Abstract

The present study investigated the role of visual exploration of artworks in relation to personal traits and aesthetic responses during a visit to the TATE Liverpool gallery. Specifically, the study tested whether visual exploration mediated the influence of individual differences in personality and cognitive style on aesthetic responses. Fifty-six visitors to the gallery viewed seven artworks while their eye movements were recorded. Participants rated their aesthetic response to the artwork and wrote their thoughts and impressions about each artwork. Written reports were analysed in terms of word count and frequency of use of aesthetic descriptors. Participants completed individual difference measures, including Openness to Experience [OTE] and Need for Cognitive Closure [NFC] before viewing artworks. The results showed that (1) the duration of looking at artworks (dwell time) mediated the relationship between OTE, NFC and word count as well as the frequency of use of aesthetic descriptors, and (2) the spatial distribution of fixations mediated the relationship between both OTE and NFC and the number of words used in response to viewing artworks. The results indicate that visual exploration plays a functional role in the experience of artworks in a real gallery setting, and that visual exploration is a mechanism through which OTE and NFC influence aesthetic responses.

Keywords: individual differences, eye tracking, aesthetics, artworks, art gallery

Introduction

The majority of work within mainstream visual cognition typically aims to understand the perceptual, attentional, cognitive, and motor processes underpinning goal-orientated visual behaviour (for example how we can successfully find a target in a visual scene). However, it is important to investigate how these processes function in the presence of objects which afford a rather different set of responses (i.e. pleasure, interest etc.) or that underpin different motivations (i.e. wanting to learn, or be entertained). The question becomes even more relevant if we consider that these types of processes and motivations are subject to influence by personality and cognitive style.

Works of visual art are a good example of this class of objects given that the viewing of art typically calls for the suspension of practical concerns and behaviours in pursuit of meaningful and often aesthetic experiences. In the United States, over fifty percent of adults attended artistic, creative or cultural activities in 2017 and nearly a quarter attended an art exhibition displaying works such as painting, sculpture, and photography that same year (National Endowment for the Arts, 2019). However, studies show that viewers spend, on average, approximately thirty seconds viewing works of art, which suggests that in many cases the level of engagement lacks depth (Carbon, 2017; Smith & Smith, 2001; Smith et al., 2017) and calls into question the quality of the experience. Accordingly, the core objective of the present work was to investigate the role of visual exploration as a mediator of the influence of personal traits on aesthetic engagement.

Current models in empirical aesthetics (e.g., Leder et al., 2004; Leder & Nadal, 2014; Pelowski et al., 2017; Pelowski & Akiba, 2011) are helpful in considering factors that might influence the visual exploration of artworks. Specifically, these models consider the potential perceptual and cognitive processes involved in viewing, how the operation of these processes

might vary across individuals (e.g. as a result of differences in attitudes (Tinio et al., 2013), curiosity (Risko et al., 2012; Silvia, 2005), personality (Chamorro-Premuzic et al., 2009; McCrae, 2007; Silvia & Nusbaum, 2011), emotion (Belke et al., 2006), cognitive style (Ostrofsky & Shobe, 2015) and expertise (Tinio et al., 2013; Wagemans, 2011) and the influence of the context in which the artworks are viewed (e.g. the laboratory versus the gallery (Brieber et al., 2014; P. Locher et al., 2007)). Based on previous research it seems that the visual exploration of artworks must be influenced by a complex interaction between the viewer, the object of art, and the context. However, at present, the role of visual exploration within this interaction is not yet fully understood. Key questions are whether visual exploration (i.e. where, when, and for how long, we pay attention) underlies how we engage and respond to art, and, if so, what factors influence it (i.e. personal traits, setting etc.)?

There are two principal lines of research that are concerned with these questions. The first line of research is the study of eye movement behaviour with artworks in the laboratory and in museums or galleries. Recording eye movements and fixations provides a real time measure of where and for how long viewers fixate on artworks (Gartus et al., 2015; Locher, 2006; Locher et al., 2007; for a review see Nodine & Krupinski, 2003; Pelowski et al., 2018). The fixations to artworks that together show a pattern of visual exploration are defined in time and space. The visual exploration of paintings is spatially and temporally limited (in both a laboratory setting [Locher et al., 2007] and in a gallery setting [Harland et al., 2014]) and linked to what is verbally reported by participants when asked to describe them (Locher, 2006; Locher et al., 2007; see also Harland et al., 2014; Prokopenya, 2017).

Studies of the visual exploration of artworks presented to participants in the laboratory have shown it to be influenced by multiple factors. These include stimulus features (e.g. form and composition, compositional balance between elements [e.g., Locher,

2006; Nodine & Krupinski, 2003; Quiroga & Pedreira, 2011; Trawiński, Mestry, et al., 2021; Trawiński, Zang, et al., 2021]), participants' task when viewing the artworks (Borji & Itti, 2014; Fuchs et al., 2011; Henderson et al., 2013; Hristova et al., 2011; Yarbus, 1967), and knowledge of the artworks and expertise (e.g., Bubić et al., 2017; Francuz et al., 2018; Kristjanson et al., 1989; Vogt, 1999; Vogt & Magnussen, 2007).

The last decade has witnessed an increase in studies of the visual exploration of artwork using mobile eye trackers in galleries and museums (e.g., Garbutt et al., 2020; Pelowski et al., 2018; Reitstätter et al., 2020; Santini et al., 2018; Savazzi et al., 2014). Quiroga and Pedreira (2011) compared fixation patterns to Millais' Ophelia painting presented as a digital image in the laboratory and to the real painting exhibited in the Tate Britain gallery. Interestingly, viewers made most of the fixations to the face when viewing the image in the lab, whereas their fixations were more distributed in other areas of the canvas when they viewed the actual painting. Walker et al., (2017) showed that eye movements to artworks recorded in a real gallery context were not only influenced by salient information and descriptions of the paintings but also depended on whether visitors were adults or children. Other research extended the visual exploration beyond paintings, for example, to contemporary three-dimensional artworks (Pelowski et al., 2018) and sculptures (Reitstätter et al., 2020). These studies conducted in galleries and museums show that the context (i.e., original artworks, curatorial descriptions, the display of an exhibition) may also be important in influencing participants' visual exploration of artworks.

The second line of research refers to personality traits and cognitive style and how these relate to aesthetic appreciation and visual behaviour (for review see Chamorro-Premuzic et al., 2009; Fayn et al., 2015; Marković, 2012; Mastandrea et al., 2009; Ostrofsky & Shobe, 2015; Pelowski et al., 2017; Vessel & Rubin, 2010). Previous research suggests

that Openness to Experience (OTE; Costa & McCrae, 1992) and Need for Cognitive Closure (NFC; Kruglanski & Webster, 1996) are aspects of personality and cognitive style, respectively, that are particularly relevant to aesthetic experience.

