of the major impulses behind Degas's ballet imagery (Kendall and Devonyar 2011, 15; Wiseman and Cole 2013) and that Degas, in the process of depicting movement, in turn, invited his viewers to become mobile (77). Degas's approach "entailed new ways of scrutinising and representing subjects such as dancers … the process of looking becomes a dynamic event" (71). As Kendall and Devonyar further argue, this transmission of mobility was deeply rooted in Degas's working methods, in his patterns of movement around his model, Marie van Goethem, whom he scrutinized from every

angle to created 2D studies of her that often assembled, on the same sheet, multiple views of the same attitude as seen from different angles (77). When one looks at these studies (e.g. *Three Studies of a Dancer*, from the Morgan Library and Museum), it is as if the model is rotating in space and that Degas placed her in a navigable virtual environment.

Art historically, the *Little Dancer Aged Fourteen* has been associated with the very beginnings of modern sculpture (Millard 1976, 7-8; Gaudichon 2010, 27-29 – the latter suggests that Picasso modelled his *Fou* [1905] in wax to situate himself in Degas's lineage and that both Matisse and Bourdelle were influenced by Degas). This is, in part, because of the realism in Degas's treatment of his subject. Far from showing an idealized female figure, what he depicted were the effects on the body of a young girl of the intense and repetitive exercises of ballet training. But what also makes the figure modern is, arguably, the above mentioned invitation to become mobile: Degas's figure seems to be best viewed in the round, as opposed to from a privileged viewpoint, as was usually the case in nineteenth-century neo-classical sculpture. Debates about the extent to which viewers should be invited to move around a statue, and the number of viewpoints it should provide, had been ongoing since the Renaissance when sculpture freed itself from the architectural features that often assigned a fixed viewing point and started to explore viewing in the round (Larsson 1974). Degas's *Little Dancer* is one of the culminating points of that development. This is something that American minimalist sculptor Richard Serra understood very well, albeit it more intuitively. As he put it "I looked at Degas's dancer this morning and came to the conclusion that the way in which his sculpture drinks the whole space from the room right into its grasp is pretty good. […] Very few figurative sculptors with the exception of Giacometti are able to do that." (cited in Potts 2001, 260). Our experiment tries to grasp some of the mechanisms involved in this art historically important transition towards mobile viewing. It is also something that museums understand well, as is evidenced by their websites. Most of them, at the very least, present multiple views of the figure, minimally 4 views corresponding to front, rear and sides. The National Gallery of Art has a figure that that can be rotated by means of a mouse or similar. It presents 11 views of the *Little Dancer*. Other museums upload tracking videos. The SCVA, where we experimented, incorporates a link to a Youtube video that includes a telling sequential montage of close-ups that pans around the figure. This treatment, compared to that given by museums to other sculptures, is distinctive.

Our aim, therefore, was to attempt to grasp the triggers / determinants of viewer mobility experimentally. It is in this respect that experimentation, for us, is inherently linked to exploring the aesthetic and cultural significance of this specific artwork, although we clearly also depart from a strict art historical approach in as much as we have tested contemporary viewers and not the viewers' of Degas's times, who are perhaps more important for art historians. That said, it would theoretically be possible to explore today, for example, how aspects of the original display at the 1881 Impressionist exhibition are likely to have impacted on visual responses, for example, the height at which the figure was displayed or the fact of having put it in a glass display cabinet.

In terms of the *Little Dancer*, examples of what interest us in terms of viewer mobility are: what are viewers' looking at when they themselves start to move? The head and torso of the figure are relatively static and frontal whilst the legs and feet introduce the idea of motion around the figure in the very position that Degas selected. Does this formal division affect the visual experience? A similar question may be asked about the arms, leading us round the back where we discover the surprise bow in her hair? Alternatively, is the weight distribution of the figure significant in terms of viewer mobility or embodied responses? The *Little Dancer* is holding ballet's fourth position, a familiar position to all trained dancers, but she is doing so in a relaxed way, with the weight on her rear foot, as opposed to evenly spread (this suggests, as do her half-closed eyes, that she is in the wings waiting rather than on

stage performing). Do viewers pay attention to the way the figure is balanced? Does this matter more for the dancers than the non-dancers? The fourth position is usually the start of a pirouette and most dancers who took part in the study had a clear sense of the direction in which Degas's figure would turn if she were to snap out of her reverie and move on to the next moment in time (they make a judgment based on the basis of the position of her feet). Do the dancers in the study follow that direction to a greater extent than non-dancers? Or the opposite direction? I.e.: how does knowledge of the fourth position affect how the work is experienced? One of the challenges of this project in terms of visual culture studies and art history is to ensure that we do not lose sight of the specific artwork that gave rise to the experiment. [5]

The viewpoint from empirical psychology

The questions that interest us from the point of view of visual culture studies and art history can be taken up in different ways within the field of experimental psychology. For example, differentiating between active and passive viewers, raises the key question of how movement modulates our perception and experience of art? Perhaps the ideal way to appreciate certain works of art is to circumnavigate them? This hypothesis has almost never been empirically addressed, especially not in a museum setting (Pelowski et al. 2017).

