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Does "Action Viewing" Really Exist? Perceived Dynamism and Viewing Behaviour

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Abstract

Throughout the 20th century, there have been many different forms of abstract painting. While works by some artists, i.e., Piet Mondrian, are usually described as static, others are described as dynamic, such as Jackson Pollock's "action paintings". Art historians have assumed that beholders do not only conceptualise such differences in depicted dynamics but also mirror these in their viewing behaviour. In an interdisciplinary eye-tracking study, we tested this concept through investigating both – the localisation of fixations (polyfocal viewing) and the average duration of fixations as well as saccade velocity, duration and path curvature. We showed 30 different abstract paintings to 40 participants – 20 laypeople and 20 experts (art students) and used self-reporting to investigate the perceived dynamism of each painting and its relationship with a) the average number and duration of fixations b) the average number, duration and velocity of saccades as well as the amplitude and curvature area of saccade paths, and c) pleasantness and familiarity ratings. We found that the average number of fixations and saccades, saccade velocity, and pleasantness ratings increase with an increase in perceived dynamism ratings. Meanwhile the saccade duration decreased with an increase in perceived dynamism. Additionally, the analysis showed that experts gave higher dynamic ratings compared to laypeople and were more familiar with the artworks. These results indicate that there is a correlation between perceived dynamism in abstract painting and viewing behaviour – something that has long been assumed by art historians but had never been empirically supported.

Keywords

Art perception, eye tracking, eye movements, abstract art, dynamism, action painting

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1. Theoretical Background

1.1. Background in Art History

Compared to representational art, perception processes of abstract art are more ambiguous. The lack of figuration and representation in abstract art leads to a stronger emphasis on the impacts of pure pictorial elements such as lines, shapes and colours on the viewer (e.g., Kelly, 2016; Schapiro, 1937). Non-representational pictures have existed for centuries (Rosenberg, 2007) but it is only around 1910 that they were declared to be art – "Abstract Art". The exhibition „Cubism and Abstract Art" organized by Alfred Barr at the MoMA in New York City in 1936 was among the very first attempts to establish a history of abstract art. His famous schematic evolutionary model of modern art, which was represented on the exhibition catalogue's cover, culminates in abstraction (Barr, 1936). Since the combination and application possibilities of the basic elements of lines and colours are endless, and since there are big differences in the way artists employ them, Barr divided abstraction into geometrical and non-geometrical approaches. Later other forms of abstract art such as Abstract Expressionism have established. They cannot be clearly assigned to one of these two categories.

Discussing the effect of the artworks on the viewer has been an important issue of art theory ever since the 18th century and became even more important with abstract art after 1910 (Rosenberg, 2007, p. 17–53). In this discourse, art critics and historians usually assume that the use of differing lines, forms, and colours in abstract artworks also leads to varying effects on the viewer (Brinkmann *et al.*, 2018a) and, depending on these effects, different ways of seeing. If, for example, a colour in a painting evokes a calming effect, this effect is assumed to be reflected in the way we look at this painting. There is a great variety of abstract art in the 20th century. Some paintings are more geometric and tend to be described as static, such as works by Piet Mondrian and Josef Albers, others are rather chaotic ("informal") and are generally described as dynamic, like the canvases by Jackson Pollock or Karl Otto Götz. However, art historians do not agree on clear-cut categories. They have described Pollock's works as "action paintings" (Rosenberg, 1952), but also Piero Manzoni's "Achromes" as "dynamic" (Celant, 1981, p. 41), even though their aesthetic qualities are completely different (see Fig. 1).

Pollock's, at the time, new way of art production, involving the whole body moving on a canvas that was laid on the floor, led to visually complex works transporting the energy of the creation process. By looking at the painting, the beholder gets an impression of the movements that have been performed to smash or drop the paint on the canvas. Ernst Gombrich

for example, stated with regard to Pollock, that the painter "must make us read his brushmarks as traces of his gestures and actions. This, I take it, is what the 'action painter' aims at" (Gombrich, 1960, pp. 286–87). In regard to an "Achrome" by Manzoni, the art critic Germano Celant wrote that it "is an expression of a living dynamic presence. One can therefore undoubtedly see the achrome as an actual being, which, like Piero Manzoni, leaves lasting traces." (Celant, 1981, p. 41). Again, the traces of the physical action performed by the artist during the creation process of the artwork are considered as "dynamic". Ulf Küster went one step further by indicating that the action of the production process is not only *perceived* by the beholder, but also *mirrored in his viewing behaviour*, when he explains "There is no 'action painting' without 'action viewing'" (Küster, 2008, p. 19).

Besides this plausible hypothesis of "action viewing", which suggests a dynamic way of viewing, in art historical literature, we can also find the hypothesis that viewers adopt a broad distribution of attention when it comes to dynamic paintings. This assumption is linked to the "all-over", a term describing a specific manner of covering big canvases completely, without, as often usual, privileging the centre and or other parts of the painting surface. This term was coined by Clement Greenberg and defined as "the 'decentralized,' 'polyphonic,' all-over picture which, with a surface knit together of a multiplicity of identical or similar elements, repeats itself without strong variation from one end of the canvas to the other and dispenses, apparently, with beginning, middle, and ending." (Greenberg, 1948, p. 222). Michael Fried, for example, suggests that, "in spite of their diversity, homogeneous visual fabric which both invites the act of seeing on the part of the spectator and yet gives his eye nowhere to rest once and for all. That is, Pollock's all-over drip paintings refuse to bring one's attention to a focus anywhere" (Fried, 1965, p. 14). Walter Kambartel, who explicitly refers to Fried, specifies this artistic strategy as a "polyfocal all-over", because the structure of the canvas ground is very homogenous (Kambartel, 1970, p. 15). This means that the viewer cannot detect a single vanishing point, identify a central motif or pinpoint a prominent part in the composition. In line with this argument, Boehm (2008) assumes that Pollock's work elicits a rambling gaze. These hypotheses, which are ultimately based on the subjective experience of the authors, are not only a topic in art history. Neuroscientist Eric Kandel argued that the work of Pollock leaves "our eyes … constantly on the move: our gaze cannot settle or focus on the canvas. This is why we perceive action paintings as vital and dynamic." (Kandel, 2016, p. 104). This is also true for Manzoni's "Achrome". It is monochromatic and consists of a canvas soaked in kaolin china clay and folded in order to obtain 20 squares. This process creates an uneven surface, which emphasizes the haptic qualities and directs the viewer's attention to the materiality of the work.