OTE is characterised by curiosity and the motivation to seek interesting new experiences (Costa & McCrae, 1992). A such, OTE is a robust predictor of art interest (Silvia & Sanders, 2010), art appreciation and creativity (Oleynick et al., 2017) and aesthetic responsiveness to artworks (Chamorro-Premuzic et al., 2009; McCrae, 2007; Silvia & Nusbaum, 2011). It is also associated with preference for abstract curvature (Cotter et al., 2017), the natural world (Harrison & Clark, 2020; Silvia et al., 2015) and music (Colver & El-Alayli, 2015). Finally, OTE is known to be associated with breadth of experience of affective and emotional states (Terracciano et al., 2003). A recent study by Rodriguez et al., (2021) reported that the emotional breadth of responses to artworks (viewed in a museum) was associated with OTE.

NFC measures dispositional cognitive-motivational preference for unambiguous information over uncertain or ambiguous information (Kruglanski & Webster, 1996). The evidence base linking NFC to aesthetic responses to artworks is more limited. There is evidence that NFC is inversely related to the liking of non-representational paintings (i.e. where the meaning is ambiguous; Ostrofsky & Shobe, 2015).

So far, we have shown that visual exploration and personality both influence responses to artworks (Harland et al., 2014; Ostrofsky & Shobe, 2015; Pelowski et al., 2017). In the current study, we investigated how visual exploration, personality and aesthetic responses are related. In particular, we studied how the overall viewing time (henceforth dwell time) and the spatial distribution of fixations when viewing artworks in a gallery are

influenced by the viewer's OTE and NFC, and how these in turn influence aesthetic responses.

There is some evidence consistent with a potential link between OTE and NFC and visual exploration. Rauthmann et al., (2012) reported a positive association between openness and mean fixation durations and dwell times when viewing abstract animations[1]. Ostrofsky and Shobe (2015) showed that higher NFC was associated with shorter viewing before making a preference decision, relative to lower NFC.

We assume that OTE and NFC are stable components in this relationship, whereas visual fixations and aesthetic responses vary as a function of OTE and NFC. Patterns of fixations are the means by which the viewer samples visual information from the artwork. Therefore, in the present study, we explore whether visual exploration plays a functional role in the relationship between individual differences in OTE and NFC and the viewers' aesthetic response to artworks in a gallery context. What we mean by functional role is that the nature of the relationship between OTE and NFC and aesthetic evaluations is contingent on dwell time and the spatial distribution of visual fixations. This translates more formally into the prediction that the way viewers visually explore the artworks will mediate the relationship between individual differences and aesthetic responses.

To test the hypothesis that visual exploration would mediate the relationship between personality traits, cognitive style and aesthetic responses, it is important to clarify how we planned to measure aesthetic responses and visual exploration. Aesthetic responses to artworks can be measured in numerous ways but in the present study we focus on written descriptions and rating scales. Open-ended written descriptions provide an immediate

[1] Risko et al., (2012) found that participants' level of perceptual curiosity (a trait conceptually related to OTE) was associated with the number of regions visited in a scene-viewing task.

measure of a participant's engagement with the artworks. Locher et al., (2007) outlined a categorical framework for classifying written descriptions made in response to viewing artworks. They coded the descriptions made by participants in response to viewing paintings in terms of whether they reflected a (1) single compositional elements; (2) several compositional elements perceived as a unit; (3) the realism of the composition; (4) the beauty of the composition; (5) the expressiveness of the composition's content; and (6) the style and form of the composition. We used Locher's categories to quantify a viewer's overall aesthetic engagement with the artworks, in terms of the total number of instances of each category in the written descriptions.

Rating scales have been used to capture the extent to which an artwork leads to a sense of liking, pleasure, enjoyment, awe, emotionality and interest. These rating scales may reflect rather different responses. For example, liking, pleasure, and enjoyment experienced in response to an artwork have been described as reflecting a 'shallow hedonic tone', while awe and 'being moved' reflect a 'deeper hedonic tone' (Schindler et al., 2017; Schubert et al., 2016). Moreover, interest is thought to be characterised by willingness to find meaning in artworks (Cupchik, 1995; Cupchik & Gebotys, 1988). Nevertheless, and despite reflecting different aspects of an aesthetic response, scores on these different scales are often shown to be highly correlated. Indeed, Silvia et al., (2015) calculated a composite aesthetic response measure from a number of scales reflecting different varieties of aesthetic response. In the present study, aesthetic responses were measured using 4 rating scales which were combined to generate a composite measure of aesthetic engagement, as well as from written descriptions made in response to viewing artworks.

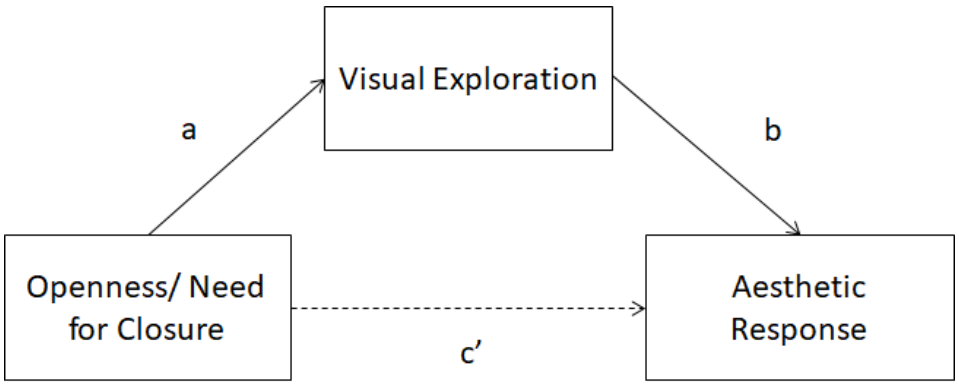
Recording and analysing eye movements in the context of a gallery is significantly more difficult than in a laboratory where conditions can be more readily controlled.

Measuring the temporal and spatial distribution of eye movements to individual artworks in a gallery is likely to lead to very significant inter-artwork variability. Therefore here, and following Smith and Smith (2001; Smith et al., 2017), we focus on measures of overall dwell time and the spatial distribution of fixations across all artworks (see also Garbutt et al., 2020; Locher et al., 2007, p. 200; Pelowski et al., 2018; Reitstätter et al., 2020; Savazzi et al., 2014 for similar approaches). The total dwell time can be extracted from the data stream of a mobile eye tracker by summing the duration of all fixations on the artworks (Niehorster et al., 2020). The spatial distribution of fixations can be measured with respect to a virtual grid that allows an estimation of the percentage of the area in each artwork that received at least one fixation (see Locher et al., 2007 for a similar method).

Taken together, in the present study we investigated if the potential relationship between OTE and NFC and visitors' aesthetic responses to the artworks was mediated by the spatial and/or temporal indices of visual exploration. These relationships were assessed using a series of mediation models. If the mediation models are significant then the association between OTE and NFC and aesthetic responses is explained by the spatial and/or temporal characteristics of visual exploration (see Figure 1). We predicted that OTE/NFC would exert an indirect effect on aesthetic responses through dwell time and the spatial distribution of fixations.