The experiment with the Degas figure presents a unique opportunity to study the differences between what one might think of as a more 'natural' way of perceiving and the more fixed vantage points usually associated with behavior in gallery spaces. As noted by Gibson (1955, 205), vision is not only a pair of eyeballs. Rather, one "sees the environment …with the eyes-in-the-head-on-the-body-resting-on-the-ground." This idea of "natural vision," a process of information pickup that is exploratory, involving looking and moving around, might be contrasted against "mediated perception" or "seeing a picture" as occurs with a static participant, for example, looking at the copy of an artwork on a computer screen. Gibson's description of what happens in "natural" viewing mirrors our study of the *Little Dancer*. Unlike the fixed perception of a seated viewer, "when [less] constraints are put on the visual system" -- as would occur in a lab where we require an individual to sit in a chair, look at a screen, or even place one's head in a chin rest -- in natural vision we move around an object "so as to see it from all sides, and go from one vista to another" (Turner and Penn 2002, 474).

In turn, free moving and where someone is looking may have important implications for perception, appraisals, and even our cognitive processing. Walking while doing simple cognitive tasks, as opposed to being seated, may lead to increased activation in the prefrontal cortex (Hamacher et al., 2015), an area of the brain tied to executive function and a key region in viewing art (Jacobsen et al., 2006). Even mentally preparing to walk to a target, as might occur upon seeing an artwork across a gallery, leads to increased activation in prefrontal and parietal areas (Suzuki, Miyai, Ono, & Kubota, 2008). Novitz (2001, p. 153) also notes that allowing one to move and explore may encourage an active/participatory mode of viewing, heightening appreciation or depth of looking. Whereas confining an individual to 'just looking' may lead to more passive non-participatory responses. This argument has been accepted for over 70 years but few studies assess it, especially with complex artifacts such as art. Limitations in how to record movement or eye-tracking have also made this particularly difficult until recent technological advancements. This study presents a compelling test case.

For the above reasons, moving around a sculpture may be required to enjoy it. The same may be said of installation works (Pelowski et al., 2018). Perhaps this is because moving leads to a more

temporal uncovering of information, which could change our understanding or create a more dynamic, evolving experience? Returning to the Degas case, one could ask whether certain patterns of movement, say clockwise or not, correlate to more liking or understanding? We might also ask about viewing distance, as this could be a critical factor in appreciation, however it is often not considered (Pelowski et al., 2017). Viewers have been shown to have high interpersonal differences in what they find to be a good distance from which to view art (Clarke et al., 1984). Viewers also sometimes choose viewing points to limit or change their viewing experience. The *Little Dancer* provides a perfect example to assess this range of behavior and link it to a rich art historical tradition, which goes back to the innovations in sculpture that took place during the Renaissance, when artists started to free themselves of the architectural structures that largely determined viewing positions during the Middle Ages.

The work also offers an opportunity to consider bodily mirroring or empathy with art. It has long been argued that one—perhaps universal and automatic—means of engaging art is via a feeling of empathy – in German "Einfühlung" (Lipps, 1903) - whereby individuals 'feel into' or embody the actions or expressions of another human (Gerger, Pelowski, & Leder, 2017). This can occur via the traces left by the artist (Freedberg and Gallese, 2007). For example, a study of viewing pointillist and impressionist paintings showed that when participants make the same actions as the artist they prefer the matching styles more (Leder, Bär, et al., 2012). Empathy can also occur via viewing content with other humans or, potentially, other depicted bodies. Notably, these reactions are supported by studies of the brain in which the observation of actions can lead to the activation of the neural networks—so called "mirror neuron" systems—that would also be active when actually making the same actions (Umilta et al., 2012). Observation of representational artworks including humans or nature as well as abstract art works have been shown to activate motor representations (Di Dio et al., 2016). Similarly, with psycho-physiological recordings, individuals automatically adjust their posture in response to abstract and representational paintings and sculptures (Kapoula, Adenis, Thanh-Thuan, Yang, & Lipede, 2011).

