

The relationship between aesthetic and drawing preferences

Article

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5

6 There are suggested to be similarities between what is aesthetically preferred and artistically
7 produced; however, little research has been conducted that directly examines this relationship
8 and its links to expertise. Here, we examined the artistic process of artists and non-artists
9 using geometric shapes as stimuli, investigating aesthetic (how pleasing they find the shapes)
10 and drawing preferences (which shape they would prefer to draw out of a choice of two). We
11 examined the cognitive processes behind these preferences using eye-tracking methods both
12 when viewing stimuli and when making drawing preferences. Drawing preference scores
13 increased with increasing aesthetic ratings regardless of expertise. We find gaze behaviour
14 when free-viewing to reflect behaviour when making a drawing preference as both artists and
15 non-artists fixated on aesthetically preferred stimuli first, for longer and more often. Artists
16 gaze behaviour when free-viewing was also influenced by what they would prefer to draw.
17 This suggests that artists have a more fluid relationship than non-artists between images
18 aesthetically preferred and those preferred for drawing. Overall, we demonstrate that there is
19 a relationship between aesthetic preference and artistic preference for production, and this
20 varies with expertise.

21

22 *Keywords:* aesthetic preference; drawing preference; eye movements; art expertise

23 There is argued to be an interaction between the aesthetic and artistic experiences
24 involved in producing an artwork (Tinio, 2013). The acts of production, perception and
25 enjoyment are suggested to be integrated as the artist behind the artwork conceptualises the
26 artwork and imagines how the perceiver will interact with the final work. The artist visually
27 evaluates their work as a perceiver of the final product in order to create something they
28 believe to be aesthetically pleasing (Dewey, 1934; Zeki & Nash, 1999). Therefore the
29 cognitive processes involved in the creation of art have been suggested to be similar to the
30 perception of art (Martindale, 2001; Tinio, 2013). Empirical research largely investigates the
31 experience of the perceiver (those perceiving final works of art) with less work examining the
32 experience of the artist. The art-making process arguably differentiates art from other
33 aesthetic forms that can be aesthetically appreciated, such as products and/or objects that are
34 designed. The artist, their behaviour, intentions and actions are important here. Yet less
35 emphasis in current empirical aesthetic research is put on understanding the artist and their
36 aesthetic experience during the art-making process (Tinio, 2013).

37 One notable attempt to understand the artistic process was put forward by Mace and
38 Ward (2002). They developed an art-making process model from the perspective of the artist.
39 Through interviews with professional artists they aimed to understand the processes of the
40 artist during the creation of their work. They identified four phases. The first phase is artwork
41 conception, which concerns when and how ideas are initially conceived. The second idea
42 development phase follows as an original idea is adapted and modified if necessary. The third
43 stage is the actual production of the artwork. The final stage involves finishing the artwork
44 and evaluating it prior to exhibition. Sapp's (1995) model specifically focuses on the initial
45 stages of art-making and conscious decisions made. Here, they explore the processes of
46 making ideas and identify the importance of making conscious decisions during the
47 production of potential ideas. Specific focus is put on how one idea is selected amongst

48 others. Mace & Ward suggest that these decisions made by artists, including idea selection as
49 presented in Sapp's model, are influenced by the artist's own aesthetic experience
50 demonstrating that there is a relationship between the artists' aesthetic and art-making
51 experience.

52

53 **Aesthetic and Art-making Experiences**

54 Initial art-making stages involve making conscious decisions on what to create.
55 Within Sapp's (1995) model for art idea conception it is explained how multiple ideas of a
56 concept are developed and a process of exploring and selecting ideas occurs until one option
57 is selected to be the most significant for a final concept. However, the model does not explore
58 what influences the decisions that are made during these early stages of art-making. Mace
59 and Ward (2002) also present an idea selection stage where a decision is to be made on what
60 to create and they suggest that the artists' aesthetic experiences impact upon decisions made
61 at this stage and indeed at any stage of the art-making process. They further state how
62 engaging in art-making activities can equally influence the artists' personal aesthetic
63 experience. Kay (1991) also suggests that this personal aesthetic experience is used by an
64 artist to construct ideas and aid thought processes when creating art, and that aesthetic
65 preferences, which are part of the overall aesthetic experience and are largely accepted as an
66 outcome of the aesthetic experience (Leder, Belke, Oeberst, & Augustin, 2004; Tinio, 2013),
67 help guide new art-making and other similar forms of experience. However, no empirical
68 research has directly investigated this relationship. Kozbelt (2017) further addresses how no
69 studies have directly examined how the artists' ideas and development of an artwork is
70 guided by aesthetic characteristics which impact perceiver's aesthetic experiences.

71 There is some empirical evidence that examines how idea selection takes place,
72 Groenendijk, Janssen, Rijlaarsdam and van den Bergh (2013) used a self-report measure to

73 gather information about adolescent students (non-artists) creative drawing activity and found
74 that very little time was spent making a decision on what to create. This may be explained by
75 a lack of expertise leading to a failure to consider alternative ideas, thus one initial idea can
76 quickly and directly become the final artwork (Sapp, 1995). Alternatively it may be because
77 aesthetic preferences are formed in a short period of time that a quick drawing decision can
78 be made (Locher et al., 2007; Willis & Todorov, 2006). No research to date explores these
79 initial art-making decisions in more depth, however indirect evidence does show some
80 similarities between preference and production which are discussed next.

81

82 **Aesthetic Preference and Art Production**

83 Indirect evidence from studies of the content of productions do show similarities
84 between images aesthetically preferred and produced. More complex designs were created
85 and aesthetically preferred by more creative artists, and less complex designs were created
86 and aesthetically preferred by less creative artists (Taylor & Eisenman, 1964). In addition,
87 images preferred for drawing were found to be dependent on the content of the stimuli to be
88 drawn, despite prior drawing experiences. This could potentially be due to the complexity in
89 producing images, but those images preferred for drawing were also aesthetically preferred
90 (Kozbelt, Seidel, ElBassiouny, Mark & Owen, 2010; Guggenheim & Whitfield, 1989).
91 Boyatzis and Eades (1999) consider children's artistic productions, preferences and
92 production choices. They found that the productions created and those selected were
93 influenced by gender stereotypical content, further showing a relationship between preference
94 and production. Furthermore, symmetry has also been found to impact art production with
95 use of symmetry in creations differing dependent on gender and age, however here it has
96 been shown that there tends to be disparities between the types of symmetry preferred and
97 those found in productions (Humphrey, 1997; Washburn & Humphrey, 2001). So, research

98 has reported similarities between preference and production, however there has been no
99 direct exploration of the relationship between preference and production considering those
100 familiar with the art-making process and those with less experience.

101

102 **Influence of Artistic Expertise**

103 There is some suggestion that stimuli preferred for creation are similar to those
104 aesthetically preferred and that this varies as a function of expertise. Individuals differ in their
105 knowledge of art and art history, and there are also distinct differences between artists and
106 non-artists regarding aesthetic experiences. Expertise influences general observation of art as
107 more experienced viewers are interested in the work itself but also in the creative process,
108 thus they consider the ideas behind the artwork and desire to understand the process and
109 materials used in order to create the art piece (Pitman & Hirzy, 2010; Gombrich, 1995).
110 When observing art, gaze patterns have been analysed and differences are apparent due to
111 long term artistic training. Participants untrained in art have been found to focus more on
112 individual elements in a composition. Fixation time towards these elements, for example to
113 human and object features, supports this. More experienced artists however explore the
114 relationships between these elements; they are interested in the global image, overall
115 composition and structural features depicted (Nodine, Locher & Krupinski, 1993; Pihko et al,
116 2011; Vogt & Magnussen, 2007).

117 Differences due to expertise are also found with regards to the art-making experience.
118 Kozbelt et al., (2010) found artists' drawings to be more accurate than non-artists; artists
119 were found to make better decisions on what features to include in their drawings thus their
120 drawings captured specific features of the face being copied, whereas non-artists drawings
121 were more generic. Artists have been found to possess greater cognitive abilities (perceptual
122 and imagery) when completing drawing tasks where actual production was required, and

123 during mental imagery performance (Calabrese & Marucci, 2006). Expertise has been found
124 to impact artistic creations with artists, not surprisingly, performing better on drawing tasks.
125 In addition to artists having a clear motor advantage, differences are apparent from gaze
126 when drawing. Artists have been found to process stimuli more easily (spend less time
127 fixating the stimulus to be copied) than non-artists regardless of the variations in stimuli
128 (familiarity/complexity) and this is suggested to be due to training (Glazek, 2012).

129

130 **Gaze: A Tool for Observing Responses to Art and a Measure of Preference**

131 As can be seen from the preceding section, research examining the eye movements of
132 artists has provided insight into the artistic process. Eye-tracking has also been a useful tool
133 for revealing cognitive processes during the aesthetic experience. Initial eye movement
134 reaction to artworks can be captured using such techniques with responses to art made within
135 100 ms being found to correlate with overall aesthetic ratings (Locher et al., 2007). Plumhoff
136 and Schirillo (2009) identified that images rated as pleasing led to greater fixation durations
137 over time than those rated as displeasing. Gaze has also been found to differ when making
138 art. Miall and Tchalenko (2001) studied an artist whilst creating art and recorded his eye
139 movements. Here, they found that the act of painting influenced gaze as fixation durations
140 were twice as long as fixations made when he was not painting. Furthermore, eye-tracking
141 has been recently used as a method for understanding preferences and studies have found
142 gaze to reflect aesthetic preferences and choices when observing multiple images (Shimojo,
143 Simion, Shimojo & Scheier, 2003; Glaholt, Wu & Reingold, 2009). Holmes and Zanker
144 (2012) found greater fixation durations and number of fixations to be made to aesthetically
145 preferred stimuli. In addition, free-viewing tasks, which do not provide the participant with
146 specific instruction, have further shown fixation to be influenced by preference with greater
147 fixation being towards faces regarded to be more attractive (Leder, Tinio, Fuchs & Bohrn,

148 2010). Thus eye-tracking is useful for further exploring art-viewing, art-making and decision-
149 making, and gaze can be used as a measure of preference.