The treatment of the surface is relatively uniform as well, and we do not find a central motif or a specific prominent area.

The emphasis on viewing behaviour and perceived dynamism in art critical texts leads to investigate both hypotheses–of action viewing and the polyfocal gaze—in an eye tracking study.

1.2. Background in Empirical Studies

The idea — that the "gesture" and the "action" of the creation process is reflected in the viewer — leads to the assumption that perceived dynamism is closely linked to "embodiment". Freedberg and Gallese (2007) suggested that mirror neurons are involved in a process they denominated "embodied resonance", when the viewer bodily responds to non-moving, static artworks such as paintings or sculptures. Sbriscia-Fioretti *et al.* (2013) empirically investigated if the movements performed by the artist during the creation process are mirrored in the viewer's brain by showing paintings by Franz Kline in an EEG experiment. Compared to Pollock's all-over paintings, the strokes by Kline are typically broad and one stroke can cover almost the complete width of the image surface. Many paintings by Kline show brushstrokes reaching across the whole canvas like a record of his own movements performed during the creation process. Sbriscia-Fioretti *et al.* (2013) found an activation of premotor and motor cortical areas in the viewers. This shows a reconstruction of actions observed with a static stimulus such as a painting in the brain. This mental reconstruction of an action such as painting with a brush is referred to as embodiment. It seems plausible that an echo of depicted dynamism in form of visible traces of motions in a painting is not only found in the viewer's brain activity but also in the viewing behaviour.

2. Gaze Behaviour and Art Viewing

Eye tracking techniques have been used successfully for a long time to examine art appreciation (Buswell, 1935; Nodine and Krupinski, 2003; Rosenberg and Klein, 2015; Yarbus, 1967). Eye tracking studies dealing with abstract art mainly focus on the comparison between representational and abstract paintings (e.g., Brinkmann *et al.*, 2014; Bubić *et al.*, 2017; Pihko *et al.*, 2011; Uusitalo *et al.*, 2009; Zangemeister *et al.*, 1995) without acknowledging the variance between different types of abstract painting. There are two papers dealing exclusively using Pollock's paintings: one by Notter (2008) and another by Taylor *et al.* (2011). Neither aim to compare the viewing behaviour between different types of abstract artworks. Notter

focused on complexity in Pollock's drip-paintings and examined eye-movement behaviour and its relation to measures of appreciation (Notter, 2008, p. 22–23). The analysis of the data investigated differences in fixation durations and saccade amplitudes for different time segments. Following Locher *et al.* (2007), the segments 0–3 sec, 3–7 sec, and 7–10 sec were analysed. The results showed that fixation duration did not differ over all images, but saccade amplitudes decreased significantly, particularly from the first to the second time segment (Notter, 2008, p. 57). There was no consistent correlation for appreciation and viewing behaviour. Taylor et al. focused on fractal structures that they found in many Pollock paintings. They showed that the use of fractals seems to increase in the course of his career (Taylor *et al.*, 2011, p. 3) and that a special fractal dimension of 1.3–1.5 was preferred by the viewers (ibd., p. 5). In a follow up eye tracking study, they found that saccade patterns follow a similar fractal dimension when the eye is in search mode. They suggest that this intrinsic movement of the eye could be the reason for the preference.

Other eye tracking studies targeting paintings and perceived dynamism showed artworks which are not purely abstract, like futurist paintings (cf. Cattaneo *et al.*, 2017; Kim et al., 2012; Mastandrea and Umiltà, 2016). Commare and Brinkmann (2016) made a first attempt to study the effect of differences in perceived dynamism and activity in abstract artworks on eye movements. They investigated the connection between perceived dynamism and the duration and distribution of fixations by recording the eye movements of 40 participants and implementing a rating task for different aesthetic effects such as perceived activity and dynamism. The set of stimuli contained ten abstract paintings by Karl Otto Götz, Vasily Kandinsky, Robert Motherwell, Sam Francis and Jackson Pollock. The results showed a correlation between perceived dynamism and the distribution of fixations. The distribution of fixations was much broader for paintings rated highly dynamic than for those rated as static. However, no differences concerning the average fixation duration in relation to perceived activity and dynamism (which can be related to action viewing) could be found in this study.

In the same way that we would expect viewers' fixations to be influenced by perceived dynamism of an artwork, we would also expect that the saccades themselves would show different patterns in their dynamics (velocity and duration) and spatial control (their metrics: the length of the saccade (amplitude) and the curved path of its trajectory). To our knowledge, this question has not been addressed so far. This questions remains open because of differences how fixations and saccades are defined (e.g., fixations will often be defined by area so that small saccadic eye movements will be considered as being part of the fixations a "fixation event" if you will) so how and if the perceived dynamism of an artwork influences saccade

control is not completely clear. Walker and McSorley (2008, see also McSorley *et al.*, 2009a) reviewed a number of experimental studies that showed that distractors (and objects considered as "non-targets") influence the control of saccades. The focus of these studies was to show that saccades latencies are affected by distractor presence and location, as are the path and eventual landing position of the saccade (McSorley *et al.*, 2009b; McSorley *et al.*, 2014). It is worth noting that distractor and "non-target" impact on saccade control has been used as an operationalization of visual attention (Tudge *et al.*, 2017).