Figure 1

Conceptual diagram of the mediation model



Note. Diagram of a mediation model where visual exploration (as indexed by total dwell time and the spatial distribution of fixations) fully mediates the association between openness/need for closure and aesthetic responses.

Method

Participants

Seventy-eight participants, who were visitors to the TATE Liverpool gallery, took part in the study between 3rd - 16th February 2020. The study formed part of a two-week TATE Exchange programme (see https://www.tate.org.uk/tate-exchange), in which visitors were encouraged to participate in activities in the gallery. The programme was advertised on the gallery website a few weeks prior to the event and flyers were distributed inside the gallery. The information provided was that visitors could walk around the gallery and view artworks while having their eye movements recorded with a portable eye tracker. Participants were recruited throughout the two-week period at the gallery, without booking, so the total number of participants could not be determined in advance. For this reason, the statistical power of observed effects was not estimated.

Due to equipment failure (4 participants), and eye-tracking recordings where participants withdrew from the study before completion (18 participants), the final sample

consisted of fifty-six participants, aged between 12 and 70 years (M = 34.8; SD = 17.5 years; 50% were females). In terms of demographics, 61% were British, 23% were from other European countries, and 16% were from overseas, with 89% of the participants currently living in the UK. Thirteen participants were professional artists or art, design or architecture students. Compared with much existing research in empirical aesthetics, which typically includes undergraduate students as participants (e.g., Francuz et al., 2018; Locher et al., 2007; Massaro et al., 2012; Pihko et al., 2011) our sample was relatively diverse in terms of age. The study was approved by the Ethics Committee of the Faculty of Science of Liverpool Hope University (Protocol number: S 18-12-19 SREC001) and was conducted in accordance with the code of practice of the British Psychological Society.

Materials and Design[2]

Data was collected from participants prior to, and during, visual exploration of artworks. Eye movements were recorded using Tobii Pro 2 eye-tracking glasses as participants viewed the series of artworks. Gaze data was collected at a sampling rate of 100 Hz. The glasses recorded first-person video through a scene camera (a wide-angle lens centred between the eyes). Viewing was binocular and movements of both eyes were recorded. The coordinate system for eye-gaze localization used an infra-red-light source to relate the pupil-centre corneal-reflection-vector to positions from the scene camera (Holmqvist et al., 2011).

Seven artworks (see Figure 2) were selected prior to the study from the 'Constellations' exhibition (2013-2021) at TATE Liverpool, which displayed artworks from the museum's permanent collection of modern and contemporary art. The sample was chosen

[2] This study forms part of a larger project, for which 3 further measures were taken during the course of the gallery visit. These additional measures (trait mindfulness, big five scales, and a rating scale about the monetary value of the artworks) fall outside the scope of the current manuscript. More details about the scope of the project can be found here: https://osf.io/498m5/

to be broadly representative of the range of media presented in the exhibition at the time the study was undertaken and included both two and three-dimensional artworks. Several of the artworks were representational - they portrayed recognizable objects - and others were non-representational or abstract. Whilst studies have shown that viewers may engage differently with abstract versus representational works of art (e.g., Schepman & Rodway, 2021), this distinction and the impact of stylistic features were not considered within the present study. The formal characteristics of individual artworks was not a significant factor in selection beyond capturing a range of styles.

Figure 2

Illustration of the artworks that visitors were instructed to view in the gallery

Note. a) Relation of Aesthetic Choice to Life Activity (Function) of the Subject (1961-62) by Billy Apple; b) Felt Suit (1970) by Joseph Beuys; c) Casserole and Closed Mussels (1964) by Marcel Broodthaers; d) The Visit (1966-67) by Willem de Kooning; e). Girl in a Chemise (1905) by Pablo Picasso; f) Untitled (1946-47) by Mark Rothko; g) Northwest Drift (1958) by Mark Tobey.

Openness was measured with the Openness/Intellect subscale from the Big Five Aspect Scales (BFAS; DeYoung et al., 2007). This subscale measures two separate, but related, traits: Openness to Experience and Intellect. Only the Openness subscale was administered (10 items), as this trait best reflects aesthetic receptivity and aesthetic emotions (DeYoung et al., 2012). The scale was administered on a 5-point Likert-type scale (0 = never, or very rarely true, 4 = very often, or always true). Sample items include: "*I see beauty in things that others might not notice*". "*I love to reflect on things*". In the current sample the subscale displayed an acceptable level of internal consistency (Cronbach's $\alpha = .68$).

NFC was measured with the brief Need for Closure scale (Roets & Van Hiel, 2011). The brief NFC scale is a fifteen-item version of Webster and Kruglanski's (1994) 42-item NFC Scale. The brief scale correlates (.95) with the original measure and is a reliable and valid measure of NFC (Roets & Van Hiel, 2011). The scale was administered using a 6-point Likert-type scale (1 = strongly disagree, 6 = strongly agree). Sample items include: "*I don't like situations that are uncertain.*" and "*When I have made a decision, I feel relieved*." The scale displayed a high level of internal consistency (Cronbach's $\alpha = .85$).

Art interest was measured using the Vienna Art Interest & Art Knowledge Questionnaire (VAIAK; Specker et al., 2020). Only Part A on art interest was administered and this contained 11 questions rated on a 7-point Likert scale (1 = not at all, 7 = very much, for items 1 to 7; 1 = less than once per year, 7 = once per week or more often, for items 8 to 11). Sample items include: "*I enjoyed visiting art class in school.*" and "*How often do you*

visit art museums or art galleries on average?" The scale displayed a high level of internal consistency (McDonald's ω = .95).

Aesthetic responses to artworks were measured by four self-report rating scales. Specifically, participants were asked "Do you find this artwork…" followed by items for pleasing, interesting, emotionally moving and familiarity. Participants responded to each item using a 7-point scale (1 = not at all, 7 = very much). Additionally, participants were instructed to write open-ended descriptions in response to each artwork.

The research materials and data for this study are available at the Open Science Framework (https://osf.io/498m5/).

Procedure

The first part of the study took place in a large semi-enclosed space dedicated to the TATE Exchange programme on the first floor of the TATE Liverpool gallery. Gallery visitors could freely enter the space and volunteer to participate in the study. If willing, participants read the information sheet and signed the informed consent form, and laptops were available for participants to complete computerised versions of the questionnaires and provide demographic information, using Psychopy software (Peirce, 2007). They then received instructions on the use of the mobile eye tracker and completed a calibration procedure before starting the eye tracking recording. The calibration with the Tobii Pro 2 glasses optimises the 3D eye model via gaze estimation algorithms. During calibration, participants were presented with a card positioned on the wall and were asked to fixate a black dot in the centre of the card. Once calibration was completed the recording could commence.