150

151 **Summary**

152 Art-making decisions made by the artist are suggested to be influenced by the artists'
153 aesthetic experience. Idea selection is a testable stage within the art-making process allowing
154 further understanding of these relationships between art-making and aesthetic experiences.
155 Previous research has identified similarities between aesthetic preference, an outcome of
156 aesthetic experiences, and production choice/creation, a process within art-making (Taylor &
157 Eisenman 1964; Boyatzis & Eades, 1999). However, here we explicitly examine these
158 relationships; importantly we do this for both non-artists and artists as differences in expertise
159 have been found regarding aesthetic and art-making experiences. Research within the field of
160 empirical aesthetics has begun to adopt more objective methods to explore aesthetic
161 experiences; here we include eye-tracking measures as a useful measure of preference that
162 also allows for further understanding of the formation of aesthetic judgements and has been
163 used in previous research exploring art-making activities.

164

165 **The Present Study**

166 Although previous research suggests that there are similarities between artistic
167 production and aesthetic preference, which may be moderated by expertise, there is little
168 research that directly tests these relationships. Here, we seek to examine these relationships in
169 more depth. Using geometric shapes as stimuli, we examine artists and non-artists aesthetic
170 (how pleasing they find the shapes) and drawing preferences (which shape they would prefer
171 to draw out of a choice of two). To provide further insight into the process of forming these
172 preferences we also track eye-movements whilst participants free-view images and make

173 their drawing preferences. To be clear, drawing preference is a term we use in relation to the
174 idea selection/drawing decision stage that is depicted in current art-making models. Here, we
175 use a drawing choice task to provide options for the participants to select from and for them
176 to indicate their drawing preferences.

177 In order to examine the suggested links between aesthetic and drawing preference we
178 use geometric stimuli. Geometric shapes (triangles, diamonds and circles) are common
179 shapes used in drawing tasks and are regularly incorporated into drawings, they are useful to
180 use when understanding relationships between aesthetically preferred stimuli and those
181 preferred for drawing as preferences for shapes can vary largely due to individual differences
182 (Chen et al., 2002; Chen, Tanaka, Matsuyoshi & Watanabe, 2016). By using geometric
183 stimuli we can provide parameters to control ideas not allowing them to be too broad, but
184 providing stimuli that share similarities yet differ (Sapp, 1995). Use of geometric stimuli also
185 provides novel stimuli reducing the factor of familiarity which can have a great impact on
186 aesthetic preferences and gaze dependent on art expertise of participants (Leder, 2001;
187 Kristjanson, Antes & Kristjanson, 1989). As previously mentioned, complexity and
188 symmetry can also impact production, and manipulations in complexity and symmetry have
189 been particularly studied to understand aesthetic preferences of geometric and abstract shapes
190 (Chen et al., 2016; Gartus & Leder, 2013; Reber, Schwarz & Winkielman, 2004; Taylor &
191 Eisenman, 1964; Winston & Cupchik, 1992; McWhinnie, 1971; Jacobsen, Schubotz, Höfel &
192 Cramon, 2006). Thus geometrical stimuli differing in complexity and symmetry are used
193 here.

194 We examine whether aesthetic preferences relate to drawing preferences: are those
195 stimuli that are aesthetically preferred also those preferred to be drawn? And is this affected
196 by expertise? Theories suggest relationships between an artists' aesthetic and art-making
197 experience (Mace & Ward, 2002; Kay, 1991) and some empirical research suggests that there

198 are similarities between images aesthetically preferred and produced, yet no direct test of this
199 has been conducted (Taylor & Eisenman, 1964; Boyatzis & Eades, 1999). Differences that
200 have been found in responses to art, production preferences and art-making abilities lead us
201 to expect differences in aesthetic and drawing preference relationships dependent on the
202 expertise of the participant. Kay (1991) states how artists' art-making experiences in
203 particular are guided by aesthetic experiences/preferences. Thus, we hypothesise that there
204 will be an association between how pleasing participants, particularly artists, find the
205 geometric images to be and how much they desire to create these.

206 Theories suggest that similar cognitive processes are involved when making and
207 observing art (Martindale, 2001; Tinio, 2013). We introduce two tasks (Free-viewing and
208 Drawing Choice) where stimuli are freely-viewed and where a drawing preference is made,
209 we examine gaze to further explore the relationships between aesthetic and drawing
210 preference during their formation. Gaze has been used as a measure of preference and it has
211 been previously found that gaze (fixation duration and count) tends to be greater for
212 aesthetically preferred stimuli. However, it is not clear how aesthetic preferences relate to
213 gaze when freely viewing images, and as we explore the aesthetic and drawing preference
214 relationship it is interesting to examine if similar findings are found in relation to images that
215 are preferred for drawing (Holmes & Zanker, 2012; Leder, Tinio, Fuchs & Bohrn, 2010).
216 When drawing preferences are made then gaze is expected to be directed by choice, thus by
217 images preferred for drawing (Shimojo, Simion, Shimojo & Scheier, 2003; Glaholt, Wu &
218 Reingold, 2009). If aesthetic preference relates to drawing preference as suggested, then
219 images aesthetically preferred should also influence gaze in a similar manner. How gaze is
220 directed during a Free-viewing and Drawing Choice task is likely to differ dependent on
221 expertise. Artists have been found to process artworks differently to non-artists when
222 observing and creating art, in fact they are more likely to consider the artistic process during

223 mere observation (Pihko et al, 2011; Glazek, 2012; Pitman & Hirzy, 2010; Kozbelt, 2001).
224 Thus, we hypothesize that similar gaze behaviour will be made during the Free-viewing and
225 Drawing Choice task as we expect similar relationships between images aesthetically
226 preferred and those preferred for drawing with gaze (first saccade latency, first fixation
227 direction, fixation duration, fixation count, last fixation duration, and last fixation direction).
228 This would be particularly so for artists. In addition, we hypothesise that this relationship will
229 be more prominent the more an image is aesthetically preferred and preferred for drawing.

230

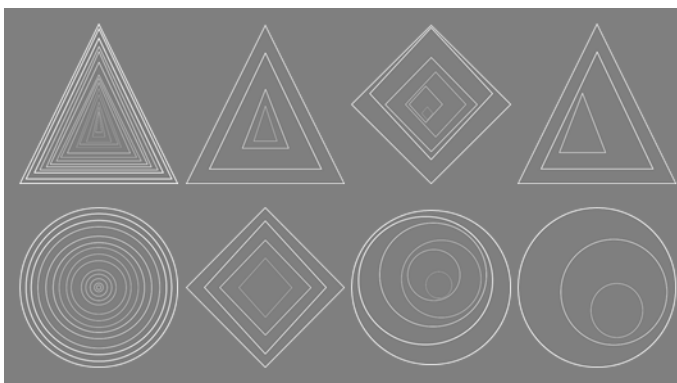
Method

231 Participants

232 A total of forty participants took part in this study. Twenty psychology students were
233 recruited from the University of Reading and were regarded as non-artists (11 females, 9
234 males; range 19-42). Twenty student artists (16 females, 4 males; range 20-35) were recruited
235 from the Fine Art department at the University of Reading. Participants were classified on the
236 basis of a background questionnaire. The questionnaire requested the participant to provide
237 the number of years of formal art training (A-level qualification and beyond) they had
238 received. A participant was regarded as an artist if they had at least 5 years of formal art
239 training and were involved in art-making on a weekly basis. Artists ranged from 5 to 7 years
240 with a mean of 5.6 years of training. The non-artists in this study had less than 1 year with a
241 mean of 0.05 years of training. All participants had normal or corrected-to-normal vision and
242 each stage of the study was completed by all participants.

243

244 Materials



245

246 *Figure 1.* Examples of stimuli used in four subsets. Column one: complex-symmetrical (subset 1); Column two:
247 simple-symmetrical (subset 2); Column three: complex-asymmetrical (subset 3); Column four: simple-
248 asymmetrical (subset 4).

249 The stimuli included 8 computer-generated geometric shapes that were fully
250 constructed of triangles, diamonds or circles (see figure 1). Geometric stimuli provide the
251 participant with potential ideas that do not give too much detail of a final product (i.e. colour
252 and texture) which will not be available at such early stages of art-making. Both complexity
253 and symmetry are manipulated here in order to evoke differences in aesthetic response not as
254 primary experimental dimensions of interest in their own right (Eisenman, 1968; Eisenman &
255 Gellens, 1968; Tinio & Leder, 2009).

256 The stimuli differed in terms of symmetry and complexity, this was confirmed by
257 piloting images beforehand requesting participants (who were not involved in the current
258 study) to rate images on a level of complexity [1(very simple) to 7(very complex)], and
259 whether they contained at least one line of symmetry. 8 images were selected and were
260 grouped into four subsets based on these ratings, each containing two images; [complex-
261 symmetrical (subset 1), simple-symmetrical (subset 2), complex-asymmetrical (subset 3) and
262 simple-asymmetrical (subset 4)].

