1 **TITLE**

2 Motion fluency and object preference: Robust perceptual but fragile memory effects

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4 **RUNNING HEADER**

5 Motion fluency and object preference

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DATA AVAILABILITY

Data, assets, supplementary analysis and an additional experiment are available at

https://osf.io/pjwht.

28

ABSTRACT

In 8 experiments, we investigated motion fluency effects on object preference. In each experiment, distinct objects were repeatedly seen moving either fluently (with a smooth and predictable motion) or disfluently (with sudden and unpredictable direction changes) in a task where participants were required to respond to occasional brief changes in object appearance. Results show that 1) fluent objects are preferred over disfluent objects when ratings follow a moving presentation, 2) there is some evidence that object-motion associations can be learnt with repeated exposures, 3) sufficiently potent motions can yield preference for fluent objects after a single viewing, and 4) learnt associations do not transfer to situations where ratings follow a stationary presentation, even after deep levels of encoding. Episodic accounts of memory retrieval predict that emotional states experienced at encoding might be retrieved along with the stimulus properties. Though object-motion associations were repeatedly paired, there was no evidence for emotional reinstatement when objects were seen stationary. This indicates that the retrieval process is a critical limiting factor when considering visuomotor fluency effects on behaviour. Such findings have real-world consequences. For example, a product advertised with high perceptual fluency might be preferred at the time, but this preference might not transfer to seeing the object on a shelf.

INTRODUCTION

49 Perceptual processes extract information from the environment to facilitate action. Such

50 processes have evolved to be as efficient as possible, where within a short period of time

51 vision can identify targets and appropriate actions can begin to be evoked (e.g., Goodale

52 & Milner, 1992; Simon, 1969; Tipper, Paul, & Hayes, 2006; Tucker & Ellis, 1998). Such

53 highly efficient processes are necessary to enable organisms to survive in complex

54 environments. Not only has evolution selected the most efficient perception-action

55 systems, but fine tuning of the system continues through an organism's experiences. This

56 fine tuning, where the most efficient processes are selected, could be supported by

57 reinforcement, where positive affect is evoked when processing is more fluent (e.g., Reber

58 & Schwarz, 2006; Winkielman, Schwarz, Fazendeiro, & Reber, 2003; Yue, Vessel, &

59 Biederman, 2007). This is the principle behind the current work.

60 Evidence for the positive emotion associated with fluent perception and action has

61 been obtained in a number of studies. For example, Reber, Winkielman, and Schwarz,

62 (1998) showed that a number of perceptual properties that facilitated processing, such

63 as contrast, priming and time of presentation, were capable of changing how much an

64 individual liked an object. Similarly, symmetry has been shown to increases preference

65 by facilitating processing in a variety of studies (e.g., Flavell, Tipper, & Over, 2017;

66 Pecchinenda, Bertamini, Makin, & Ruta, 2014). In terms of action fluency, Cannon, Hayes,

67 and Tipper (2010) observed positive emotional embodied states during fluent action and

68 Hayes, Paul, Beuger, and Tipper (2008) demonstrated that merely observing another

69 person's fluent actions evoked increased liking of acted upon objects. Importantly, such

70 fluency effects can have real-world effects, as when more fluently named stocks increase

71 in value, outperforming disfluently named stocks (e.g. Alter & Oppenheimer (2006).

72   This current work extends previous studies of perception-action fluency and

73   engages with new issues. Previous work has shown that when assessing patterns of

74   movement, some forms of motion are preferred (e.g., Stevanov, Spehar, Ashida, & Kitaoka,

75   2012; Wright & Bertamini, 2015; Zeki & Stutters, 2012). However, to our knowledge

76   studies examining preference for objects' identity (rather than objects' motion) have only

77   examined properties of static object displays. Little published research has investigated

78   the effects of motion on object judgments in situations where the motion itself was

79   irrelevant and not declared to be judged (i.e. where participants were only instructed to

80   rate the object itself, rather than the motion property of the object). Motion, as a critical

81   property of the environment, could be manipulated as a technique for shifting preference.

82   Is it the case that the fluency and predictability of an object's motion influences an

83   observer's judgements of the object itself?

84   The second issue to be engaged is whether there is learning of the association

85   between an object's identity and its fluency of motion. In other words, does preference

86   for an object increase/decrease following repeated exposures to that object always

87   possessing fluent/disfluent motion? Such associative learning between an object and its

88   motion can be considered similar to evaluative conditioning (for a review see De Houwer,

89   Thomas, & Baeyens, 2001). That is, the neutral target property of identity can be

90   considered as a conditioned stimulus (CS) property, while the associated pattern of fluent

91   or disfluent movement can be considered as a positive or negative unconditioned

92   stimulus (±UC) property.