When looking at abstract art, we normally have no task to perform nor a specific "target" or a "distractor" to look at. The most common setting of art perception is a free viewing task. Nevertheless, the different compositional structures of various abstract artworks provide a different degree of visual features within the painting, which can be interpreted as implicit "targets", "distractors" and "non-targets". Thus, we might expect to see the structural elements of the artworks that drive perceived dynamism impact on visual attention and selection which then manifest as different patterns of corresponding eye movement patterns.

3. The Present Study

The aim of the present study was to find out whether viewing behaviour differs when viewing a painting that is perceived as highly dynamic, compared to other abstract works that are classified as static. In accordance with our main interest, which is the influence of perceived dynamism on eye movements, we addressed two hypotheses: the assumption of 1) the polyfocal gaze and 2) action viewing.

Because of the very homogenous canvas Kambartel (1970) refers to, all-over paintings by Pollock, or Manzoni's *Achromes* might encourage a "polyfocal gaze" which is less focused due to missing "visual targets". As a measure of attention, the *accumulation of fixations* at a specific *location* on the artworks gives an indication if an artistic strategy, such as the all-over technique, leads to a decentralized and polyfocal viewing behaviour. *Action Viewing* can be operationalized with the average *duration of fixations* and average *saccade velocity, duration, amplitude and path curvature.* We assumed the more dynamic an abstract painting is perceived, the higher the average saccade velocity and the shorter the average saccade duration. We also assumed that the shape of the saccade itself, or more precisely, the curvature of its path, would vary: Initial saccade path deviation from a straight path from one fixation to another over the first 10 ms of the saccade and curvature area should increase with an increase in perceived dynamism.

For the present study we utilized the Eye Link II head mounted eye tracker by SR Research (Ottawa) and a broader set of stimuli compared to the Commare and Brinkmann (2016) study (see Table 1 for an overview). Using a 500 Hz high-speed eye tracker enabled us to focus not only on fixations but on saccades as well, which is—compared to fixations, when the eyes stand still—the actual *movement* when it comes to viewing behaviour and crucial for the hypotheses referring to the link between perceived dynamism and saccades. Dynamism can also contribute to the degree of *pleasantness* that an artwork evokes. The studies mentioned above reported that artworks showing the brushstrokes made by the artist, affected the aesthetics ratings (liking). We therefore asked participants to rate their liking of every picture, also in regard to a previous study stating that greater cortical activation leads to higher aesthetic ratings (Sbriscia-Fioretti *et al.*, 2013). We presented the stimuli to art students who we considered "experts", and students with no artistic background. This is important, since we know that gaze patterns differ between experts (artists as well as art historians) and laypersons (Koide *et al.*, 2015; Rosenberg, 2011; Rosenberg and Klein, 2015). It might be possible that artists are more sensitive or have a superior sense for depicted dynamism.

3.1. Method

3.1.1. Participants

We tested 40 participants from the University of Reading (20 psychology students all female, age range 18–33; 20 art students, 17 females, 3 males; age range 20–29) who had to complete a questionnaire on their educational background. The questionnaire requested the participant to provide the number of years of formal art training they had received (A-level qualification and beyond). Artists were regarded as experts if they had at least 5 years of formal art training and were involved in art making on a weekly basis. The training of the art students ranged from 5 to 11 years (M = 6.1; SD = 1.71). The laypeople are represented by psychology students with no or less than 2 years of training (M = 0.2; SD = 0.82). All participants had normal or corrected-to-normal vision and all participants completed each stage of the experiment.

3.1.2. Stimuli

We showed high quality reproductions of 30 abstract paintings in a randomized order without any additional information such as titles. The paintings were selected in order to cover a broad variety of different abstract styles like constructivism, action painting, or colour field painting. They are by different artists, from different periods and were chosen by the authors affiliated

with the Art History department of the University of Vienna in order to have a broad overview of 20th century abstract art, reflecting high variance in sensed dynamics. A full list of the artworks is provided in Table 1. The stimuli were not manipulated or edited, since we aimed for a more natural presentation of the original works. Stimuli were presented in random order as high resolution reproductions on a 21" 1600 × 1200 pixel colour monitor that had a refresh rate of 75 Hz and was luminance and colour calibrated. The distance between the monitor and participant was 57 cm.

3.1.3. Procedure

After welcoming, participants were informed that they will be presented with 30 paintings. They were asked to look at them in a free viewing task and to rate each individual artwork on a scale of 1–7 for dynamism, pleasantness and familiarity. Obviously, our main interest lies on the interaction of perceived dynamism and eye movements. However, we asked for familiarity, to control for a mere-exposure effect. The question about pleasantness was not only asked to learn about the appreciation of the works, but also to create the same "aesthetic viewing mode" for all participants.

Viewing duration was 30 seconds for each painting. The eye tracker calibration process was successful for all participants (average error less than 0.5 degree). Calibration was maintained for each trial using a drift correction procedure between trials in order to correct any errors that might be due to small movements in camera alignment (e.g., caused by headband slippage). Eye movements were recorded with an Eye Link II tracker with a sampling rate of 500 Hz. We used a chin rest, and participants were placed in a set position and requested not to move during the study.

A fixation cross was displayed before each painting for 1000 ms in the middle of the monitor. After viewing the paintings, participants rated dynamism, pleasantness and familiarity via self-reports on the screen, by using a 7-point scale. In each case, left and right terms presented the opposite sides of the dimensions (very static- very dynamic).