263 **Pleasantness Scale.** A 7-point scale measuring pleasantness was used to gather aesthetic
264 ratings [1(very displeasing) to 7 (very pleasing)] (Russell & George, 1990).

265 **Drawing Preference Scale.** A drawing choice task presented participants' with multiple
266 options from which they could select the image they preferred to draw. Participants were
267 requested to make a selection by indicating how much they preferred to draw the image using
268 a relative preference scale. This scale was used to categorise drawing responses [1 (indicating
269 a strong preference for the left image) to 7 (a strong preference for the right)]. Relative
270 preference towards the two images was calculated by a key press of numbers 1-3 indicating a
271 preference for the left image or 5-7 for the right image (the more extreme values represent a
272 stronger preference), with 4 representing no preference (Park, Shimojo & Shimojo, 2010).

273 This scale provided drawing preference scores for each image from one response and
274 provided detail on how much more the participants wanted to draw one image over another.

275

276 **Apparatus**

277 Stimuli were presented on a 21" colour desktop PC that had a refresh rate of 75Hz.
278 The distance between the monitor and participant was 57cm. All images were presented on a
279 grey background and sized to 480 x 480 pixels. Stimulus width and height subtended 11.9°
280 and 11.9° of visual angle. Eye movements of the right eye were recorded using an Eyelink II
281 tracker with a sampling rate of 500Hz. A chin rest was used to constrain head movements and
282 participants were placed in a set position. At the beginning of each eye-tracking task a
283 standard 9-point grid was used to calibrate eye movements. All participants calibrated
284 successfully (average error less than 0.5 deg). Calibration was maintained for each trial using
285 a drift correct procedure between each trial that corrected fixation errors due to small
286 movements in camera alignment (e.g. caused by head band slippage).

287

288 **Procedure**

289 A repeated measures design was used; all participants completed all sections of the
290 experiment. Initially participants read the instructions provided and completed a consent
291 form. At the end of the study participants were provided with a debrief form

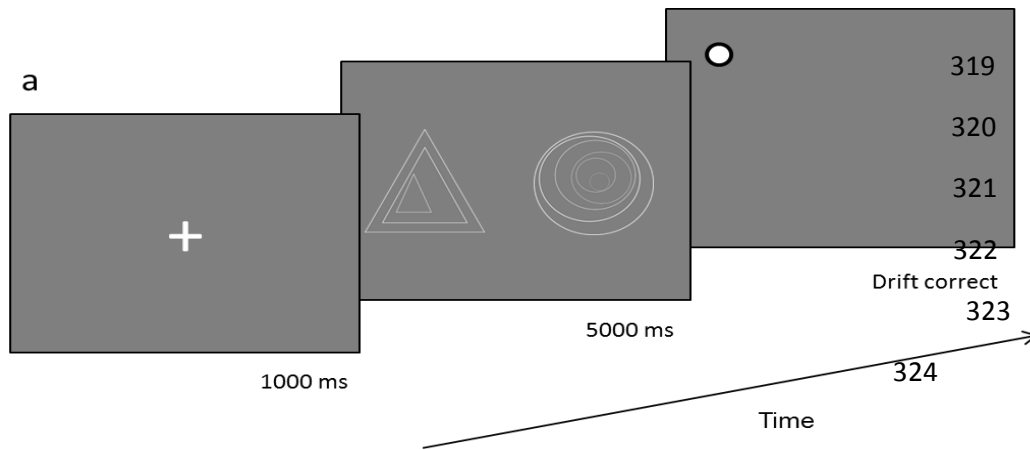
292 **Aesthetic Rating Task.** Half of the participants gave aesthetic ratings for all images
293 prior to the eye-tracking tasks (Free-viewing & Drawing Choice) while the remaining
294 completed this at the end of the study. All images were presented for 5000ms prior to making
295 an aesthetic judgement.

296 **Free-viewing Task.** 24 possible image pair combinations were viewed whilst eye
297 movements were recorded and were randomised for all participants. For the free-viewing task
298 a fixation cross was displayed before each trial for 1000ms then participants were presented
299 with two images for 5000ms (see figure 2). 48 trials were completed at random (all stimuli
300 combinations were presented twice allowing each image in a pair to be presented on either
301 side of the screen); no further information was provided for this task. The Free-viewing task
302 was always completed prior to the Drawing Choice task to avoid bias, and eye-movements
303 were recorded during both tasks.

304 **Drawing Choice Task.** Participants then completed a Drawing Choice task during
305 which eye movements were recorded whilst participants made a preference on which image
306 of two they would prefer to draw (see figure 2). 24 possible image pair combinations were
307 viewed; this order was randomised for each participant. A fixation cross was first displayed
308 for 1000ms; images were then presented until a preference was made as no time limit was
309 imposed. 96 trials were completed at random (all stimuli combinations were presented four
310 times allowing each image in a pair to be presented on either side of the screen twice). Here,
311 more trials were incorporated as it was expected that the drawing preference scores would be
312 less stable (for example, due to naïve participants' lack of familiarity with making this
313 drawing preference judgement rather than a more common aesthetic preference judgement).
314 We measured drawing preference using a relative preference scale to gather responses on
315 what participants would choose to create and how much they preferred to create this
316 compared to the other image displayed.

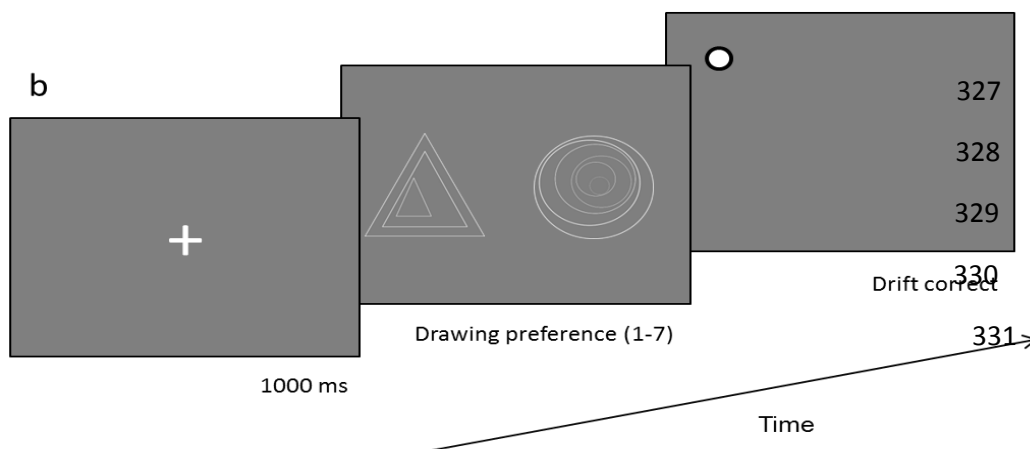
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325

326



332

333

334 *Figure 2. Free-viewing (a) and Drawing Choice (b) task trial examples*

335

336 **Eye-tracking Analyses**

337 A variety of gaze metrics were used including first fixation direction (to the left or
 338 right stimulus), first saccade latency (the response time from stimuli onset to the start of the
 339 first saccadic eye movement response), total fixation duration (the total amount of time spent
 340 on each stimulus), and number of fixations (the total number of fixations on each stimulus).
 341 In addition, for the Drawing Choice task in which a choice between stimuli is made, the last
 342 fixation position (image that was being fixated when choice was made) and last fixation
 343 duration (how long the last image was fixated as choice is made) were also reported. Such
 344 gaze metrics are useful to examine and have been analysed in past research (Holmes &

345 Zanker, 2012). Fixations were classified as such if they exceeded 100ms; if fixation along the
346 x-axis was less than 800 pixels then this was regarded as fixation to the left image, if greater
347 than 800 pixels, then fixation was to the right image.

348

349 **Data Analyses**

350 **Repeated Measures ANOVA.** Two-way repeated measures ANOVAs were run to
351 examine which images were fixated on more due to aesthetic and drawing preference. Each
352 trial of both the Free-view and Drawing Choice tasks was categorised and the aforementioned
353 gaze responses derived on the basis of the aesthetic rating that participant gave for each
354 image, e.g., the duration and number of fixations made on the most preferred image and the
355 duration and number of fixations on the least preferred image on each trial (answering the
356 question of whether gaze behaviour relates to the images aesthetically preferred). The same
357 trials from both tasks were then reclassified on the basis of the drawing preference score
358 given for each image (answering the question of whether gaze behaviour relates to the images
359 preferred for drawing). Note that trials in which there was no preference found between the
360 images were removed.

361 **Multi-level Model Analyses.** Mixed-effect models were conducted using multi-level
362 modelling, using the function “lmer” in the “lme4” package for the statistical program R
363 (Bates, Maechler & Walker, 2013). Multi-level modelling considers that there is unexplained
364 variability in all levels (Snijders & Bosker, 2012). Random intercepts for participant were
365 included to take into account the variability due to differences between participants. The
366 random intercept of image takes into account the variation caused by differences between
367 images observed.

368 ***Aesthetic and drawing preference.*** Aesthetic ratings of each image were recorded and
369 a drawing preference score for each image was calculated across the trials. We investigated

370 whether aesthetic preference associated with drawing preference. A mixed-effects model was
371 conducted with drawing preference as the dependent variable. Aesthetic preference and
372 expertise were included as fixed variables. We used a within-subject mean centering
373 approach.

374 *Proportion of fixation on aesthetic and drawing relative preference.* Mixed-effects
375 models were also conducted with proportion of fixation on preference (aesthetic or drawing)
376 as the dependent variable. The difference between ratings (aesthetic and drawing preference)
377 and expertise were included as fixed variables. We used a within-subject mean centering
378 approach. We investigated whether proportion of fixation towards preference (aesthetic or
379 drawing) associated with the difference between ratings (aesthetic or drawing preference). In
380 order to run this analysis, the differences in ratings (aesthetic or drawing preference) given to
381 each image on each trial and the proportion of time spent fixating each image was calculated.