93   A further issue is whether any learning of the object-motion association

94   generalizes to other situations in which the object is not moving. That is, after repeated

95   exposure to moving stimuli, are fluently associated objects preferred over disfluently

96   associated objects when those objects are seen stationary with no cues to motion?

97   Whether or not perceptual fluency effects on preference are confined to objects with their

98   associated fluent/disfluent motion (as opposed to stationary objects) is an important

99   issue. For broader effects where manipulated preference for stimuli can have real-world

100   consequences, it will be necessary for fluency effects to be detected in different contexts.

101   For example, a particular consumer product might be preferred within an experiment

102   because it has greater movement fluency but can we demonstrate that this initial

103   preference transfers to situations where the product may be encountered without the

104   motion cue to fluency such as on a supermarket shelf? This generalization is clearly

105   important for preference effects to reach beyond the laboratory setting where they may

106   be initially demonstrated.

107   Therefore, in the presented experiments we aim to answer 3 questions. First, does

108   the motion fluency of an object influence liking of that object? Second, if fluency effects

109   exist, are object-motion associations learnt following repeated exposures or are they

110   immediately evident following a single presentation? Finally, if fluency effects exist, do

111   object-motion associations survive from moving to static presentations of object?

112

113   **GENERAL METHODS**

114   Elements common to each of our 8 experiments are described in General Methods.

115   Experiments 1 to 4 feature traversing objects and are described in Part I. Experiments 5

116   to 8 feature rotating objects and are described in Part II. Details of each experiment are

117   described in the relevant sections of each individual Method section.

118

119 **Participants.** All participants were recruited from the University of York's Department

120 of Psychology participant recruitment system. Participants received either course credit

121 (Department of Psychology students only) or financial compensation for participation.

122 No participant completed more than one experiment. Participation numbers are

123 provided in each experimental section. Exclusion criteria are described below in Data

124 Exclusion and Analysis. Protocols were approved by the University of York's Psychology

125 Departmental Ethics Committee and were in accord with the tenets of the Declaration of

126 Helsinki. Participants gave written consent but were naïve to the purpose of the research

127 until participation was complete.

128

129 **Apparatus & Stimuli.** Participants sat at a table in a dimmed room facing a 27" touch

130 screen monitor (Iiyama (Tokyo, Japan) ProLite T2735MSC-B2, 1920×1080 pixels) at

131 approximately 60 cm distance. A keyboard was positioned on the table between the

132 participant and the screen. Participants and the keyboard response keys were position at

133 the screen's horizontal centre (Figure 1). A PC (Dell (Round Rock, USA) XPS, Intel (R) Core

134 (TM) i5-4430, 3 GHz CPU, 12 GB RAM, 64 bit Windows 7) generated stimuli and recorded

135 responses. Stimuli were presented at 60 Hz in all experiments. Experimental stimuli are

136 described later in Parts I and Part II. Image assets for each experiment are available at

137 https://osf.io/pjwht.

138

139
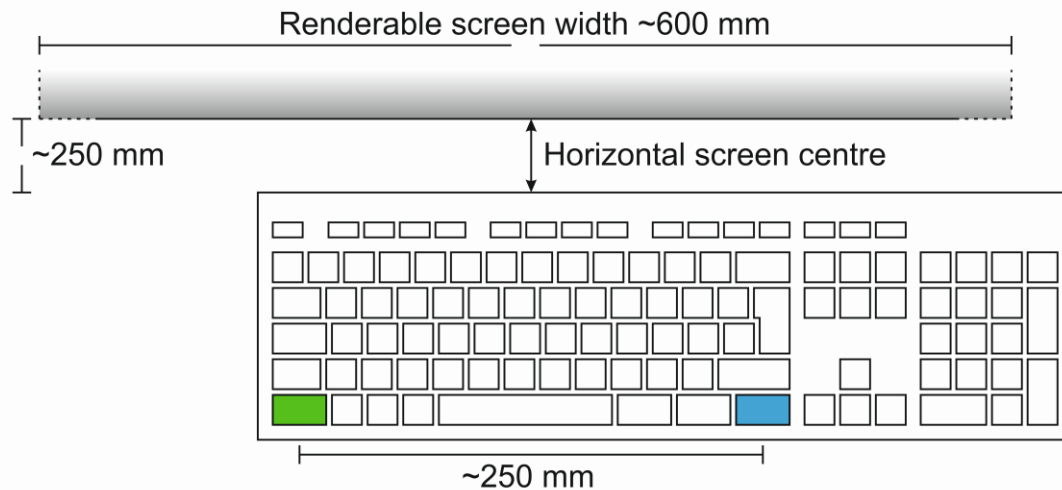
140 Figure 1. Schematic representation of the keyboard and screen. In response to changes in

141 target appearance participants pressed the space bar (long lower key) in Experiments 1

142 to 7, or pressed left (green) and right (blue) response in Experiment 8. The control keys

143 were coloured similarly on the actual keyboard.