3.1.4. Data Analyses

For the event detection of fixations and saccades, we used the SR Research velocity and acceleration algorithm. Saccades were detected using velocity and acceleration thresholds of 30 deg/s and 8000 deg/s^2. These thresholds are recommended by SR Research for cognitive research. The events are detected "on-line" as the data is recorded. Our first step was to complete a *descriptive analysis* based on heatmaps created with the data viewer software by

SR Research to answer the question on the *distribution and location of fixations per image*. We chose to use density-based heatmaps, showing overlapping fixations, to make sense of fixation's concentration. There is one heatmap per artwork and it indicates the area in the artwork with the highest concentration of fixations made by all participants for that specific image. The number is given in percentage and can be understood as the peak of the heatmap. A high percentage can be interpreted in a way that there is a prominent area in the image where many fixations accumulate. A low percentage means that no prominent area could be found in a painting or that the area where fixations accumulate draws not as much attention compared to other artworks with a higher density percentage.

To test our hypotheses, we carried out linear mixed effects models in a second step to examine whether perceived dynamism was associated with the average fixation count and duration and average saccade count, velocity, duration and amplitude. Two measures of the curvature of saccade paths were also computed. The initial saccade path deviation from a straight path from one fixation to another over the first 10 ms of the saccade shows path trajectory deviation in the earliest part of the saccade. The curvature area of the path deviation from a straight path across the entire saccade gives an overall picture of trajectory deviation across the whole saccade (see Tudge *et al.*, 2017).

To assess the impact of perceived dynamism on the different parameters of fixations and saccades we conducted a series of eight linear mixed models (LMM), using the "lmer" in the "lme4" (Version 1.1-19) package for the statistical program R (Bates, Maechler and Walker, 2013) and applied Satterthwaite approximation for p values. The eight parameters we analysed are for fixations a) number (or count) and b) duration and for saccades c) number (or count), d) duration, e) amplitude and curvature measured with f) average path deviation and g) curvature area as well as h) velocity. The LMMs were conducted separately for each of the eight parameters, with "perceived dynamism" as the dependent variable. We also included random slopes for participants which allowed us to consider the variability between participants and take into account the natural variances that can occur between participants as a result of performing a study (e.g., some participants tend to use the extremes of a rating scale). Furthermore, using the random intercept of the image takes into account the variation caused by differences between the 30 images observed.

3.2. Results

3.2.1. Analysis of Perceived Dynamism

A descriptive analysis looking at the mean of the dynamic ratings (as mentioned above perceived dynamism was rated on a 7-point scale) showed that the paintings rated the most dynamic are the works “Achrome” by Manzoni (M = 4.50, SD = 1.83) “Silver over Black” by Pollock (M = 4.47, SD = 1.96) and “Composition” by Wols (M = 4.40, SD = 1.75). The paintings rated least dynamic on average are Mark Rothko’s No 14 (M = 3.72, SD = 1.75) and Sam Francis “Untitled (M = 3.72, SD = 1.97). Since the rating range was 1–7, it is clear that none of the 30 artworks was rated as highly dynamic on average. A two-way repeated measures ANOVA was run to examine the differences in perceived dynamism per painting within subjects. The results show that the differences between the images in the dynamic ratings are not significant. However, data analysis revealed that experts gave higher dynamic ratings (*M* = 4.34, SD = 0.35) compared to non-artists (*M* = 3.87, SD = 0.29, *F* (1, 38) = 4.63, *MSE* = 14.41, $p < .05$, $\eta^2 = 0.10$). The distribution of the data shows that the dynamic ratings are highly individual and heterogeneous.

Due to the broad variety of abstract paintings, it seems useful to look into different subgroups of images based on their visual features such as in Barr’s chart mentioned above. Therefore, in a second step, two art historians divided the images in three subgroups, one containing geometrical, hard-edged paintings, one semi-controlled, less strictly geometrical composed paintings such as monochromes showing the traces of the production process and a third group with paintings with a composition, which can be described as “uncontrolled”. The third group also contained action paintings, which are traditionally referred to as very dynamic in an art historical discourse. Three of the originally chosen and presented images could not clearly be assigned to one of these three groups. Therefore, we excluded them from the subgroup data analysis. Each of the image groups holds 9 paintings. Table 1 shows all presented images in alphabetical order, the numbers in front of the artist’s name indicates the subgroup number.

An ANOVA with the different subgroups of images was run. It showed no significant differences between the three groups when it comes to perceived dynamism, $F(2,24) = 0.28$, MSE = 0.87, p = .76Since group 1 consists of images which are structured geometrical, many of these artworks have a more static and controlled appearance at first sight. However, even if the composition is static and symmetrical and the application of paint seems smooth and polished, one might sense a certain manner of dynamism on second sight, especially with knowledge about a specific artist. Due to their visual features, Mondrian’s paintings for example, are assigned to group 1, yet, the artist himself theorized about the “dynamic-

equilibrium" and the dynamism in his paintings (see Tosaki, 2017, p. 92). Since we could not find differences in the dynamic ratings for the different image groups, we did not consider that variable for the further analyses.

3.2.2. Analysis of Fixations

3.2.2.1. Descriptive analysis density of fixations. Descriptively we compared the accumulation (or "density") of the fixations made by all 40 participants for each of the 27 paintings included into the analysis. This analysis is based, as described above, on density-heatmaps that allow identifying those areas per image where the most fixations have accumulated. This analysis revealed that the average density of fixations for the complete viewing time was the least in Franz Kline's work "Untitled" (1.91%). This work shows the brushstrokes in a very explicit manner. Jackson Pollock's painting "Silver over Black, White, Yellow and Red" displayed above, had the second least density percentage (2.01%). However, other paintings with an all-over technique elicited a higher density of fixations, such as Manzoni's "Achrome" (3.69%), or Lee Krasner's "The Civet" (3.25%). Yet, compared to the paintings with the highest density of fixations at one location, Wols' "Composition" (7.52%) and Frank Stella's "Newburyport" (7.48%), the average accumulation of fixations at one location can still be considered relatively low (see Fig. 2).