382

383

384

Results

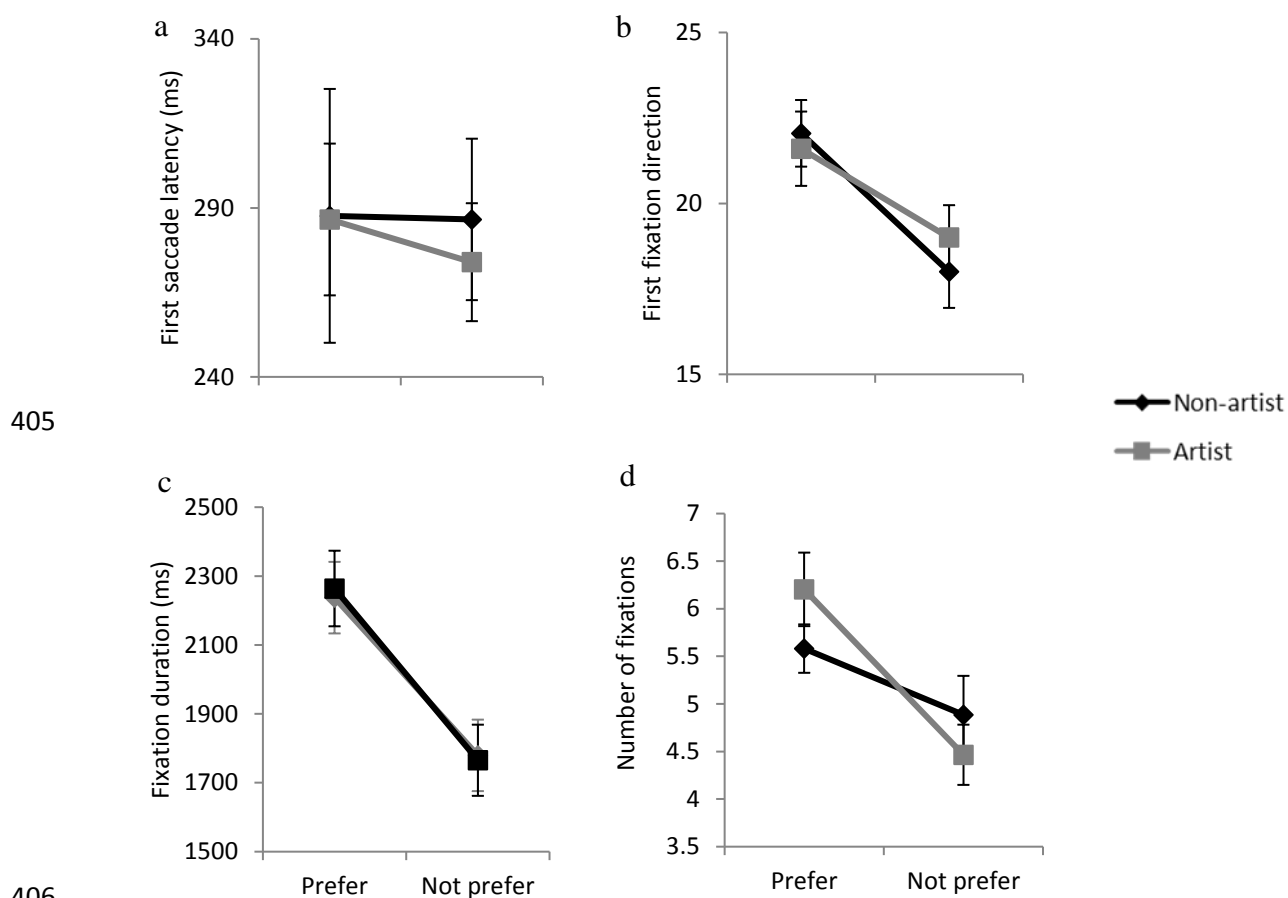
385 We first report mixed-effects models examining the association between aesthetic and
386 drawing preference (see Aesthetic and Drawing Preference Relationship Section). Gaze
387 behaviour during Free-viewing is then reported. Trials are classified first by aesthetic
388 preference (Free-viewing and Aesthetic Preference) and then by drawing preference (Free-
389 viewing and Drawing Preference) for artists and non-artists. Finally, we report gaze
390 behaviour elicited during the Drawing Choice task in the same manner as the Free-viewing
391 task: trials classified first by aesthetic preference (Drawing Choice and Aesthetic Preference)
392 and then by drawing preference (Drawing Choice and Drawing Preference). In the sections
393 where gaze is reported, we also present mixed-effects models for the proportion of fixation
394 made towards preferences (aesthetic or drawing) dependent on differences between ratings
395 (aesthetic or drawing preference).

396

397 **Aesthetic and Drawing Preference Relationship**

398 A mixed-effects model was conducted to investigate whether aesthetic preference
399 associated with drawing preference. Drawing preference scores increased with increasing
400 aesthetic ratings ($\beta = 0.869$, $SE = 0.0972$, $t = 8.940$, $p < 0.001$). There was no significant effect
401 of expertise ($\beta < 0.001$, $SE = 0.127$, $t < 0.001$, $p = 1.000$) nor was there an interaction between
402 expertise and aesthetic ratings ($\beta < 0.001$, $SE = 0.0.138$, $t = 0.003$, $p = 0.998$).

403

404 **Free-viewing and Aesthetic Preference**

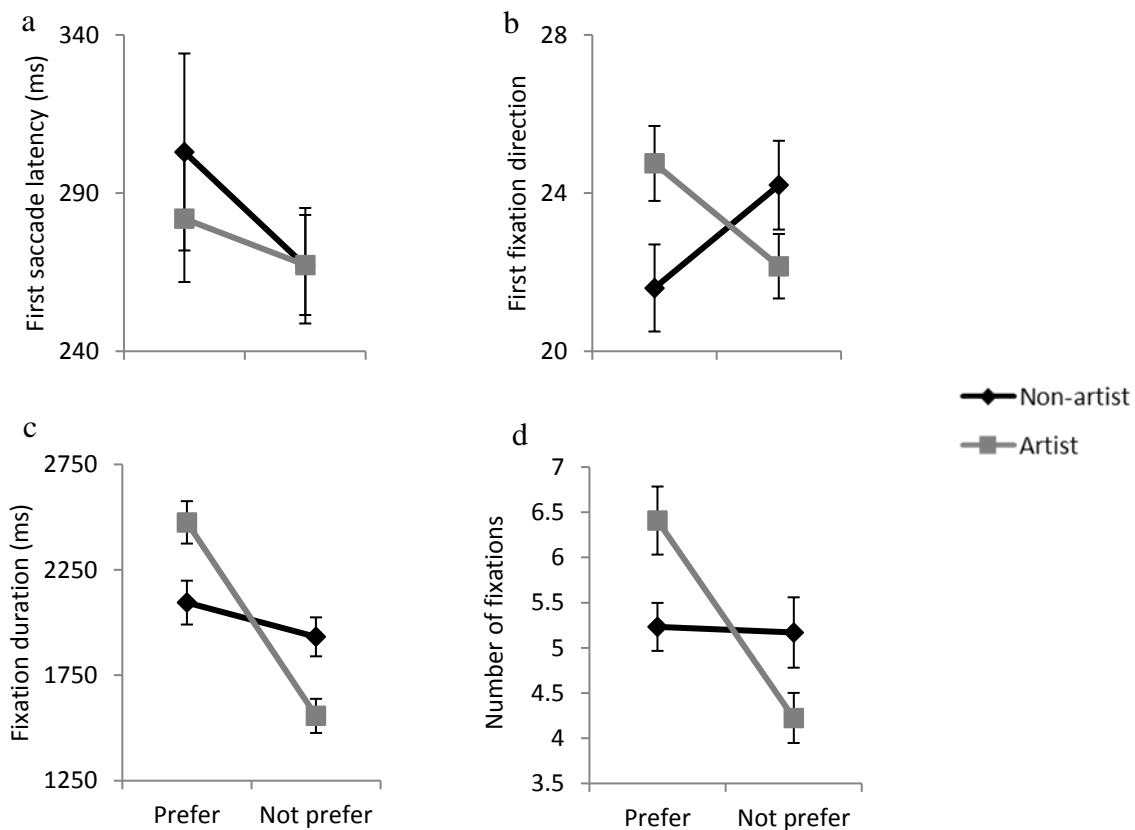
407 *Figure 3.* Free-viewing task (Aesthetic Preference). Shows gaze behaviour when image pairs are classified on
 408 the basis of aesthetic preference: gaze on the aesthetically preferred stimulus and that on the non-preferred
 409 stimulus. Upper row shows first saccade response: the latency of the response in milliseconds (Left) and its
 410 direction (Right). Lower row shows overall fixation behaviour: mean total fixation duration in milliseconds
 411 (Left) and the mean number of fixations (Right).