144

145 **Procedure.** Every experiment consisted of a practice block, a task block and at least one

146 rating block. Participants carried out a 'detection task' in the practice and task blocks with

147 the former intended as rehearsal for the latter. The somewhat demanding detection task

148 was to ensure that participants continuously attended to the presented objects. It

149 required the participant to tap the space bar as soon as possible when they detected a

150 temporary change in an object's pattern. For all experiments, the response window was

151 the period when any portion of the changed object appearance was visible (~750 ms in

152 Part I and 500 ms in Part II). Trials on which the object changed are referred to as 'catch

153 trials' and those in which it didn't change are 'standard trials'. An object's changed pattern

154 is referred to as its 'catch pattern' and its unchanged pattern is its 'standard pattern'.

155 Participants were unaware whether the current trial was a catch until the object changed.

8

156   In the rating blocks, participants would rate each standard pattern object from the

157   exposure block for liking. These measures of object liking were used to assess fluency

158   effects. On a rating trial an object would be presented either as it would have appeared in

159   the task trials or stationary in the centre of the screen (detailed in each Experiment

160   section). The object would then disappear and there would be one second of blank screen

161   before a 50 cm long Likert scale was presented horizontally in the centre of the screen

162   for the participant to input their rating. The scale was a line with brackets at each end but

163   no other demarcations. Instructions to '…rate how much you liked the object…' were

164   presented on screen and verbally by the experimenter. Participants were told to tap the

165   scale towards the right if they liked the object, towards the left if they didn't, with how far

166   left or right they tapped indicating how much they did or didn't like the object. Details of

167   all rating instructions are available at https://osf.io/pjwht.

168   Presentation order was randomised in every block. Participants could take short

169   breaks before each block when the experimenter would provide instructions for the

170   upcoming block and subsequently answer any questions. Details of practice and exposure

171   blocks are provided in each experiment section presented later.

172

173   **Data exclusion & analysis.** Data were analysed using Matlab R2015a (The MathWorks

174   Inc., Natick, USA). Participants who made errors on 25% of standard or 25% of catch trials

175   in the task blocks were removed from the data set. An error on a standard trial is

176   responding (pressing the space bar) at any point. An error on a catch trial is responding

177   before or after the catch period, or failing to respond at all. Error rates are detailed in

178   Results for each experiment section.

179   Liking ratings made on the Likert scale were converted to values between -100

180   (most extreme possible response to the left i.e. minimum liking rating) and 100 (most

181   extreme possible response to the right i.e. maximum liking rating). Statistical tests were

182   assessed with α of .05 throughout. The analysed liking ratings for each experiment and a

183   brief discussion of data normality are available at https://osf.io/pjwht.

184

185   **PART I: EXPERIMENTS 1 TO 4**

186   Experiments 1 to 4 were executed using E-Prime 2.0 (Psychology Software Tools, Inc.,

187   Pittsburgh, USA). In each trial of the detection task (see Procedure earlier) an object

188   moved across the screen either fluently or disfluently and passed behind black occluders

189   en route (see Figure 2). Objects were scaled to fit into 60 mm square boxes.

190   Fluent movements were smooth and predictable whereas disfluent movements

191   were less so in that they could make sudden direction changes whilst visible, and that it

192   was not possible for participants to predict an object's re-emergence position following

193   occlusion (further trajectory information and video examples of object movements are

194   available at https://osf.io/pjwht). Object movements could be leftwards (as shown in

195   Figure 2) or rightwards and inverted for either direction to give 4 fluent and 4 disfluent

196   trajectories. The total movement time was always 5000 ms made up of alternating

197   periods of visible motion (total 2500 ms) and occluded motion (total 2500 ms).

198   At the start of a trial, an object would appear and remain stationary for 500 ms

199   before moving for 5000 ms. The object would remain stationary for 500 ms at the end of

200   it's movement before disappearing. On a standard trial, the object would wear its

201   standard pattern for the whole movement whereas, on a catch trial, the object would

202   wear its standard pattern throughout apart from between one pair of adjacent occluders

203   where it would wear its catch pattern (either between the first and second or between

204   the second and third occluders; see Figure 3). The objects used are shown in Figure 4.