This explorative and descriptive analysis suggests that a uniform and therefore all-over application of lines and/or colours on the canvas leads indeed to a broader distribution of attention with less accumulation of fixations at one location, which is in line with the hypothesis and confirms a decentralized and polyfocal gaze for this type of abstract paintings. The high density of fixations at one specific location in Wols' painting can be explained by the face-like or at least anthropomorphic creation in the centre of the painting with a thick red spot, obviously drawing the viewer's attention. Previous studies have shown that faces and hands attract the viewer's attention the most (cf. Harris, 1989) and this is obviously also the case for centred patterns in abstract paintings.

3.2.2.2. Statistical analysis of fixations. The results show that the *number of fixations* (fixation count) was found to increase as a function of perceived dynamism ($\beta = 1.18$, $SE = 0.43$, $t = 2.75$, $p < 0.01$) and there was no significant effect of expertise or an interaction ($\beta = 0.24$, $SE = 5.58$, $t = 0.04$, $p = .967$; $\beta = 0.14$, $SE = 50.6$, $t = 0.24$, $p = .812$). However, *average fixation duration* was not found to be associated with perceived dynamism ratings ($\beta = –3.2$, $SE = 3.44$,

t = –0.93, p = .360). There was no significant effect of expertise nor an interaction (β = 21.45, SE = 42.5, t = 0.51, p = .617; β = –4.73, SE = 4.79, t = –0.99, p = .332), see Table 3.

3.2.3. Analysis of Saccades

The *number of saccades made* (saccade count) was found to increase with an increase in perceived dynamism (β = 1.17, SE = 0.43, t = 2.73, p = .01). There was no effect of expertise (β = 0.14, SE = 5.61, t = 0.03, p = .980) and no interaction (β = 0.15, SE = 0.60, t = 0.26, p = .800). However, we found a significant relationship between average *saccade duration* and perceived dynamism. The duration of saccades decreased with an increase in perceived dynamism (β = –1.99, SE = 0.38, t = –5.22, p = .001) which is in line with our hypothesis. There was no effect of expertise (β = –8.63, SE = 6.21, t = –1.39, p = .173) and no interaction (β = 0.80, SE = 0.53, t = 1.52, p = .140). Also, average *saccade velocity* did associate with perceived dynamism, an increase in saccade velocity with an increase in perceived dynamism was found (β = 1.25, SE = 0.43, t = 2.93, p = .0038). There was no significant effect of expertise nor an interaction (β = –5.5, SE = 6.65, t = –0.83, p = .412; β = –0.26, SE = 0.59, t = –0.44, p = .659).

The results show that average *saccade amplitude* was not found to be associated with perceived dynamism (β = –0.05 SE= 0.03, t= -1.5, p= .136) and there was no significant effect of expertise nor an interaction (β= -0.27, SE= 0.46, t= -0.59, p= .559; β= -0.05, SE= 0.05, t= -1.02, p= .140). Initial *saccade path deviation* was also not found to be associated with perceived dynamism (β= 0.01, SE = 0.01, t = 1.59, p = .120). While there was no effect of expertise (β = 0.02, SE = 0.09, t = 0.26, p = .795, nor an interaction (β = –0.01, SE = 0.01, t = –0.96, p = .343). *Curvature area* was not found to be associated with perceived dynamism either (β = 0.07, SE = 0.05, t = 1.5, p = .142), and there was no effect of expertise nor an interaction (β = 0.27, SE = 0.24, t = 1.12, p = .265; β = –0.06, SE = 0.07, t = –0.87, p = .388) respectively, see table 2.

3.2.4. Analysis of Pleasantness Ratings

Pleasantness ratings were found to increase with an increase in perceived dynamism (β = 0.46, SE = 0.06, t = 7.17, p < .001). There was no effect of expertise (β = 0.36, SE = 0.14, t = 0.88, p = .383). However, an interaction between dynamism ratings and expertise was found (β = –0.18, SE = 0.088, t = –2.05, p = .048). When examining artists and laypeople separately,

associations between pleasantness and perceived dynamism were found for both (artists: β = 0.45, SE = 0.07, t = 6.61, $p < .001$, laypeople: β = 0.28, SE = 0.06, t = 4.95, p = .001) although it is clear that the relationship found was stronger for artists, see Table 3.

3.2.5 Analysis of Familiarity Ratings

We took a closer look on the interaction between perceived dynamism and familiarity to control for the above mentioned mere-exposure effect. A LMM with familiarity, dynamism and expertise showed no relationship between familiarity and dynamic ratings (β = 0.08653, SE = 0.05898, t = 1.467, p =.1515), but there is an effect of expertise (β = –0.89365, SE = 0.32605, t = –2.741, p = .0102). which can be seen from Fig. 3. Not surprisingly, experts (M = 3.17; S.D = 0.91) are more familiar with the paintings than laypeople (M = 1.9; S.D = 0.58).

4. Discussion

We examined the relationship between perceived dynamism in abstract paintings and viewing behaviour. To conclude, we can say that the degree to which an abstract painting is perceived as dynamic is mirrored in the movements of the eye. We therefore argue that participants' viewing behaviour is linked to the perceived dynamism of the stimuli – something that has long been assumed by art historians but had never been empirically supported. However, to our surprise, the ratings on perceived dynamism were very individual and on average no image has been rated as "highly dynamic". In general, perceived dynamism was found to be influenced by expertise (which is defined here as experience in artistic education). The different subgroups of images did not lead to differences in perceived dynamism. But we found, that pleasantness ratings increase with an increase in perceived dynamism. This supports results from Mastandrea and Umilità (2016) and Cattaneo *et al.* (2017) where perceived movement was found to correlate with beauty and liking.