412

413 Figure 3 shows gaze behaviour elicited during the Free-viewing task when images are
 414 classified by aesthetic preference. A two-way ANOVA was conducted examining first
 415 saccade latency (fig. 3a) with aesthetic preference and expertise as factors. No main effects or
 416 interactions were found, all p 's > .737. A series of two-way ANOVAs with the same factors
 417 were conducted examining first fixation direction (fig. 3b), fixation duration (fig. 3c) and
 418 number of fixations (fig. 3d). An effect of aesthetic preference was found with participants

419 fixating more on preferred stimuli: First Fixation Direction: $F(1, 38)=7.097$, $MSE=31.1155$
420 $p=0.011$, $\eta^2=0.157$; Fixation Duration: $F(1, 38)=17.092$, $MSE=411278.275$, $p<0.001$, η^2
421 $=0.310$; Number of Fixations: $F(1, 38)=12.717$, $MSE=2.329$, $p<0.001$, $\eta^2=0.251$,
422 respectively. There was no main effect of expertise and no significant interaction, all
423 $p's>0.135$.

424 **Proportion of Fixation Towards Aesthetic Preference and Differences Between**
425 **Aesthetic Ratings.** A mixed-effects model was conducted to investigate whether the
426 proportion of fixation towards aesthetic preferences associated with the differences in
427 aesthetic ratings. The proportion of fixation spent on the aesthetically preferred image
428 increased with an increased difference in aesthetic ratings ($\beta= 0.033$, $SE= 0.008$, $t= 3.939$,
429 $p<0.001$). There was no effect of expertise ($\beta=-0.041$, $SE= 0.036$, $t=-1.138$, $p=0.263$). There
430 was no interaction between the fixed effects ($\beta= -0.01$, $SE= 0.012$, $t=-0.801$, $p=0.423$).
431

432 **Free-viewing and Drawing Preference**

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434

435 *Figure 4.* Free-viewing task (Drawing Preference) shows gaze behaviour when image pairs are classified on the
 436 basis of drawing preference: gaze on the image that is preferred for drawing and that on the non-preferred.
 437 Organisation of figures corresponds with figure 3.

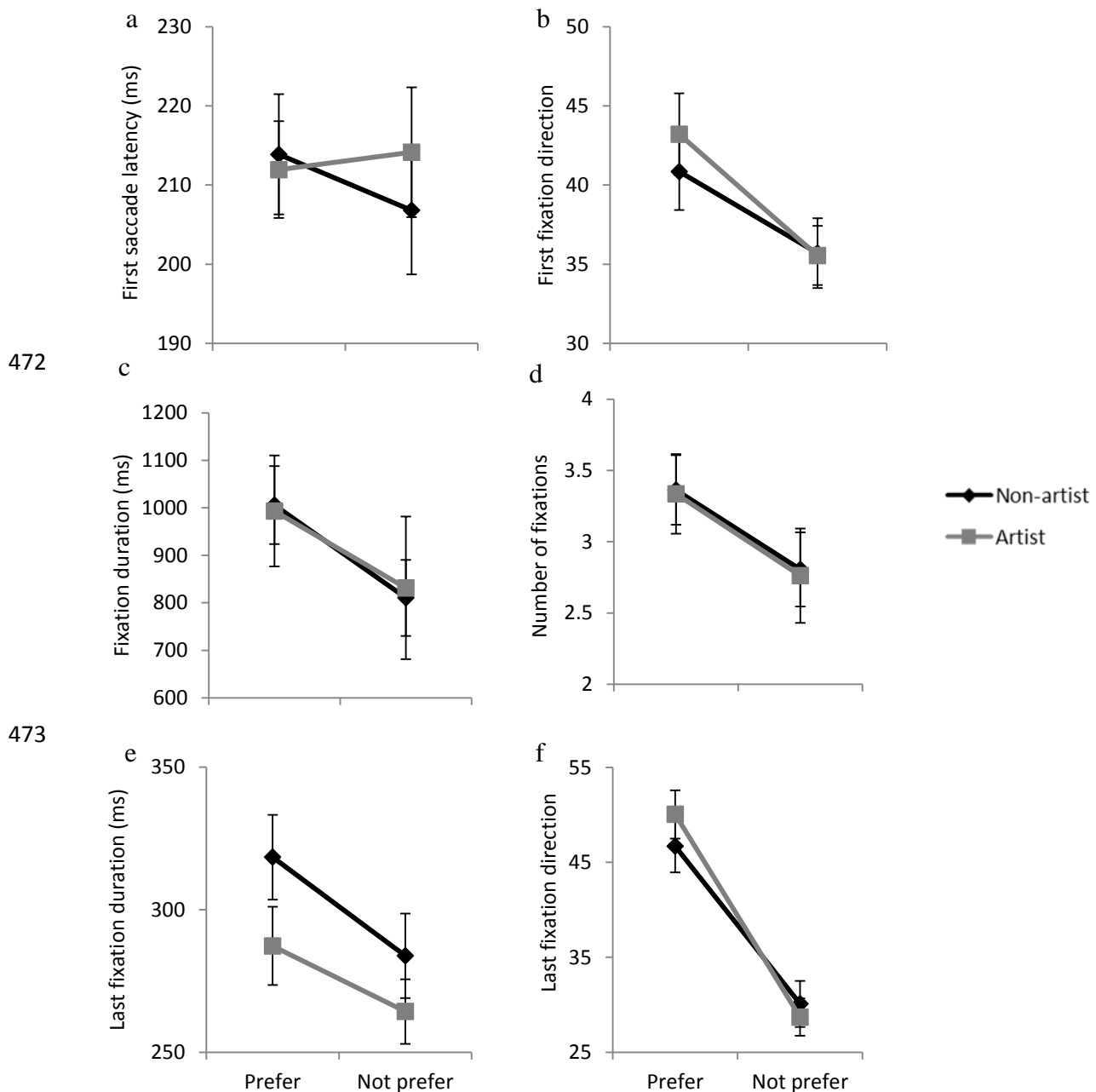
438

439 Figure 4 shows gaze behaviour elicited during the Free-viewing task when images are
 440 classified by drawing preference. A two-way ANOVA was conducted examining first
 441 saccade latency with drawing preference and expertise as factors. First saccade latency (fig.
 442 4a) was found to be quicker towards stimuli less preferred for drawing ($M=267.15$) than
 443 preferred ($M=292.44$), $F(1, 38)=4.592$, $MSE=2785.269$, $p=0.039$, $\eta^2=0.108$, there was no
 444 main effect of expertise or any significant interactions, all $p's > .371$. A two-way ANOVA was
 445 conducted examining first fixation direction with the same factors (fig. 4b), this showed no
 446 main effects, all $p's > .101$, but did show a marginal interaction between drawing preference

447 and expertise $F(1, 38)=3.536$, $MSE=135.2$, $p=0.068$, $\eta^2=0.085$. Pairwise comparisons show
448 that artists made more first fixations ($M=24.75$) to images preferred for drawing compared to
449 non-artists ($M=21.6$), $F(1, 38)=4.698$, $MSE=99.225$, $p=0.037$, $\eta^2=0.110$. Further two-way
450 ANOVAs examining fixation duration (fig. 4c) and then number of fixations (fig. 4d) showed
451 only an effect of drawing preference with participants fixating for longer and more often on
452 the stimulus they preferred to draw: Fixation Duration $F(1, 38)=17.765$, $MSE=328432.033$,
453 $p<0.001$, $\eta^2=0.319$; Number of Fixations: $F(1, 38)=12.724$, $MSE=1.979$, $p<0.001$, η^2
454 $=0.251$. There was no effect of expertise, all p 's >0.744 ; however, an interaction between
455 drawing preference and expertise for both fixation duration and number of fixation metrics
456 was found, $F(1, 38)=8.688$, $p<0.001$, $\eta^2=0.186$; $F(1, 38)=11.403$, $p=0.002$, $\eta^2=0.231$,
457 respectively. Pairwise comparisons show that only artists fixated significantly longer on
458 images preferred for drawing ($M=2475.2$) than less preferred images ($M=1557.4$), $F(1,$
459 $38)=25.650$, $p<0.001$, $\eta^2=0.403$, and made more fixations to images preferred for drawing
460 ($M=6.4$) than those less preferred ($M=4.2$), $F(1, 38)=24.108$, $p<0.001$, $\eta^2=0.388$.

461 **Proportion of Fixation Towards Drawing Preference and Differences Between**
462 **Drawing Preference Scores.** Further multi-level model analyses were conducted to examine
463 if the proportion of fixation to drawing preferences associated with the differences in drawing
464 preference scores. The proportion of fixation spent on the image preferred for drawing
465 increased as the differences in drawing preference scores increased ($\beta=0.042$, $SE=0.008$, $t=$
466 5.364 , $p<0.001$). There was an effect of expertise ($\beta=-0.093$, $SE=0.031$, $t=-2.984$, $p<0.01$)
467 which suggests that the proportion of fixation to drawing preference was greater for artists
468 ($M=0.612$) compared to non-artists ($M=0.519$). However, no interaction was found between
469 expertise and difference in scores ($\beta=-0.019$, $SE=0.011$, $t=-1.673$, $p=0.095$),