Participants received a map of the gallery which marked the position of the 7 artworks related to the study. Participants were free to decide the order in which they wished to view the artworks and were instructed to complete the aesthetic rating scales and open-ended written descriptions after viewing each artwork. At the end, participants were fully debriefed about the aims of the study. The completion of the entire study (questionnaires and viewing the artworks) took on average one hour per participant.

Data Analysis

Eye tracking

Eye tracking recordings were analysed using Tobii Analyzer Pro software (Tobii Technology, Stockholm, Sweden, www.tobii.com). Fixations were classified using the default settings: Noise reduction -> Moving median, window size (samples) = 3; Velocity calculator -> Window length = 20 ms; I-VT classifier -> Threshold (°/s) = 100; Merge adjacent fixations -> Max time between fixations = 75 ms, Max angle between fixations = 0.5; Discard short fixations -> Minimum fixations duration = 60 ms (Oslen, 2012). For each artwork, gaze data was automatically mapped onto images of the artwork using the Tobii Analyzer Pro Real-World Mapping function. Following this procedure, the accuracy of the mapping was checked manually and if necessary corrected, and gaze data that could not be mapped automatically was coded manually. For each participant, the total viewing duration (henceforth dwell time) on each artwork was calculated by summing the durations of all fixations made on the artwork during the viewing period. The viewing window started when the viewer made two sequential fixations on the artwork and ended with the participants' final fixation on the artwork.

Analysis of the spatial distribution of viewers' fixations used an adapted version of the grid method originally proposed by Locher, (2006). A 4 x 5 (width, height, see Figure 3)

grid was superimposed over each artwork and the number of fixations made within each cell was calculated. The physical size, and ratio of height to width, differed across the artworks, therefore the size of the superimposed grid cells necessarily differed across artworks. However, we were only interested in the relative spatial distribution of fixations on the artworks and so, for each participant, the spatial distribution of eye movements on each composition was calculated as the percentage of grid cells that contained at least one fixation.

Figure 3

Illustration of the 4 x 5 grids superimposed on the artworks by 1) Apple, 2) Beuys, 3) de Kooning, 4) Picasso, and 5) Rothko

Note. The grids were used to derive the spatial distributions of fixations on the artworks. Spatial distributions were unable to be computed for artworks by Tobey (due to its visual

uniformity) and Broodthaers (due to its 3D nature). Nevertheless, these artworks were selected for the study to include a wide range of artistic objects, and all other measures were analysed for these artworks except spatial distribution.

Written descriptions

Written descriptions were quantified in two ways. The first was the total number of words used in the written descriptions across all artworks. We considered this measure as reflecting a viewer's broad aesthetic engagement with the artworks. The second, more conservative, measure aimed to quantify more precisely the aesthetic evaluation of the artworks. This measure, which we term 'aesthetic descriptors', consisted of the frequency of occurrence of words or phrases in the written descriptions that clearly reflected aesthetic evaluation, according to the classification scheme of Locher et al., (2007). Written descriptions were coded as belonging to (1) single compositional elements (e.g., "coarse felt material"); (2) several compositional elements perceived as a unit (e.g., "The girl looks rather stern"; (3) the realism of the composition (e.g., "rather abstract"); (4) the beauty of the composition (e.g., "beautiful greens catch the light"); (5) the expressiveness of the composition's content (e.g., "it gives off energy and movement"); and (6) the style and form of the composition (e.g., "it's very surreal"). Examples given are participants' comments. For each participant, the aesthetic descriptor measure was the total number of instances across all six categories and for all of the artworks.

Coding was conducted by two co-authors (JK and TT), both trained in the visual arts, who worked independently. There was a high positive correlation between the frequencies computed by the two raters for the aesthetic descriptors ($r_s = .90$, $p < .001$, $N = 56$). Cases in which the two raters disagreed were moderated through discussion.

Results

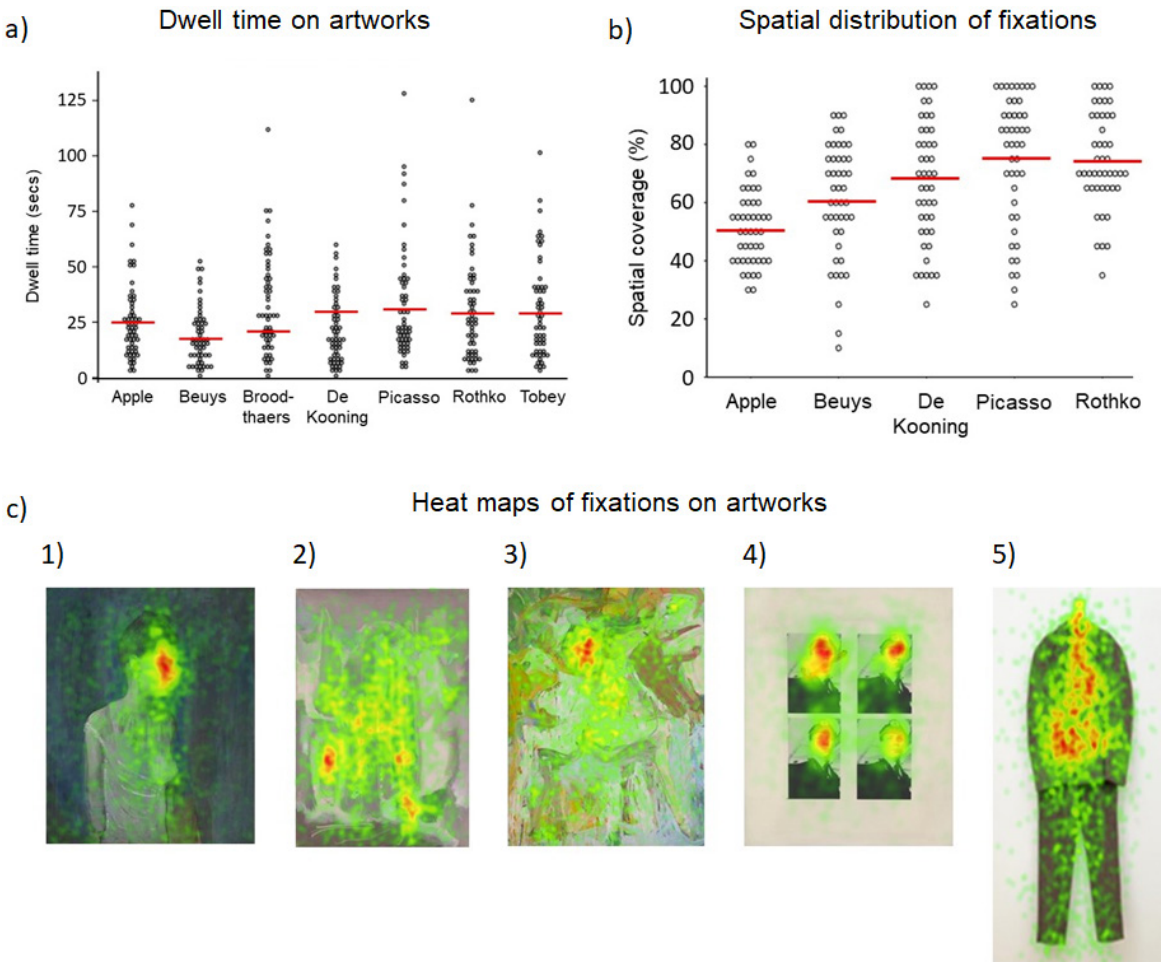
The results are structured in two steps. First, we present the descriptive analysis of our data. Second, we report the mediation analyses.