Referring to the question in the title of this paper "Does 'action viewing' really exist?", we can state that the answer depends on the definition and operationalization of "action viewing". Commare and Brinkmann (2016), who used a 120 Hz eye tracker by SMI, could not find any "action viewing" in the gaze behaviour since there was no significant difference in the average fixation duration. This result was confirmed in our present study, perceived dynamism had also no influence on the fixation duration—although using different hard- and software. However, if the focus of the analysis lies on the *saccades*, the results suggest that perceived dynamism is indeed mirrored in the eye of the viewer: We provide quantitative evidence, that saccade count, duration and velocity show an overall effect of perceived dynamism. Yet, it is important to note that "action viewing" is a phenomenon that accompanies perceived dynamism in any abstract painting and not solely Pollock's action paintings.

The hypothesis that the compositional structure of the artwork influences the accumulation of fixations at specific locations was especially addressed with reference to all-over paintings, which are assumed to elicit a decentralized and polyfocal gaze. This is supported by the descriptive analysis based on density heatmaps which show that the accumulation of fixations is much lower for abstract paintings with an all-over structure or, as in the Kline image, very broad and visible traces of brush-strokes, compared to others. Due to such compositional elements, we do not find a high accumulation of fixations.

This means that paintings which are rated as almost equally dynamic, such as the Wols, the Pollock and the Manzoni, elicit a similar behaviour in the saccades but not in the average density of fixations at a specific location within the image. Therefore, differences between abstract artworks are important to acknowledge. As the brief theoretical context of this paper hints to, this is something art history is very aware of. However, when it comes to empirical research, there seems to be less awareness. It is difficult and too reductionist to study the perception of "abstract art" without differentiating or reflecting on the variety within abstract art styles (such as perceived dynamism, which was investigated in the present study) and their implications.

5. Limitations and Future Research

One limitation might be the fact that we did not use originals but reproductions of art works. We are sensitive to the fact that these are not the artworks themselves, especially when it comes to materiality. Yet, the reproductions we showed are high quality and high-resolution reproductions allowing to see brushstrokes, the paint, the canvas and so on. This was important

to us, because it is essential for our questions on the polyfocal gaze and the concept of "action viewing".

The results of our study suggest that there is indeed a relationship between perceived dynamism in abstract painting and eye movements. Yet, we do not know at this point if these results are due to top down factors, suggesting that "action viewing" starts with the viewer's experience that an abstract work appears as dynamic and continues with reflecting this effect in the eye movements, or the other way round, as stated by Kandel: *Because* the stimulus (bottom up) induces a fast viewing behaviour and a broader distribution of fixations, it is perceived as dynamic. Here, future research is needed. Furthermore, the questions remain, what makes an abstract work "dynamic" and which aspects contribute to an observer's viewing pattern when getting confronted with abstract painting?

Locher and Stappers (2002) investigated how factors such as edge alignment of compositional elements; physical weight distribution or activity directions contribute to the implicit dynamic quality of static abstract designs. Though the stimuli shown in their study were created by artists, they are very simple patterns and not comparable with abstract painting. Until now, no clear definition has been delivered in regard to abstract paintings. The example of Pollock and Manzoni in our study shows, that two formally completely different paintings can be perceived on average as almost equally dynamic. One possible aspect of dynamism we focused on in this paper is the comprehension of traces left by the artist and referring to the actions performed during the creation process. This contributes to an ongoing discourse in psychology related to embodiment. The paintings perceived on average as most dynamic (Wols, Pollock, Manzoni) can be considered to show different kinds of traces of the creation process. Yet, we are sensitive to the fact that there are more aspects, which might contribute to a dynamic effect of an abstract painting such as the composition or a more theoretical concept behind the painting as mentioned above in the case of Mondrian. This could also be one potential reason for the heterogeneous ratings on the level of single paintings. Maybe the use of the rating scale was not entirely clear, or the concept of "dynamic" was understood in different ways. Since we did not provide participants with an official description, their concept of perceived dynamism could have differed.

The question of which factors in an abstract painting contribute to a dynamic impression of this work needs to be studied deeper in future research – both from a theoretical perspective and with empirical research.

Note

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Figure Captions

Figure 1. Left: Jackson Pollock Painting (Silver over Black, White, Yellow and Red), 1948 © Pollock-Krasner Foundation/ Bildrecht Wien, 2019. Right: Piero Manzoni Achrome, 1959–1960 © Bildrecht Wien, 2019.

Figure 2. Average Fixation Density for all 40 participants per image in percentage.