470

471 **Drawing Choice and Aesthetic Preference**

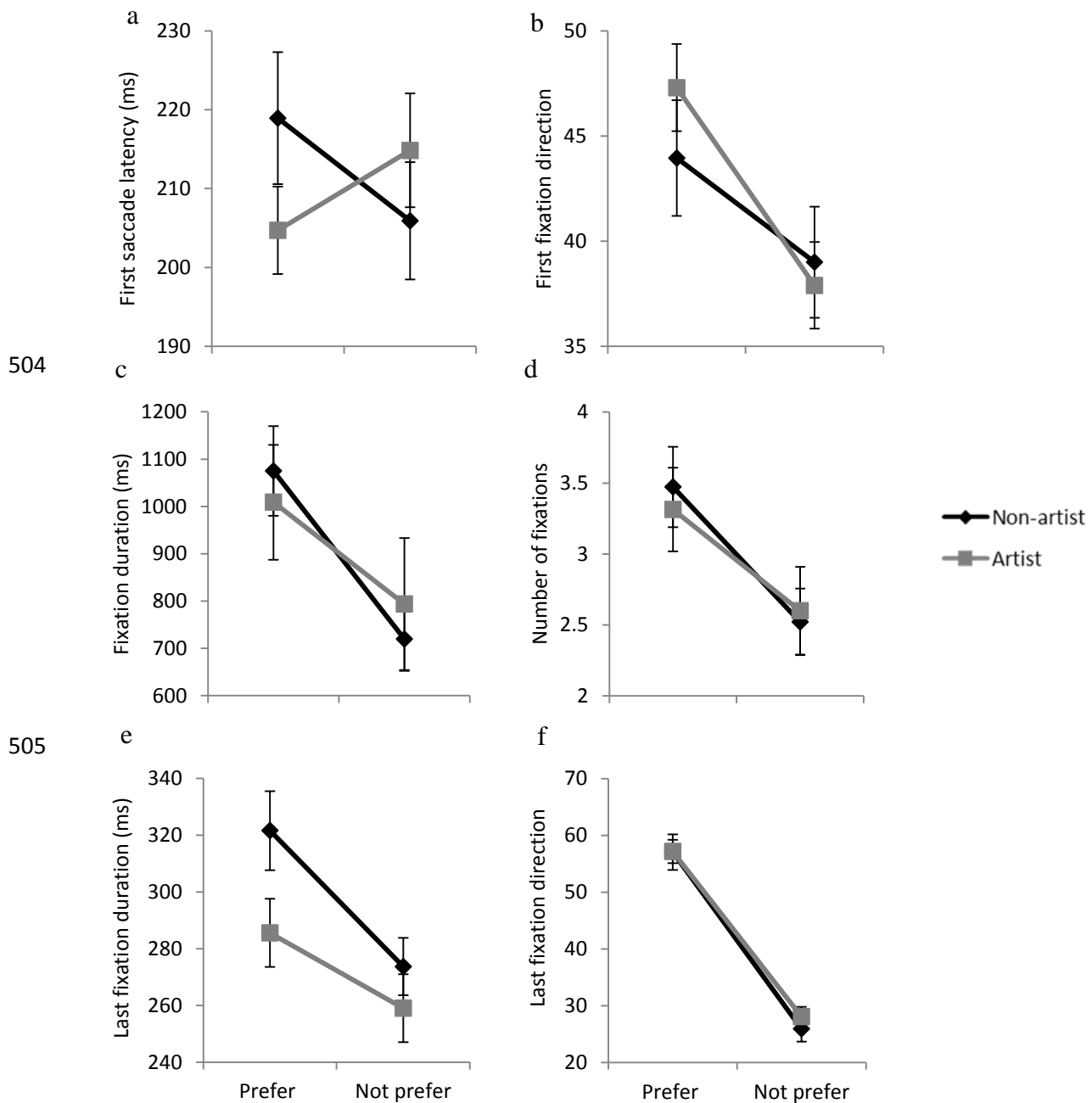
474

475 *Figure 5. Drawing Choice task (Aesthetic Preference):* shows gaze behaviour when image pairs are classified
 476 on the basis of aesthetic preference: gaze on the image that was aesthetically preferred and that on the non-
 477 preferred image. Upper row shows first saccade response: the latency of the response in milliseconds (Left) and
 478 its direction (Right). Middle row shows overall fixation behaviour: mean total fixation duration in milliseconds
 479 (Left) and the mean number of fixations (Right). Lower row shows last fixation behaviour: last fixation duration
 480 (Left) and its direction (Right).

481 The previous two sections examined the behavioural results from the Free-viewing
482 task. Here, we move on to the results from the Drawing choice task. The same data analysis
483 approach will be taken. Figure 5 shows gaze behaviour elicited during the Drawing Choice
484 task when images are classified by aesthetic preference. A series of separate two-way
485 ANOVAs were conducted, for each dependent variable. No main effects or interactions of
486 aesthetic preference and expertise were found for first saccade latency (fig. 5a), all p 's > .329.
487 A main effect of aesthetic preference was found with participants fixating more on stimuli
488 they aesthetically preferred for first fixation direction (fig. 5b) $F(1, 38)=7.872$,
489 $MSE=104.067$, $p=0.008$, $\eta^2=0.172$, fixation duration (fig. 5c) $F(1, 38)=21.002$,
490 $MSE=30436.297$, $p<0.001$, $\eta^2=0.356$, number of fixations (fig. 5d) $F(1, 38)=24.995$,
491 $MSE=0.256$, $p<0.001$, $\eta^2=0.397$, last fixation duration (fig. 5e) $F(1, 38)=10.381$,
492 $MSE=1600.295$, $p=0.003$, $\eta^2=0.215$, and last fixation direction (fig. 5f) $F(1, 38)=51.160$,
493 $MSE=140.755$, $p<0.001$, $\eta^2=0.574$. No effect of expertise or interactions were found, all
494 p 's > 0.376.

495 **Proportion of Fixation Towards Aesthetic Preference and Differences Between**
496 **Aesthetic Ratings.** A mixed-effect model was conducted to examine if the proportion of
497 fixation to aesthetic preferences associated with the differences in aesthetic ratings. The
498 proportion of fixation spent on the image aesthetically preferred increased as the differences
499 in aesthetic ratings increased ($\beta=0.03$, $SE=0.005$, $t=5.502$, $p<0.001$). No effect of expertise
500 was found and there was no interaction ($\beta=0.007$, $SE=0.026$, $t=0.276$, $p=0.784$; $\beta=-0.002$,
501 $SE=0.008$, $t=-0.273$, $p=0.785$).

502

503 **Drawing Choice and Drawing Preference**

506

507 *Figure 6.* Drawing Choice task (Drawing Preference): shows gaze behaviour when image pairs are classified on
 508 the basis of drawing preference: gaze on the image that is preferred for drawing and that on the non-preferred.
 509 Organisation of figures corresponds with figure 5.

510 Figure 6 shows gaze behaviour elicited during the Drawing Choice task when images
 511 are classified by drawing preference. First saccade latency behaviour was examined as a
 512 function of aesthetic preference and expertise. A two-way ANOVA showed no main effects,

513 all p 's > .666, but did show an interaction between expertise and drawing preference, $F(1,$
514 $38)=12.152$, $MSE=2679.466$, $p<0.001$, $\eta^2=0.242$ which shows that artists' first saccade
515 latency (fig. 6a) was quicker to images preferred for drawing ($M=204.7$) than those not
516 preferred ($M=214.8$), $F(1, 38)=4.654$, $p=0.037$, $\eta^2=0.109$. Whereas non-artists first saccade
517 latency was quicker to images not preferred for drawing ($M=205.9$) than those preferred
518 ($M=218.9$), $F(1, 38)=7.687$, $p=0.009$, $\eta^2=0.168$. Similarly to previous sections, a series of
519 separate two-way ANOVAs were conducted for first fixation direction, fixation duration,
520 number of fixations, last fixation duration and direction with preference and expertise as
521 factors. A main effect of drawing preference was found with participants fixating more on
522 those stimuli they would prefer to draw for first fixation direction (fig. 6b) $F(1, 38)=6.909$,
523 $MSE=149.023$, $p=0.012$, $\eta^2=0.154$, fixation duration (fig. 6c) $F(1, 38)=53.844$, $MSE=$
524 30221.218 , $p<0.001$, $\eta^2=0.586$, number of fixations (fig. 6d) $F(1, 38)=63.458$, $MSE=0.218$,
525 $p<0.001$, $\eta^2=0.625$, last fixation duration (fig. 6e) $F(1, 38)=22.998$, $MSE=1204.925$, $p<0.01$,
526 $\eta^2=0.377$ and last fixation direction (fig. 6f) $F(1, 38)=130.327$, $MSE=139.268$, $p<0.001$, η^2
527 $=0.774$. No effect of expertise or interactions were found, all p 's > 0.176.

528 **Proportion of Fixation Towards Drawing Preference and Differences Between**
529 **Drawing Preference Scores.** Multi-level models were carried out to examine if the
530 proportion of fixation to drawing preferences associated with the differences in drawing
531 preference scores. The proportion of fixation spent on the image preferred for drawing
532 increased with increasing differences in drawing preference scores ($\beta= 0.025$, $SE= 0.005$, $t=$
533 4.915 , $p<0.001$). There was no effect of expertise, nor was there an interaction ($\beta=0.025$, $SE=$
534 0.022 , $t= 1.143$, $p=0.260$; $\beta=- 0.00002$, $SE= 0.007$, $t=-0.003$, $p=0.998$).

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Discussion

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Aesthetic and Drawing Relationship

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Similarities in cognitive processes have been suggested between the creation and perception of art (Martindale, 2001). However, research has not been conducted directly examining the artist's aesthetic and art-making experience, although these relationships are suggested in current art-making models (Kozbelt, 2017; Mace & Ward, 2002). Here, we investigate the experience of the artist prior to considering both the perceiver and artist relationships suggested in Tinio's mirror model of art. To date studies have only made indirect conclusions suggesting that there are similarities between preference and production (Taylor & Eisenman, 1964; Boyatzis & Eades, 1999), but here we gathered aesthetic and drawing preferences from both artists and non-artists to directly probe these relationships. Moreover, in order to explore the formation of aesthetic and drawing preference we recorded gaze behaviour examining the cognitive processes during perception (Free-viewing task) and consideration for creation (Drawing Choice task). We analyse eye-tracking trials on the basis of aesthetic and drawing preference to make conclusions on the relationships between aesthetic, drawing preferences and the formation of these judgements.