Degas aimed to depict as naturally as possible a ballet dancer in the fourth position. Do individuals naturally mimic the posture and can this be tracked in their physiological responses? Does this impact appreciation? Early conceptions of "Einfühlung," for example, described such embodied kinaesthetic simulations as essential to aesthetic experiences (Jahoda, 2005). Does this require expertise in the viewer? In one of the groundbreaking studies in this domain (Calvo-Merino et al., 2004), researchers showed movies of either ballet or capoeira to professionals of each domain. The results suggested that the responses in the brains of the seated, unmoving viewers watching the movies were similar to those of the dancers, but only for the experts of each style of dance. Here too, Degas's sculpture makes a perfect case.

Practicing multidisciplinarity

One of the hallmarks of the research we have undertaken as a group is its combination of different disciplinary methodologies. Truly interdisciplinary research is not easy; it takes a lot of patience and a great deal of stretching of our intellectual boundaries. It also takes a lot of stretching of the boundaries of what we expect to do in a day's work, as for the first time, the arts and humanities scholars on the project spent days and weeks recruiting research participants, and two days strapping equipment onto them, doing basic eye tests on them, handing out surveys, etc. We have agonized over highly detailed questions of research design and methodology, in a domain that as arts and humanities scholars, we

may have thought we had a good grasp of: looking at art. For the purposes of the experiment, however, we had to try to set aside all of our assumptions, expectations and theories. While the whole team aimed at obtaining data from as naturalistic an experience as possible of viewers' interactions with the sculpture in the museum, and while we all accepted that the process of strapping on the various bits of tracking equipment was a disruption of naturalism, from an arts and humanities perspective we were left with questions as to whether it was so significant a disruption that it was wholly unlike a 'normal' interaction with art in a gallery space? For our colleagues in biomechanics, the project has often meant having to repeat many times what were for them obvious aspects of tracking experiments, such as determining which eye movements could be tracked on what size objects and addressing generalized technological quandaries regarding device synchronisation and calibration.

As we brainstormed further potential extensions of our experiment, we discovered differences in what we might take for granted. For example, in discussing the potential for a virtual reality version of the experiment, for researchers in biomechanics the assumption was that this should not make a great difference to how viewers interact with the sculpture, so long as the VR was realistic, whereas for arts and humanities, this was an open question, as we are more likely to be critical of claims to realism in any form (Carusi 2016).

What has been the motivation to keep us working within a collaboration which was not straightforward? The core motivation for this was a shared interest in trying to unpack what it means to think of vision as related to other aspects of embodiment, i.e. a shared interest in 'embodied vision', which is more than a gaze that happens to emanate from a body, which, in principle, could be abstracted from vision. Rather, the notion implies that vision is essentially related to embodiment. However, we do not share this notion of 'embodied vision' as such. The methods of our empirical research are focused on probing the relations that might exist between looking and moving. From a phenomenological perspective, a close interconnection between looking and moving is to be expected from classical accounts in, for example, Maurice Merleau-Ponty's *Phenomenology of Perception*. Merleau-Ponty disrupted a long line of classical philosophy of perception by claiming the *body* as the subject of perception, and in many fields, in the humanities and beyond, the ripple effects of this bold move have still not been fully taken on board. He accomplished this through the painstaking methods of phenomenology, which each leading figure in phenomenology exemplifies in different ways, and has quite different ideas on. Like psychologists, phenomenologists aim to arrive at a general theory of embodied vision, and have distinctive ways -- even 'methods' sometimes -- of achieving this. For example, Merleau-Ponty turned to a certain type of art as itself exemplifying a phenomenological method which he considered to reveal the hidden connections between looking, being a moving body and interacting in spatial environments in embodied vision. And we see in Degas's own practice as an artist a profound meditation on movement. For Degas, art is in part a method – indeed many methods – for understanding movement. But what is that method and what does it show about the relationship between seeing and rendering movement to vision through art? This is an art historical as well as philosophical question. We may well ask what it is that philosophers, artists and art historians, might gain from experimental methods that are essentially measuring and from quantifying approaches to phenomena that from their perspective, precisely resist measurement and quantification? Or the opposite: what is it that our colleagues in psychology and biomechanics might gain from working with our essentially qualitative and conceptual methods? In answer we might say that the more theoretical, historical and critical approaches might hope to gain empirical evidence in support of the notion of embodied vision that will further support this way of understanding vision, and will be a further nail in the coffin of the disembodied gaze. And on the side of our colleagues in biomechanics, aside from investigating the interaction between eye movements and body movements in response to observing an object within the environment there is the advantage of testing equipment and seeing how well it

performs. . However, importantly, there is also the other side of this interdisciplinary collaboration, the need to ask: what are the limits of interdisciplinarity? How convergent are our understandings of the phenomenon we are exploring: research participants wearing various devices measuring and tracking eye and body movements while they observe an art work; answering survey questions; movement represented in art; movement understood through phenomenological philosophy and through art.