205   Response errors were indicated to the participant by a short tone issued by the PC at the

206   end of a trial.

207

208
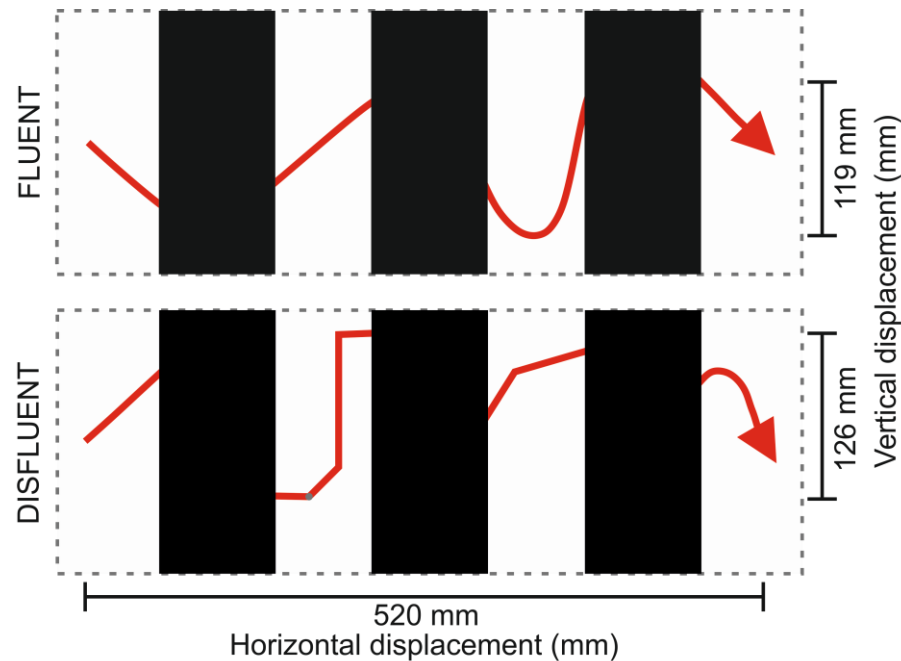
209   Figure 2. Schematic representations of object trajectories (red lines) in Experiments 1 to

210   4 in the fluent (top panel) and disfluent (bottom panel) conditions. Note that trajectory

211   paths were not visible during the experiment and are provided here for illustrative

212   purposes only.

213
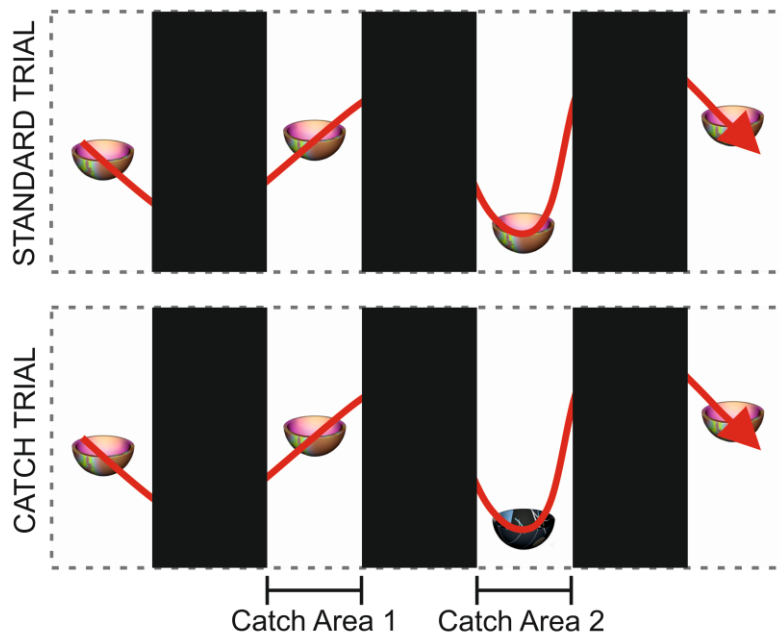
Figure 3. Schematic representations of standard and catch trials in the fluent condition. On a standard trial (top panel), the object would wear its standard pattern throughout the trial. On a catch trial (bottom panel), the object would wear its standard pattern apart from between one of two pairs of adjacent occluders (either Catch Area 1 or 2) where it would wear its catch pattern.