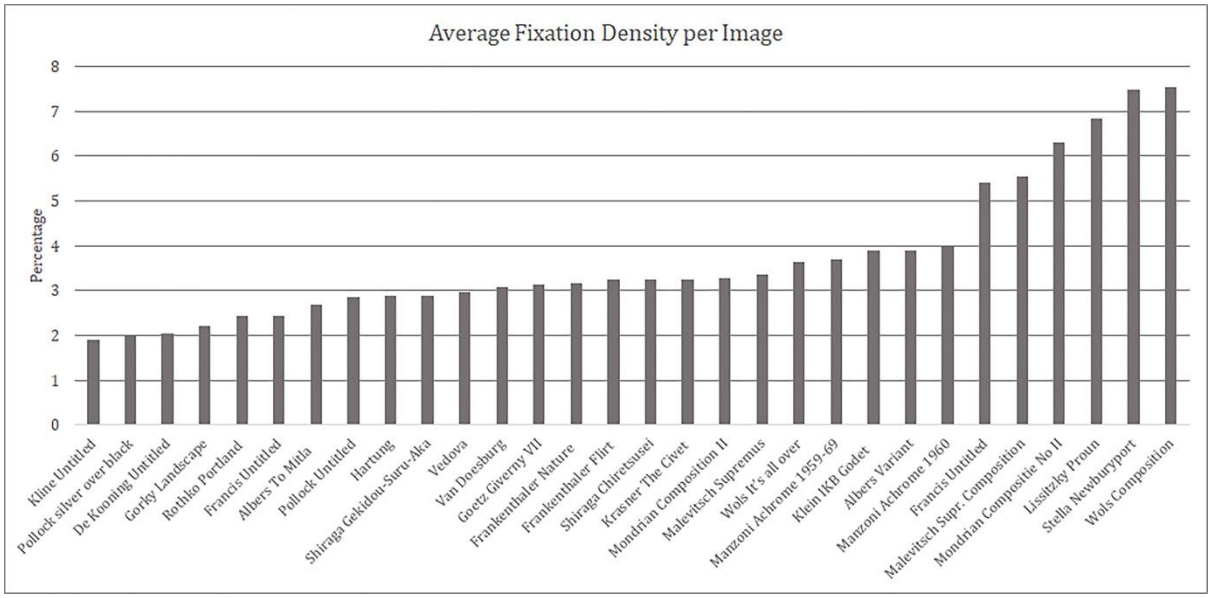

Figure 3. Scatter Plot Relationship between perceived dynamism and familiarity.

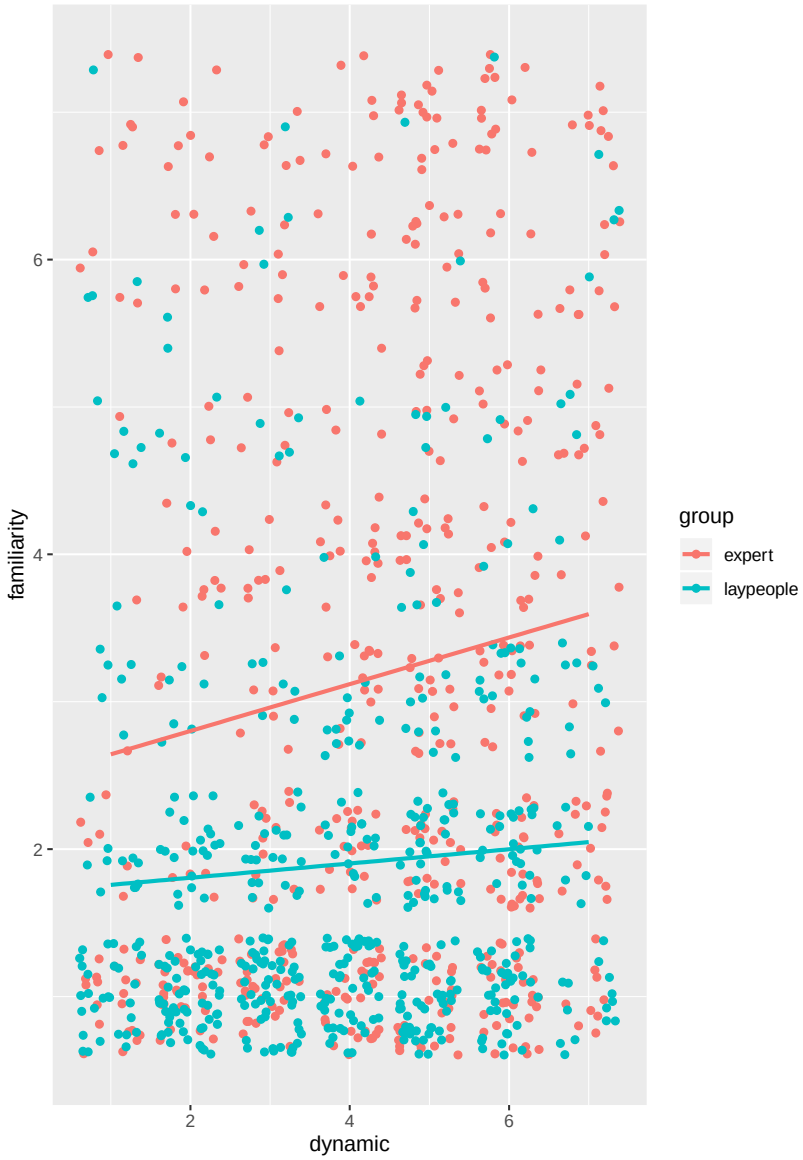

Table 1. Stimuli presented in the eye tracking task.