The discussions and deliberations of what is possible for us to do as a group are as important as the results that we will obtain once the data has been processed and interpreted. Collaboratively engaging with research design has been challenging, as we each had to formulate what our common research questions were and reach a consensus as to what is realistic to achieve experimentally. But it has also been a creative and productive process. However, we do also ask what is the nature of the evidence gained through experiments to track vision and movement? If, for example, our expectations of the relationship between vision and movement are not backed up through our empirical experiments, will we give up the notion of embodied vision that we have gained through phenomenology and art? What will be the relationship between movement measured and movement observed and meditated upon? Part of what differentiates these two kinds of movements is the type of subject constructed by each difference - in psychology, the viewing subject is a statistical construct, for humanities scholars, it is an historical one, a cultural subject and perhaps sometimes even a version of the self. To what extent can arts and humanities approaches meaningfully interact with, and even potentially influence, the measuring culture of the engineering approach to movement? These questions are as much a part of our interdisciplinary collaboration as obtaining results. As we are carrying out this interdisciplinary research, we are also reflecting on what does not work, as well as on what does, what is easy and what, instead, is difficult, where do the different ways of approaching movement flow together, where do they come apart, and where do they encroach upon one another?

The divergences between disciplines are also linguistic divisions, which have got to do, for example, with the ways in which a humanities approach might be more interested in what lies beyond the grasp of technology, whereas an empirical might simply decide not to focus on that. Eye-tracking allows us to determine the movements of the beholder's pupils at the level of milliseconds, which in turn allows us to deduce what viewers are looking at. But what viewers are looking is something different from what they "see", a broader, fuzzier category. One aspect of vision that eye-tracking leaves out is peripheral vision. Creating maps of the most frequently made fixations and saccades says little, for example, about how a viewer might be taking in the overall colour effects of a work of art, or its surface patina, if it is a 3-D work. It focuses us on representational content, especially human figures and on local detail as opposed to the whole work. This may perhaps be an unavoidable consequence of the limitations of the available technology. Nevertheless, the question remains of how to deal discursively with what the technology misses.

Conclusion

During the course of our work together we started to think about ways of presenting our approach to empirical experimentation visually. Although we did not, in the end, think that it was useful to fix what we were doing in some encompassing diagramme, the visual model that we found the most satisfying involved depicting our various approaches as forming a moving spiral around the central dyad made

up of the work + the viewer. In this diagramme, each successive level of analysis (discipline) takes up and reworks what has already been done by others at another level. In this spiraling motion, each level of analysis is in turn product and basis for another level of analysis. This is no more than a visual metaphor, but it is useful in suggesting the way in which different disciplinary perspectives may be brought into play with one another, without one of them taking precedence over the other or eclipsing the alternative views made possible by disciplinary shifts. Moving between different levels of analysis, which correspond to the different methods and approaches of different disciplines, is a good working model of how multi-disciplinary collaboration might ideally work.

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[1] The SCVA holds one of the bronze casts made posthumously by A.A. Hébrard, edition unknown. We are grateful to the SCVA for granting access and for supporting the experiment.

[2] Funded by the Leverhulme Trust (2015-2018).

[3] For a detailed presentation of the project see the introduction to the special issue of *Senses and Society* [13(3)] devoted to the Network, (Reynolds and Wiseman 2018).

[4] In some of its aspects this project echoes nineteenth century interest in physiological and sensory responses to art, which at the time were also often approached empirically. Vernon Lee’s psychological aesthetics, for example, traced bodily changes in posture and breathing that resulted from “empathetic” reactions to art (see: Susan Lanzoni 2009). One might also have cited her collaborator Clementina Anstruther-Thomson. Looking at similar connections from a different perspective, Robert Michael Brain (2016) has shown to what extent artistic practices associated with modernism were indebted to late nineteenth-century experimental physiology, such as Etienne-Jules Marey’s graphic method, developed for recording and transcribing movement in the form of graphs (lines).

[5] A crucial aspect of the Leverhulme workshops that has informed our approach to Degas’s work was its museum-based handling sessions. One of them gave rise to a series of

responses that further illustrate qualitative approaches to sensing (as opposed to simply viewing) art. See David Howes, Eric Clarke, Fiona Macpherson, Beverley Best & Rupert Cox (2013). For an historical study of multi-sensory ways of engaging with art see Constance Classen's *The Museum of the Senses* (2017).