Descriptive results

Overall, our sample had a moderate level of interest in art (VAIAK interest scale: M = 32.80; SD = 11.05). On average, participants looked at each artwork for between 18 to 32 seconds (see Figure 4a) and made at least one fixation in 66% of the grids (Figure 4b). Heat maps of fixations across all participants are displayed in Figure 4c. On average, each participant wrote 64 words in total, and the average number of aesthetic descriptors per participant was 9. The total number of words (here termed 'total words') and the frequency of occurrence of the 'aesthetic descriptors', using the categories from Locher et al. (2007), are reported for each artwork in Table 1. Descriptive statistics for the rating scales are displayed in Table 2.

Figure 4

Visual exploration of the artworks



Note. a) Dwell time on each of the seven artworks are plotted for each participant. b) The percentage of grid cells containing at least one fixation are plotted for each participant. In plots a and b, the red horizontal lines indicate the mean values. c) Heat maps of fixations. The heat maps illustrate the location of fixations (lower fixation count in green through to greater fixation count in red) made by participants for artworks by 1) Apple, 2) Beuys, 3) de Kooning, 4) Picasso and 5) Rothko.

Table 1

Total number of words and frequency of occurrences of aesthetic descriptors for each artwork

	Artworks							
Measure	Apple	Beuys	Broodt-haers	De Kooning	Picasso	Rothko	Tobey	All artworks
Aesthetic descriptors								
1. Single elements	13	9	1	7	14	7	0	51
2. Several elements as a unit	3	1	7	2	2	3	0	18
3. Realism	0	0	1	7	0	10	8	26
4. Beauty	6	3	2	7	9	9	2	38
5. Expressiveness	37	31	32	32	41	34	22	229
6. Style and form	9	8	8	13	12	23	20	93
Total aesthetic descriptors	68	52	51	68	78	86	52	455
Total words	630	520	442	469	452	656	420	3589

Table 2

Mean (and SD) ratings for each artwork

	Artworks							
Measure	Apple	Beuys	Broodt- haers	De Kooning	Picasso	Rothko	Tobey	All artworks
Pleasure	4.55 (1.56)	3.29 (1.74)	3.88 (1.77)	3.82 (1.96)	4.48 (1.48)	4.27 (1.80)	3.77 (1.86)	4.01 (1.23)
Interest	5.25 (1.38)	3.80 (1.77)	4.59 (1.59)	4.73 (1.79)	4.52 (1.46)	4.96 (1.55)	3.98 (1.84)	4.55 (1.05)
Emotionally Moving	3.54 (1.69)	2.91 (1.87)	2.52 (1.57)	4.07 (1.93)	4.41 (1.66)	3.88 (1.95)	3.02 (1.84)	3.48 (1.16)
Familiarity	1.84 (1.63)	2.13 (1.74)	2.02 (1.77)	2.21 (1.97)	2.95 (1.99)	2.20 (1.75)	1.95 (1.54)	2.18 (1.45)

There were large inter-item correlations (all $r_s > .73$) between responses on the pleasing, interesting, emotionally moving and familiarity rating scales. In addition, we conducted a Principal Component Analysis to provide statistical evidence for reduction of multiple ratings into one component (Kaiser, 1961). The first principal component accounted for almost 80% of total variance with an eigenvalue of 3.18. Thus, the first component dominates the variance and provides sufficient evidence for merging multiple ratings, as remaining eigenvalues are all relatively small and of comparable size (Jolliffe, 2002; Peres-Neto et al., 2005). Therefore, following the procedure proposed by Silvia et al., (2015), we calculated a composite rating score, using the mean of the four ratings[3]. Mean scores on each

[3] The same pattern of results for correlations with visual exploration was found using the rating scales individually: all correlation coefficients for dwell time and spatial distribution and the four individual rating scales were < .21.

of the individual difference measures, and the intercorrelations between these measures are reported in Table 3.

Table 3

Descriptive Statistics and Zero-Order Correlations Between Measures

Measure	Mean	SD	1.	2.	3.	4.	5.	6.
1. Openness to Experience	28.57	5.53						
2. Need for Closure	54.75	11.60	-.31*					
3. Composite ratings	3.55	1.09	.34*	-.01				
4. Total words produced	64.09	66.16	.49***	-.32*	.41**			
5. Aesthetic descriptors	9.27	7.60	.47***	-.13	.26	.85***		
6. Dwell time (secs)	191.83	106.28	.50***	-.37**	.12	.51***	.47***	
7. Spatial distribution (%)	66.04	14.49	.30*	-.39**	-.02	.39**	.27*	.75***

*p < .05; ** p < .01; *** p < .001

Note. Dwell time is the total time (i.e., sum of all fixation durations) spent viewing all the seven artworks.

Mediation analysis

Mediation analyses were conducted using the PROCESS macro for SPSS (Hayes, 2018a). The method tests the significance of the indirect effect of the predictor on the outcome through the mediating variable (Hayes, 2018b). Confidence intervals for the indirect effect that do not contain zero indicate the presence of a significant mediation. A full mediation is obtained when the indirect effect is significant *and* the direct is not significant, whereas a partial mediation is obtained when both the indirect and direct effects are significant. Figure 1 displays the mediation models being tested. Potential relationships were examined using a percentile bootstrapped mediation analysis. This technique computed bias-corrected confidence intervals at the 95% level for the indirect effect of the mediator using z = 5000 bootstrap samples.

Correlations between OTE and dwell time, OTE and total words, OTE and descriptors, and between dwell time and total words, and dwell time and aesthetic descriptors, were all significant. The correlations between NFC and dwell time and NFC and total words, and between NFC and aesthetic descriptors, were significant. Mediation models were tested, with dwell time as the mediator, for OTE and total words, OTE and aesthetic descriptors, NFC and total words, and NFC and aesthetic descriptors. The same four mediation models were also conducted with spatial distribution of eye movements as the mediator.

A precondition to run the mediation analysis was that there were significant correlations between the predictor and the mediator and between the mediator and the outcome. In order to run a mediation analysis a significant correlation between the predictor and outcome, while important, is not a necessary condition (Bollen, 1989; Hayes, 2018a)[4]. Mediation analyses could not be conducted where the outcome variable was composite ratings, as the correlations between composite ratings (outcome variable) and dwell time (mediator) and composite ratings and spatial distribution (mediator) did not reach significance.