Artist	Title	Year	Technique	Size of Original	Repository
1 Albers, Josef	*Variant/Red, Violet around Orange, Pink*	1948	Oil on masonite	43.2 × 53.3 cm	Josef and Anni Albers Foundation
1 Albers, Josef	*To Mitla*	1940	Oil on masonite	53.3 x 71.1 cm	Josef and Anni Albers Foundation
2 Arshile, Gorky	*Landscape – Table (Table-paysage)*	1945	Oil on canvas	92 x 121 cm	Centre Georges Pompidou, Paris
1 Van Doesburg, Theo	*Composition VIII (The Cow)*	c. 1918	Oil on canvas	37,5 x 63,5 cm	MoMa, New York City
3 Francis, Sam	*Untitled*	1988 – 1989	Acrylic on canvas	242.8 x 167.6 x 4 cm	Les Abattoirs, Toulouse
X Francis, Sam	*Untitled*	1962	Acrylic on canvas	59.8 x 91.5 cm	
2 Frankenthaler, Helen	*Nature Abhors a Vacuum*	1973	Acrylic on canvas	262.9 x 284.5 cm	National Gallery of Art, Washington D.C.
2 Frankenthaler, Helen	*Flirt*	1995	Colour screen print	67.9 x 100.3 cm	Private Collection
3 Götz, Karl Otto	*Giverny VII*	1988	Mixed media on canvas	200 x 260 cm	Collection Sylvia and Ulrich Ströher, Darmstadt
2 Hartung, Hans	*Signs (Caractères)*	1948	India ink and pastel on paper	48.5 x 73 cm	Centre Georges Pompidou, Paris
2 Klein, Yves	*IKB Godet*	1958	Pigment	150 x 198 cm	Private Collection
2 Kline, Franz	*Untitled*	1957	Oil on paper	18.7 x 23.4 cm	Phillips Collection
X de Kooning, William	*Untitled*	1976	Oil on newspaper mounted on canvas	57.79 x 72. 71 cm	National Gallery of Art, Washington D.C.
3 Krasner, Lee	*The Civet*	1962	Lithograph in black on arches wove paper	Image: 47 x 73 cm Sheet: 56 x 76 cm	National Gallery of Art, Washington, D.C.
1 Lissitzky, El	*Proun (Study for Proun S. K.)*	1922 – 1923	Watercolour, gouache, ink, graphite, conté crayon, and varnish on paper	21.4 x 29.7 cm	Solomon R. Guggenheim Museum, New York City
1 Malevich, Kazimir	*Supremus No. 55*	1916	Oil on canvas	80 x 80 cm	The State Russian Museum, St. Petersburg
1 Malevich, Kazimir	*Suprematist Composition*	1915	Oil on canvas	54.2 x 53.7 cm	Hudozestvennyj Museum, Ivanovo
2 Manzoni, Piero	*Achrome*	1959 – 1960	Kaolin on canvas	80 x 100 cm	Städel Museum, Frankfurt
2 Manzoni, Piero	*Achrome*	1960	Kaolin on canvas	18.1 x 24.3 cm	MoMa, New York City
1 Mondrian, Piet	*Compositie No. II*	1929	Oil on canvas	52 x 52 cm	Museum Boijmans Van Beuningen
1 Mondrian, Piet	*Composition II in Red, Blue, and Yellow*	1930	Oil on canvas	46 x 46 cm	Kunsthaus Zürich
3 Pollock, Jackson	*Untitled*	1948 – 1949	Dripped ink and enamel on paper	56.8 x 76.2 cm	Metropolitan Museum of Art, New York City
3 Pollock, Jackson	*Painting (Silver over Black, White, Yellow and Red)*	1948	Enamel primer on paper, mounted on canvas	61 x 80 cm	Centre Georges Pompidou
2 Rothko, Mark	*No. 14*	1951	Oil on canvas	143.51 x 165.1 cm	Collection of Kate Rothko Prizel
3 Shiraga, Kazuo	*Chiretsusei Katsusemba*	1961	Oil on canvas	130 x 161 cm	Private Collection
3 Shiraga, Kazuo	*Gekidou Suru Aka*	1969	Oil on canvas	183 x 229 cm	Private Collection
1 Stella, Frank	*Newburyport*	1926	Oil on canvas	77.5 x 154.3 cm	Yale University Art Gallery
3 Vedova, Emilio	*Del nostro tempo*	1972	Paint on paper on canvas	59.5 x 80.5 cm	Private Collection
X Wols	*Composition*	1948	Oil on canvas	80,3 x 81 cm	Collection Fondation Gandur pour l'Art, Ginebra, Suiza – permanent loan to: Museo Nacional Centro de Arte Reina Sofia
3 Wols	*It's all over - The city*	1946 – 1947	Oil, grattage, and tube marks on canvas	81.28 x 81.28 cm	Menil Collection, Houston

Table 2. Linear Mixed Models Gaze Behaviour and Perceived Dynamism

	Dynamism				Expertise				Expertise*Dynamis		
	Estimate	Std. Error	t value	Pr (>|*t*|)	Estimate	Std. Error	t value	Pr (>|*t*|)	Estimate	Std. Error	t value
	1.18	0.43	2.75	.00958**	0.24	5.58	0.04	.96664	0.14	50.60	0.24
on	-3.2	3.44	-0.93	.36	21.45	42.5	0.51	.617	-4.73	4.79	-0.99
	1.17	0.43	2.73	.0102*	0.14	5.61	0.03	.9796	0.15	0.60	0.26
on	-1.99	0.38	-5.22	.001***	-8.63	6.21	-1.39	.173	0.8	0.53	1.52
ude	-0.05	0.03	-1.5	.136	-0.27	0.46	-0.59	.559	-0.05	0.05	-1.02
eviation	0.01	0.01	1.59	.12	0.02	0.09	0.26	.795	-0.01	0.01	-0.96
ure Area	0.07	0.05	1.5	.1424	0.27	0.24	1.12	.2654	-0.06	0.07	-0.87
y	1.25	0.43	2.93	.00383**	-5.5	6.65	-0.83	.41286	-0.26	0.59	-0.44

Gaze behaviour results based on parallel LMMs conducted with lme4 package in R.
Significance codes: '***' 0.001 '**' 0.01 '*'0.05

Table 3. Linear Mixed Models Pleasantness, Familiarity and Perceived Dynamism

	Dynamism				Expertise				Expertise*Dynamis		
	Estimate	Std. Error	t value	Pr (>|*t*|)	Estimate	Std. Error	t value	Pr (>|*t*|)	Estimate	Std. Error	t value
	0.46	0.06	7.17	.001***	0.36	0.41	0.88	.3831	-0.18	0.088	-2.05
pert)	0.45	0.07	6.61	.001***	-	-	-	-	-	-	-
ypeople)	0.28	0.06	4.95	.001***	-	-	-	-	-	-	-
	0.09	0.06	1.47	.151	-0.89	0.33	-2.74	.010**	-0.86	0.08	-1.04

Ratings based on parallel LMMs conducted with lme4 package in R.
Significance codes: '***' 0.001 '**' 0.01 '*'0.05