Drawing preference is found to be associated to aesthetic preference regardless of expertise supporting that a relationship exists between preference and production. We can conclude that the more pleasing an image is found to be the greater the preference is to draw it. Over the next two sections we look further into the relationship between aesthetic and drawing preference by examining how preferences (aesthetic and drawing) relate to gaze when both free-viewing and making a drawing preference.

560 Free-viewing Task

561 When non-artist and artist participants freely viewed pairs of stimuli we find
562 aesthetically preferred images to be fixated on for longer periods of time, more often, fixated
563 first and more on the image the more they prefer it. This supports previous research that
564 suggests gaze is influenced by preference (Shimojo, Simion, Shimojo & Scheier, 2003;
565 Holmes & Zanker, 2012). When we re-categorised free-viewing trials by drawing preference
566 differences were found due to expertise with only artists' gaze being influenced by drawing
567 preference. They fixated for longer on the image they preferred to draw, made more fixations
568 and fixated on these more at the earliest opportunity. However, both artists and non- artists
569 fixated more on the image they preferred to draw the more they desired to draw it. These
570 differences between expertise may reflect previous reports of experienced artists being more
571 deeply engaged (e.g., longer fixation durations) with the stimuli and the creative process
572 (Nodine, Locher & Krupinski, 1993; Tinio, 2013). When viewing art, artists may be
573 interested in understanding the processes required to create the artwork and may observe and
574 analyse images as a medium that can be reproduced (Pitman & Hirzy, 2010). Artists may
575 consider drawing preferences at this stage of viewing an image as they consider more about
576 the artist behind the production. It has been suggested, in regards to paintings, that artists
577 visualise more of the underdrawings whereas non-artists cannot visualise beyond the surface
578 features (Chatterjee & Vartanian, 2016). This suggests that the observation of art is not a
579 passive process, particularly for an artist. Observing art results in similar experiences when
580 both producing and appreciating art (Dewey, 1934; Tinio, 2013).

581

582 Drawing Choice Task

583 When a drawing preference was being made we find similar gaze patterns compared
584 to free-viewing. This supports the suggestion that similar cognitive processes are involved in

585 both the perception and creation of art (Martindale, 2001). Aesthetically preferred stimuli and
586 those preferred for drawing were fixated on more, for longer, at the first opportunity, lastly,
587 for longer before making a drawing preference and was fixated on more the more the image
588 was preferred (aesthetic and drawing). These results further support that gaze is influenced by
589 preference and reflects choice (Holmes & Zanker, 2012; Shimojo, Simion, Shimojo &
590 Scheier, 2003; Glaholt, Wu & Reingold, 2009).

591 During this task, stimuli were only viewed for a short period of time before a drawing
592 preference was made supporting that this choice is made rapidly (Groenendijk, Janssen,
593 Rijlaarsdam & van den Bergh, 2013), in fact we find that artists first fixated their drawing
594 preference more quickly (first saccade latency) whereas non-artists first fixated images less
595 preferred for drawing more quickly. Differences here may be due to gaze gradually shifting
596 towards the preferred choice (Shimojo, Simion, Shimojo & Scheier, 2003); non-artists may
597 not consider which image they would draw at this early stage. However, more first fixations
598 were made to images preferred and those preferred for drawing regardless of expertise.
599 Nevertheless, artists may be more aware of choices they will make as they consider the art-
600 making process more and were found to fixate more on what they would prefer to draw when
601 free-viewing stimuli.

602

603 **Limitations and Future Directions**

604 In an attempt to allow both non-artists and artists to realistically be able to produce
605 the stimuli, geometric shapes were used here rather than artworks. The use of abstract
606 geometric shapes can also be suggested to be more reflective of the decisions made in the
607 initial stages of art-making avoiding features of artworks that develop in later stages such as
608 the addition of colour and texture. However, geometric shapes may be considered to be
609 relatively far removed from the common sources of inspiration upon which art is created. To

610 address this, the approach adopted here can be further developed by the use of stimuli such as
611 photographs of real world scenes as would be used in landscape art. These can be used to
612 form the basis of drawing decisions. This research can also be further extended to consider
613 expert artists, particularly those with specific expertise in drawing. Artists were involved in
614 the current study; however it has been reported that art students verbalise and acknowledge a
615 lack of skill in drawing (McManus et al., 2010). Therefore, a useful next step in this area of
616 research would be to replicate this study with other groups of art experts and other forms of
617 art.

618 It is important to examine how the artists' own experience directs art-making
619 decisions, which has been explored here. However, when we consider the relationship
620 between aesthetic and drawing preference we can also consider a deeper experience of art-
621 making. Future research will examine the relationships between aesthetic and drawing
622 experiences when making art at different stages of the process.

623

624

Conclusion

625 An association between aesthetic and drawing preferences was found, drawing
626 preference scores increased with increasing aesthetic ratings regardless of expertise. Gaze
627 behaviour when free-viewing reflects behaviour when making a drawing preference as gaze
628 appears to be directed by the images aesthetically preferred during both tasks. For artists,
629 their gaze when free-viewing was also influenced by images preferred for drawing. This
630 suggests that a more fluid relationship exists for artists between images aesthetically
631 preferred and those preferred for drawing. We suggest that during initial stages of art-making
632 the aesthetic judgements of ideas are an important component in their selection. A strong
633 relationship between the two was found with support from gaze behaviour. Here, we focus on
634 the experiences of just the artist, but further studies are required to explore the artist in

635 relation to the perceiver of the final product. Such research enables a greater understanding of
636 this interaction where we can explore the artist and their creation process in conjunction with
637 the perceiver and their aesthetic experience (Tinio, 2013; Vartanian, 2014).

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References

640 Bates, D., Maechler M., Bolker B., & Walker S. (2014). lme4: Linear mixed-effects models
641 using Eigen and S4. R package version 1.1-7. <http://CRAN.R-project.org/package=lme4>.

642 Boyatzis, C. J., & Eades, J. (1999). Gender differences in preschoolers' and kindergartners'
643 artistic production and preference. *Sex Roles, 41*(7-8), 627-638.
644 <https://doi:10.1023/A:1018855707332>

645 Calabrese, L., & Marucci, F. S. (2006). The influence of expertise level on the visuo-spatial
646 ability: differences between experts and novices in imagery and drawing abilities. *Cognitive*
647 *Processing, 7*(1), 118-120. <https://doi:10.1007/s10339-006-0094-2>

648 Chatterjee, A., & Vartanian, O. (2016). Neuroscience of aesthetics. *Annals of the New York*
649 *Academy of Sciences, 1369*(1), 172-194. <http://doi:10.1111/nyas.13035>

650 Chen, C., Kasof, J., Himsel, A. J., Greenberger, E., Dong, Q., & Xue, G. (2002). Creativity in
651 Drawings of Geometric Shapes A Cross-Cultural Examination with the Consensual
652 Assessment Technique. *Journal of Cross-Cultural Psychology, 33*(2), 171-187.
653 <http://doi:10.1177/0022022102033002004>

654 Chen, N., Tanaka, K., Matsuyoshi, D., & Watanabe, K. (2016). Cross preferences for colors
655 and shapes. *Color Research & Application, 41*(2), 188-195. <http://doi:10.1002/col.21958>

656 Dewey, J. (1934). Having an experience, in *Art as experience*, 36-59. New York: Penguin.

657 Eisenman, R. (1968). Semantic differential ratings of polygons varying in complexity-
658 simplicity and symmetry-asymmetry. *Perceptual and Motor Skills, 26*(3c), 1243-1248.
659 <http://dx.doi.org/10.2466/pms.1968.26.3c.1243>

- 660 Eisenman, R., & Gellens, H. K. (1968). Preferences for complexity-simplicity and symmetry-
661 asymmetry. *Perceptual and motor skills*, 26(3), 888-890.
662 <http://dx.doi.org/10.2466/pms.1968.26.3.888>
- 663 Gartus, A., & Leder, H. (2013). The small step toward asymmetry: aesthetic judgment of
664 broken symmetries. *i-Perception*, 4(5), 361-364. [http://doi: 10.1068/i0588sas](http://doi:10.1068/i0588sas)
- 665 Glaholt, M. G., Wu, M. C., & Reingold, E. M. (2009). Predicting preference from
666 fixations. *PsychNology Journal*, 7(2), 141-158.
667 <https://pdfs.semanticscholar.org/3666/f7eb9d5e43f3e3dd7977d18dcb36550d47ab.pdf>
- 668 Glazek, K. (2012). Visual and motor processing in visual artists: Implications for cognitive
669 and neural mechanisms. *Psychology of Aesthetics, Creativity, and the Arts*, 6(2), 155-167.
670 <http://dx.doi.org/10.1037/a0025184>
- 671 Gombrich, E. H. (1995). *The story of art* (Vol. 12). London: Phaidon.
- 672 Groenendijk, T., Janssen, T., Rijlaarsdam, G., & van den Bergh, H. (2013). Learning to be
673 creative. The effects of observational learning on students' design products and
674 processes. *Learning and Instruction*, 28, 35-47.
675 <http://dx.doi.org/10.1016/j.learninstruc.2013.05.001>
- 676 Guggenheim, J., & Whitfield, T. W. A. (1989). Fechner's method of production: An
677 application to aesthetics. *Perceptual and Motor Skills*, 68(3c), 1330-1330. [http://doi:](http://doi:10.2466/pms.1989.68.3c.1330)
678 [10.2466/pms.1989.68.3c.1330](http://doi:10.2466/pms.1989.68.3c.1330)
- 679 Holmes, T., & Zanker, J. M. (2012). Using an oculomotor signature as an indicator of
680 aesthetic preference. *i-Perception*, 3(7), 426-439. <http://doi:10.1068/i0448aap>