All mediation models were conducted with the scores from the VAIAK entered as a covariate to control for the potential influence of art interest in the relation between OTE/NFC and total words/aesthetic descriptions.

Dwell times: Mediation models

Openness to Experience

[4] Among the two eye-tracking factors of interest and two aesthetic outcome factors there were positive correlations. Nevertheless, the Variance Inflation Factor (VIF) estimates suggest that there were no multicollinearity issues among any of the factors and their interactions in the tested models (VIFs < 2.78).

The direct effect of OTE on total words was not significant (p = .269, 95% CIs [-1.78, 6.26]). The confidence interval for the indirect effect [0.47, 5.60] excluded zero, which is evidence of a significant indirect mediation effect. Therefore, dwell time fully mediated the relationship between OTE and the total number of words (see Figure 5a).

For aesthetic descriptors, the direct effect of OTE was not significant (p = .153, 95% CIs [-0.13, 0.83]). The confidence interval for the indirect effect [0.01, 0.63] excluded zero. Therefore, dwell time fully mediated the relationship between OTE and aesthetic descriptors (Figure 5b).

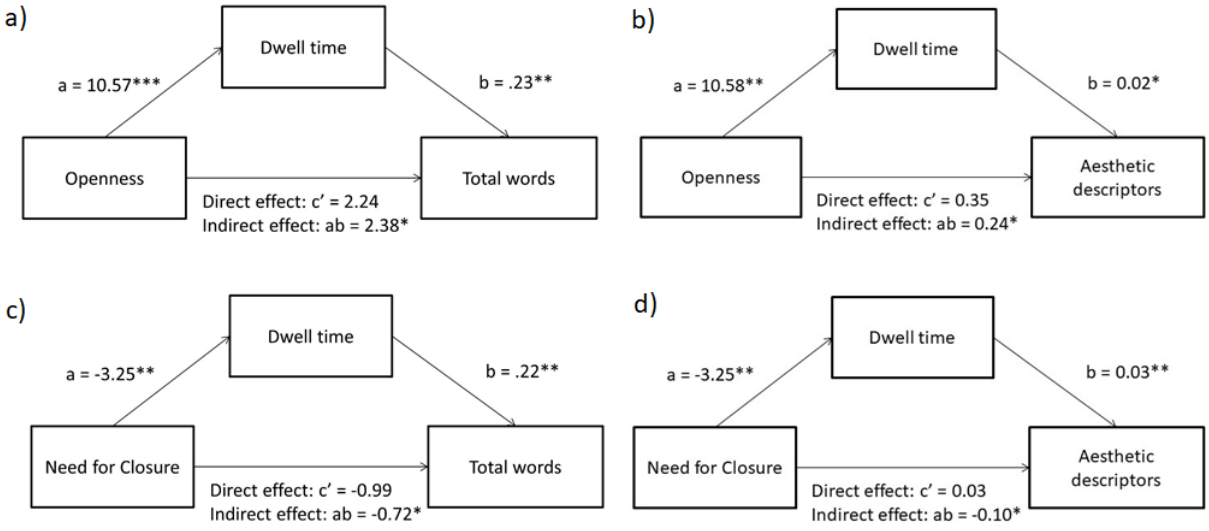
Need for Cognitive Closure

The direct effect of NFC on total words was not significant (p = .150, 95% CIs [-2.36, 0.37]). The confidence interval for the indirect effect [-1.40, -0.19] excluded zero, which is evidence of a significant indirect mediation effect. Therefore, dwell time fully mediated the relationship between NFC and the total words (see Figure 5c).

For aesthetic descriptors, the direct effect of NFC was not significant (p = .753, 95% CIs [-0.14, 0.19]). The confidence interval for the indirect effect [-0.19, -0.02] excluded zero. Therefore, dwell time fully mediated the relationship between NFC and aesthetic descriptors (Figure 5d).

Figure 5

Graphical display of the mediation models with dwell time as mediator



* $p < .05$; ** $p < .01$; *** $p < .001$.

Note. Unstandardised regression coefficients for the relationship between a) Openness and total number of words, which was fully mediated by dwell time; b) Openness and aesthetic descriptors, which was fully mediated by dwell time, and c) Need for Closure and total words, which was fully mediated by dwell time, and d) Need for Closure and aesthetic descriptors, which was fully mediated by dwell time. VAIAK scores were included as a covariate in all mediation models.

Spatial distribution of fixations: Mediation models

Openness to Experience

The direct effect of OTE on total words was not significant ($p = .136$, 95% CIs [-0.96, 6.89]. The confidence interval for the indirect effect [0.14, 3.96] excluded zero, which is evidence of a significant indirect mediation effect. Therefore, the spatial distribution of fixations fully mediated the relationship between OTE and total words (Figure 6a).

The direct effect of OTE on aesthetic descriptors was significant ($p = .046$, 95% CIs [0.01, 0.97]. The confidence interval for the indirect effect [-0.04, 0.31] included zero, which

provides evidence that no mediation effect occurred. Therefore, the spatial distribution of fixations did not mediate the relationship between OTE and aesthetic descriptors (Figure 6b).

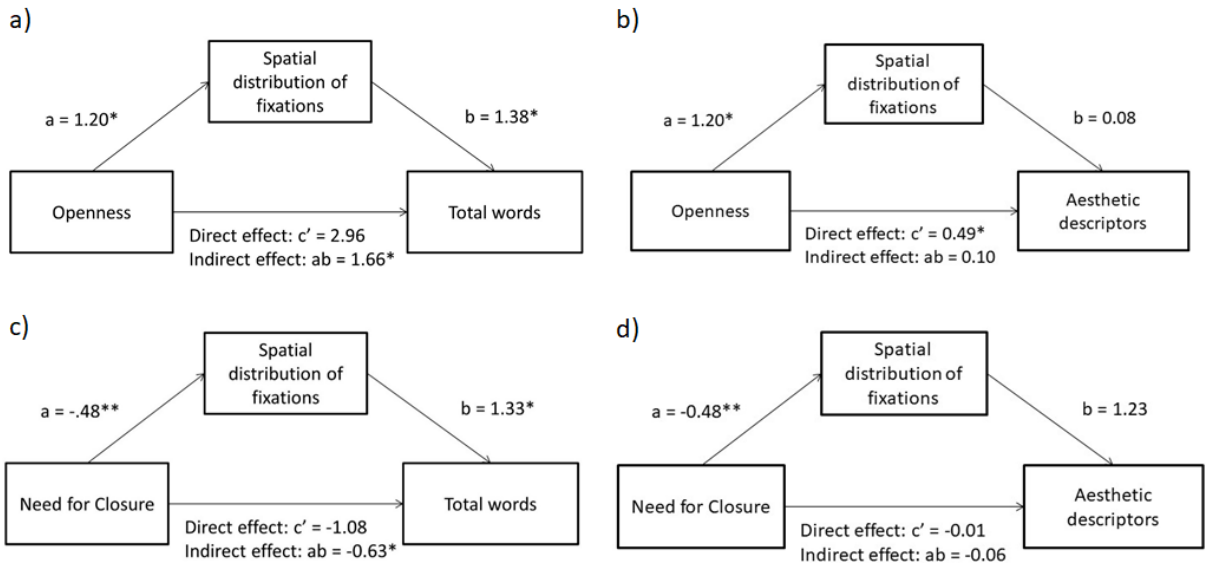
Need for Cognitive Closure

The direct effect of NFC on total words was not significant (p = .129, 95% CIs [-2.48, 0.33]. The confidence interval for the indirect effect [-1.24, -0.09] excluded zero, which is evidence of a significant indirect mediation effect. Therefore, the spatial distribution of fixations fully mediated the relationship between NFC and total words (see Figure 6c).

The direct effect of NFC on aesthetic descriptors was not significant (p = .91, 95% CIs [-0.19, 0.17]. The confidence interval for the indirect effect [-0.14, 0.01] included zero, which provides evidence that no mediation effect occurred. Therefore, the spatial distribution of fixations did not mediate the relationship between NFC and aesthetic descriptors (Figure 6d).

Figure 6

Illustration of the mediation models with spatial distribution of fixations as mediator



* $p < .05$; ** $p < .01$.

*Note***.** Unstandardised regression coefficients for the relationship between a) Openness and total words, which was fully mediated by spatial distribution of eye movements, b) Openness and aesthetic descriptors, which was not mediated by spatial distribution of eye movements, c) Need for Closure and total words, which was fully mediated by spatial distribution of eye movements, and d) Need for Closure and aesthetic descriptors, which was not mediated by spatial distribution of eye movements. VAIAK scores were included as a covariate in all mediation models.

Discussion

The present study explored the role of visual exploration in relation to individual differences and aesthetic evaluations of works of art by members of the public at TATE Liverpool. We hypothesised that visual exploration would play a key role in explaining the association between OTE and NFC and aesthetic responses to artworks. Visual exploration was measured in terms of both the overall dwell time and the spatial distribution of fixations made when viewing artworks. Aesthetic responses were measured using open-ended written

descriptions and rating scales. Open-ended written descriptions were classified in two ways; firstly, using the total number of words in the written descriptions, and secondly using the frequency of use of aesthetic descriptors.

The results showed an indirect relationship between OTE and NFC and the total number of words which was mediated by the overall dwell time and the spatial distribution of fixations to artworks. Specifically, OTE and NFC influenced how long visitors spent looking at the artworks and how much of the area of the artwork they fixated. In turn, dwell time and spatial distribution of fixations was positively associated with the number of words that the visitors used to provide their responses in the case of OTE, and negatively associated with the number of words in the case of NFC. As such, both dwell time and spatial distribution of fixations are intervening components mediating the influence of OTE and NFC on the total number of words used by participants to describe responses to artworks. In contrast, overall dwell time but not the spatial distribution of fixations mediated the association between OTE and NFC and the frequency of use of aesthetic descriptors. This finding suggests that the relationship between OTE and NFC and evaluation of the aesthetic qualities of the artworks is mediated by dwell time alone.

The mediated relationships between OTE and NFC and the number of words used to describe response to artworks and the number of aesthetic descriptors used are not accounted for by an interest in visual art. Interest in visual art was measured in the present study using the VAIAK. Scores on the VAIAK were entered into the mediation analyses as a covariate such that the analyses controlled for differences across participants in their interest in visual art. Visual exploration alone explains the relationship between OTE and NFC and participants' responses to artworks.

The results add to an emerging literature on the role of individual differences in aesthetic evaluations (e.g., Chamorro-Premuzic et al., 2009; Fayn et al., 2015; Ostrofsky &

Shobe, 2015) and emotional responses to artworks (Rodriguez et al., 2021). They do so by showing that More broadly, the current findings also invite future research to focus on understanding the role of individual differences in eye movement behaviour in different types of scenes (e.g., built environments, landscapes etc), and how these differences are related to the viewers' evaluation of these scenes (de Haas et al., 2019; Risko et al., 2012).

It is instructive to discuss the results in terms of Locher's (2014) and Pelowski et al.'s (2017) models of aesthetic processing. In Locher's (2014) model, the spatial distribution of attention is important only during the initial stages of viewing in order to process the lower-level pictorial and compositional elements. Locher argued that once perceptual analysis of the pictorial elements is accomplished, the viewer then maintains localised attention on the most salient compositional elements, and high visual exploration is a key mechanism through which individual differences exert an influence on aesthetic evaluation. er-level aesthetic evaluations of the artwork are derived from these elements. The present data support Locher's account in the sense that only dwell time, and not the spatial distribution of fixations, is important for generating aesthetic descriptors in response to an artwork. According to Pelowski's model, OTE and NFC would exert an influence on aesthetic responses at later stages of the aesthetic processing. What the current study adds to these accounts is evidence that the set of associations between OTE and NFC and aesthetic descriptions is accounted for by dwell time.

Evidence of a role for OTE and NFC in dwell time during an aesthetic encounter raises an important question. Does the influence of OTE and NFC on dwell time reflect solely the efficient bottom-up extraction of visual information on which to base aesthetic evaluation? Or do OTE and NFC also influence internally-directed reflective processing occurring during the experience of an artwork (see Silvia, 2009; Vessel et al., 2013; Walker et al., 2017)? Our study was not designed to disentangle bottom-up and top-down processes

when extracting visual information from the artworks. However, the finding that overall dwell time, and not the spatial distribution of fixations, is associated with the use of aesthetic descriptors seems to sit most easily with the idea of internally-directed processing.

We suggest that OTE and NFC influence visual exploration when viewing artworks by encouraging a mutually reinforcing interaction between bottom-up perceptual analysis and internally focussed self-reflections. Here, aesthetic reflections and cognitions stimulate deliberate reorientation of attention back to the artwork to extract more visual information, which in turn would lead to further aesthetic evaluations. This sequence of recurrent feedback between cognitive and perceptual processes is a key aspect of extended viewing times according to Leder and Nadal (2014) and may underlie the type of temporally extended interactions with the artwork that Smith and Smith (2001) described as 'savouring'.