- 681 Humphrey, D. (1997). Preferences in symmetries and symmetries in drawings: Asymmetries
682 between ages and sexes. *Empirical Studies of the Arts*, 15(1), 41-60.
683 <http://doi:10.2190/DF5N-HGFB-MVPK-U34D>
- 684 Jacobsen, T., Schubotz, R. I., Höfel, L., & Cramon, D. Y. V. (2006). Brain correlates of
685 aesthetic judgment of beauty. *Neuroimage*, 29(1), 276-285.
686 <http://doi:10.1016/j.neuroimage.2005.07.010>
- 687 Kay, S. (1991). The figural problem solving and problem finding of professional and
688 semiprofessional artists and nonartists. *Creativity Research Journal*, 4(3), 233-252.
689 <http://doi:10.1080/10400419109534396>
- 690 Kozbelt, A. (2001). Artists as experts in visual cognition. *Visual Cognition*, 8 (6), 705-723.
691 <http://doi:10.1080/13506280042000090>
- 692 Kozbelt, A. (2017). Tensions in naturalistic, evolutionary explanations of aesthetic reception
693 and production. *New Ideas in Psychology (In press)*.
694 <https://doi.org/10.1016/j.newideapsych.2017.03.006>
- 695 Kozbelt, A., Seidel, A., ElBassiouny, A., Mark, Y., & Owen, D. R. (2010). Visual selection
696 contributes to artists' advantages in realistic drawing. *Psychology of Aesthetics, Creativity,
697 and the Arts*, 4(2), 93-102. <http://dx.doi.org/10.1037/a0017657>
- 698 Kristjanson, A. F., Antes, J. R., & Kristjanson, A. K. (1989). Eye movement analysis of
699 artists and nonartists viewing paintings. *Visual Arts Research*, 21-30.
700 <http://www.jstor.org/stable/20715702>
- 701 Leder, H. (2001). Determinants of preference: When do we like what we know?. *Empirical
702 Studies of the Arts*, 19(2), 201-211. <http://doi:10.2190/5TAE-E5CV-XJAL-3885>

- 703 Leder, H., Belke, B., Oeberst, A., & Augustin, D. (2004). A model of aesthetic appreciation
704 and aesthetic judgments. *British journal of psychology*, *95*(4), 489-508. [http://](http://doi:10.1348/0007126042369811)
705 doi:10.1348/0007126042369811
- 706 Leder, H., Tinio, P. P., Fuchs, I. M., & Bohrn, I. (2010). When attractiveness demands longer
707 looks: The effects of situation and gender. *The Quarterly Journal of Experimental*
708 *Psychology*, *63*(9), 1858-1871. <http://doi:10.1080/17470211003605142>
- 709 Locher, P., Krupinski, E. A., Mello-Thoms, C., & Nodine, C. F. (2007). Visual interest in
710 pictorial art during an aesthetic experience. *Spatial Vision*, *21*(1), 55-77.
711 <http://doi:0.1163/156856807782753868>
- 712 Mace, M. A., & Ward, T. (2002). Modeling the creative process: A grounded theory analysis
713 of creativity in the domain of art making. *Creativity Research Journal*, *14*(2), 179-192.
714 http://doi:10.1207/S15326934CRJ1402_5
- 715 Martindale, C. (2001). How does the brain compute aesthetic preference. *The General*
716 *Psychologist*, *36*(2), 25-35.
- 717 McManus, I. C., Chamberlain, R., Loo, P. W., Rankin, Q., Riley, H., & Brunswick, N.
718 (2010). Art students who cannot draw: Exploring the relations between drawing ability,
719 visual memory, accuracy of copying, and dyslexia. *Psychology of Aesthetics, Creativity, and*
720 *the Arts*, *4*(1), 18-30. <http://dx.doi.org/10.1037/a0017335>
- 721 McWhinnie, H. J. (1971). A review of selected aspects of empirical aesthetics III. *Journal of*
722 *Aesthetic Education*, 115-126. <http://doi:10.2307/3331624>
- 723 Miall, R. C., & Tchalenko, J. (2001). A painter's eye movements: A study of eye and hand
724 movement during portrait drawing. *Leonardo*, *34*(1), 35-40.
725 <http://doi:10.1162/002409401300052488>

- 726 Nodine, C. F., Locher, P. J., & Krupinski, E. A. (1993). The role of formal art training on
727 perception and aesthetic judgment of art compositions. *Leonardo*, 219-227.
728 <http://doi:10.2307/1575815>
- 729 Park, J., Shimojo, E., & Shimojo, S. (2010). Roles of familiarity and novelty in visual
730 preference judgments are segregated across object categories. *Proceedings of the National
731 Academy of Sciences*, 107(33), 14552-14555. <http://doi:10.1073/pnas.1004374107>
- 732 Pihko, E., Virtanen, A., Saarinen, V. M., Pannasch, S., Hirvenkari, L., Tossavainen, T.,
733 Haapala., & Hari, R. (2011). Experiencing Art: The Influence of Expertise and Painting
734 Abstraction Level. *Frontiers in Human Neuroscience*, 5, 94.
735 <https://doi.org/10.3389/fnhum.2011.00094>
- 736 Pitman, B., & Hirzy, E. C. (2010). *Ignite the power of art: Advancing visitor engagement in
737 museums*. Dallas Museum of art.
738 [http://www.creatingquality.org/Portals/1/DNNArticleFiles/634684617231136642Ignite%20the
739 e%20Power%20of%20Art.pdf](http://www.creatingquality.org/Portals/1/DNNArticleFiles/634684617231136642Ignite%20the%20Power%20of%20Art.pdf)
- 740 Plumhoff, J., & Schrillo, J. (2009). Mondrian, eye movements, and the oblique effect.
741 *Perception*, 38, 719–732. <http://doi:10.1068/p6160>
- 742 Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure:
743 is beauty in the perceiver's processing experience? *Personality and Social Psychology
744 Review*, 8(4), 364-382. http://doi:10.1207/s15327957pspr0804_3
- 745 Russell, P. A., & George, D. A. (1990). Relationships between aesthetic response scales
746 applied to paintings. *Empirical Studies of the Arts*, 8(1), 15-30.
747 <https://doi.org/10.2190/AU1R-6UXE-T14R-04WQ>

- 748 Sapp, D. D. (1995). Creative Problem-Solving in Art: A Model for Idea Inception and Image
749 Development. *The journal of creative behavior*, 29(3), 173-185. [http:// doi: 10.1002/j.2162-](http://doi:10.1002/j.2162-6057.1995.tb00747.x)
750 [6057.1995.tb00747.x](http://doi:10.1002/j.2162-6057.1995.tb00747.x)
- 751 Shimojo, S., Simion, C., Shimojo, E., & Scheier, C. (2003). Gaze bias both reflects and
752 influences preference. *Nature neuroscience*, 6(12), 1317-1322. [http:// doi:10.1038/nn1150](http://doi:10.1038/nn1150)
- 753 Snijders, T. A. B., & Bosker, R. J. (2012). Discrete dependent variables. *Multilevel analysis:*
754 *an introduction to basic and advanced multilevel modeling*, 304-307.
- 755 Taylor, R. E., & Eisenman, R. (1964). Perception and production of complexity by creative
756 art students. *The Journal of Psychology*, 57(1), 239-242.
757 <http://doi:10.1080/00223980.1964.9916693>
- 758 Tinio, P. P. (2013). From artistic creation to aesthetic reception: The mirror model of
759 art. *Psychology of Aesthetics, Creativity, and the Arts*, 7(3), 265-275.
760 <http://dx.doi.org/10.1037/a0030872>
- 761 Tinio, P. P., & Leder, H. (2009). Just how stable are stable aesthetic features? Symmetry,
762 complexity, and the jaws of massive familiarization. *Acta Psychologica*, 130(3), 241-250.
763 <http://doi:10.1016/j.actpsy.2009.01.001>
- 764 Vartanian, O. (2014). Empirical aesthetics: hindsight and foresight. In P.P. Tinio & J. K.
765 Smith, *The Cambridge Handbook of the Psychology of Aesthetic and the Arts* (pp.6-34).
766 Cambridge: Cambridge University Press.
- 767 Vogt, S., & Magnussen, S. (2007). Expertise in pictorial perception: eye-movement patterns
768 and visual memory in artists and laymen. *Perception*, 36(1), 91-100. <http://doi:10.1068/p5262>

- 769 Washburn, D., & Humphrey, D. (2001). Symmetries in the mind: Production, perception, and
770 preference for seven one-dimensional patterns. *Visual Arts Research*, 57-68.
771 <http://www.jstor.org/stable/20716037>
- 772 Willis, J., & Todorov, A. (2006). First impressions making up your mind after a 100-ms
773 exposure to a face. *Psychological science*, 17(7), 592-598.
774 <http://journals.sagepub.com/doi/abs/10.1111/j.1467-9280.2006.01750.x>
- 775 Winston, A. S., & Cupchik, G. C. (1992). The evaluation of high art and popular art by naive
776 and experienced viewers. *Visual Arts Research*, 1-14. <http://www.jstor.org/stable/20715763>
- 777 Zeki, S., & Nash, J. (1999). *Inner vision: An exploration of art and the brain* (Vol. 415).
778 Oxford: Oxford University Press.