Moreover, Cupchik et al., (2009) proposed a distinction between an aesthetic and a more pragmatic mode of viewing. In their study, participant's brain activity was recorded using fMRI while they were instructed to view a set of representational and non-representational paintings in either a pragmatic (i.e., everyday) or an aesthetic (i.e., engaged, receptive) manner. Focusing on the pragmatic aspects of the paintings activated the right fusiform gyrus, which is usually associated with object recognition processes. In contrast, viewing paintings in an aesthetic orientation activates the lateral prefrontal cortex (LPFC). The LPFC is an area involved with higher-order self-referential processing and with the evaluation of internally generated information (see Northoff et al., 2006). The difference in patterns of brain activation reported across the two viewing conditions was interpreted by Cupchik et al. (2009) as evidence for the two modes of viewing. Cupchick's study supports the notion that an aesthetic mode of viewing would entail self-reflective processes while engaging with works of art (see also Vessel et al., 2013). It is unlikely that an internally-directed process while viewing artworks would occur at an early stage because this would

require the recruitment of higher-order cognitive processes. It is also important to consider the context in which the viewer engages with works of art. Experiencing artworks in the real gallery context (as opposed to a controlled lab environment) may more naturally predispose participants in entering into what Nanay (2015) called an 'aesthetic mode of attention' (though see Fazekas, 2016). In the current study, a self-reflection process while viewing the artworks may be expressed in the influence that OTE and NFC exert on aesthetic responses via dwell time. Future studies will be useful in investigating this idea further.

For some of the artworks attention was captured by salient features, such as faces and other prominent objects (see heatmaps for artworks 1 and 4 in Figure 4c), hence limiting the overall spatial distribution of fixations (e.g., Theeuwes, & Van der Stigchel, 2006; Trawinski et al., 2021). Attentional capture by prominent anchoring points in these artworks may have prevented the spatial distribution of fixations from mediating the relationship between OTE/NFC and aesthetic descriptors. It remains an open question as to whether the presence and spatial distribution of salient objects within an artwork influences the relationship between OTE/NFC and aesthetic descriptors. We propose that this question should be explored using carefully selected sets of artworks based on the number and distribution of salient objects.

The present study extends the literature exploring aesthetic responses in a gallery setting using eye tracking while visitors inspected artworks (e.g., Garbutt et al., 2020; Pelowski et al., 2018; Quiroga & Pedreira, 2011; Reitstätter et al., 2020; Santini et al., 2018; Savazzi et al., 2014; Smith & Smith, 2001; Tröndle & Tschacher, 2012; Tschacher et al., 2012; Wagemans, 2019; Walker et al., 2017). However, conducting the study in the gallery setting led to some challenges that may have impacted the results we report. We list these challenges here.

First, the flow of people into the gallery, allied to the fact that it took longer to gain visual exploration data than to complete the individual difference measures, meant that it was not practical to counterbalance the tasks. One legitimate question is whether the fact that participants completed the individual difference measures before exploring the artworks affected the results. Research practice is mixed on this issue, even in the lab setting where counterbalancing procedures is generally not problematic. Some studies measured individual differences before other visuo-cognitive measures were taken (e.g., McCaffery et al., 2018 in face matching task; Muhl-Richardson et al., 2018 in visual search task; Sarsam et al., 2021 in scene perception task; Trawiński, Mestry, et al., 2021; Colver & El-Alayli, 2015 in art appreciation task), others take visuo-cognitive before individual difference measures (Peltier & Becker in visual search task, 2017; Risko et al., 2012; Ganczarek et al., 2015; Sherman et al., 2015), while some counterbalance tasks (e.g., Megreya & Bindemann, 2013 in face identification task). Moreover, we could not find clear evidence that task order influences visual exploration, with the exception of one study for which subsequent analyses did not find evidence of such an effect (Trawiński et al., 2020). However, there are two main points to be made about the potential influence of task order on visual exploration for the present study. First, OTE and NFC scales were embedded in a larger set of individual difference measures. If the act of considering answers to questions exploring these personal dimensions was sufficient to influence subsequent visual exploration, it occurred without the scales being explicitly identified by the participants. Second, the data remain important even if questions exploring OTE and NFC influenced subsequent visual exploration of artworks. OTE and NFC are stable personal factors and cannot be generated by filling in a series of questions. The questionnaires may have offered an opportunity for the participants to reflect on their personality and cognitive characteristics which are part of who they are. Whether it is the presence of these traits or the renewed awareness of these traits that allowed the effect to

come into surface it does not matter, because we cannot have the second without the first. Therefore, the fact that participants had a chance to reflect on their personal traits before visually attending some artworks does not change the result that OTE and NFC are relevant characteristics associated with their aesthetic experience.

Thoughts about the influence of task order on the results must also be considered in the context of a self-selecting participant group with differing motivations to visit the gallery (e.g. desire to view artworks, escape the rain etc.). Consideration of the implications of this fact must be made when interpreting all studies done in the gallery setting. For the present study, the influence of participant motivation to visit the gallery on the visual exploration of artworks is likely to be greater than any unintended effect of answering questions about OTE and NFC.

The second issue of concern is that we cannot rule out that the correlation between total dwell time and number of words was influenced by participants being able to view the artworks while they wrote their responses. However, given that our measure of dwell time included only fixations on the artworks, it is unlikely that participants were looking directly at the artworks while simultaneously writing on the response sheet.

The third issue of concern is that the artworks viewed by participants were highly varied in style (both representational and non-representational) and format (paintings and installations). The varied stimulus set went beyond the level of variation typically used in studies examining the viewing of artworks in the real setting as we felt it important to capture the experience of being in the gallery in a holistic sense. Our results showed that participants' ratings of aesthetic judgments did not significantly correlate with visual exploration and as such we could not conduct the mediation analysis with the ratings. A potential explanation for the fact that participants' ratings did not significantly correlate with visual exploration is that, although there was a relatively high reliability (estimated *r*(splits)'s >.72) within

participants across artworks, the ratings across participants for each artwork showed a somewhat lower reliability (estimated *r*(splits)'s >.6; see Appendix for full analysis). We note that, similarly, a previous study in which participants viewed a series of abstract and representational artworks in a gallery did not find an association between viewing time, as measured using a mobile eye tracker, and ratings of aesthetic judgements (Heidenreich & Turano, 2011). On the other hand, Brieber et al., (2014) found a correlation between viewing time and art experience scales when participants viewed a series of artworks in a museum but, perhaps importantly in their case, the artworks were all by the same artist. Together, these results suggest that Likert-type scales may not be sufficiently sensitive to successfully quantify aesthetic responses in a museum context when viewing artworks by multiple artists with different styles and formats. More studies are needed to clarify in which contexts evaluations measured by rating scales may or may not be associated with visual behaviour.

Conclusions

In summary, the present study shows that when participants view artworks in a gallery, dwell time is a mediating factor in the relationship between OTE and NFC and measures of aesthetic experience. The results add to an emerging literature on the role of individual differences in aesthetic evaluations (e.g. Chamorro-Premuzic et al., 2009; Fayn et al., 2015; Ostrofsky & Shobe, 2015) and emotional responses to artworks (Rodriguez et al., 2021). The current research suggests that studies investigating individual differences in aesthetic responses could usefully include measures of viewing behaviour in order to more fully understand how different individual traits influence aesthetic outcomes. More broadly, the study contributes to an emerging literature on the role of individual differences in eye movement behaviour in real-world settings.

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