221
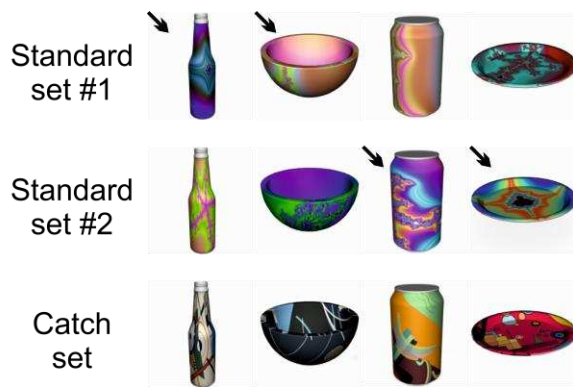
222 Figure 4. Standard (top two rows) and catch (bottom row) patterns for each object type

223 in Experiments 1 to 4. Standard pattern set #1 and #2 featured in Experiments 1, 2 and

224 3. Only standard patterns marked with an arrow were used in Experiments 4.

225 Participants rated only the standard pattern objects. Image assets are available at

226 https://osf.io/pjwht

227

228 <div align="center">**EXPERIMENT 1**</div>

229 The first experiment is a baseline study to verify that motion fluency does indeed

230 influence object preference ratings.

231

232 **Method.** The experiment consisted of a practice block, then a task block and finally a

233 rating block. Trials in the practice and task blocks were presented in a random order.

234 Objects in the practice block were a bottle, a bowl, a can and a plate, each with

235 unique standard and catch patterns. We designed the patterned objects used throughout

236 this article to be similar to artworks (interesting, distinctive and attractive) to ensure the

237 object liking task had ecological validity – where everyday preference decisions are made

238 based on such sensory properties. Two objects moved fluently (one in a standard trial

13

239 and one in a catch trial) and two disfluently (one in a standard trial and one in a catch

240 trial). Each object featured in a single trial.

241   The task block featured 8 objects of two standard patterns each for the bottle,

242 bowl, can and a plate (see Figure 4). One set of standard patterns would always move

243 fluently and the other disfluently. This was counterbalanced so that half of participants

244 experienced standard pattern set #1 as fluent and standard pattern set #2 as disfluent,

245 and the other half of participants experiencing the opposite pairing. Each object featured

246 in 8 standard trials and 2 catch trials. This created 80 task trials (8 objects × 10 trials).

247 The standard trials for a given object included two of every combination of

248 rightwards/leftwards direction and standard/inverted orientation. The trajectory for a

249 given object's catch trial was selected at random from the 8 possible combinations of

250 direction, orientation and catch area (e.g. a trajectory might be rightwards, inverted and

251 feature a catch pattern in catch area 2). Each catch trajectory was used only once for the

252 fluent objects and once for the disfluent objects.

253   In the rating block, at the end of the experiment, the final exposure to each object

254 was either fluent or disfluent as it would have been in the task block. Object assignment

255 to a trajectory was otherwise random with the constraints that for both the fluent and

256 disfluent sets: half of the objects moved rightwards and half leftwards, and half of each

257 direction were inverted. Trial order in the rating block alternated between fluent and

258 disfluent objects.

259   Further information on trajectory assignment in every block is available at

260 https://osf.io/pjwht.

261

262 **Determining power.** A power analysis was conducted in RStudio (RStudio Team, Boston,

263 MA) for a planned two-sided paired samples t-test with a target power of 0.8 and Cohen's

264 *d* of 0.5. This yielded target samples of 34 but in an effort to maximise the robustness of

265 our investigation we increased our target sample size to 40.

266

267 **Participants.** Forty participants were tested (6 males, age mean ± SD = 19.00 ± 1.43). No

268 participant erred on more than 11 of 64 (mean ± SD = 1.8 ± 1.94) standard trials or on

269 more than 4 of 16 (mean ± SD = 1.5 ± 1.0) catch trials.

270

271 **Results & Discussion.** The liking ratings for fluent and disfluent objects are shown in

272 Figure 5. Note that due to technical error, two ratings were missing from different

273 participants, one was for a fluent object rating, the other for a disfluent object rating. Due

274 to balancing of fluent/disfluent ratings, we calculated each participant's means as normal.

275 A two-tailed paired samples t-test indicated that liking of disfluent objects was

276 significantly less than liking of fluent objects ($t(39) = 2.164$, $p = .037$, $d = .342$, $\Delta = 10.7$).

277   These results confirm our predictions concerning motion fluency and object

278 preference, extending previous research by demonstrating that an object's motion path

279 influences emotional responses which is reflected in the liking of that object. In

280 Experiment 2 we seek to replicate this novel finding and investigate whether learning

281 and memory processes mediate preference change.

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283
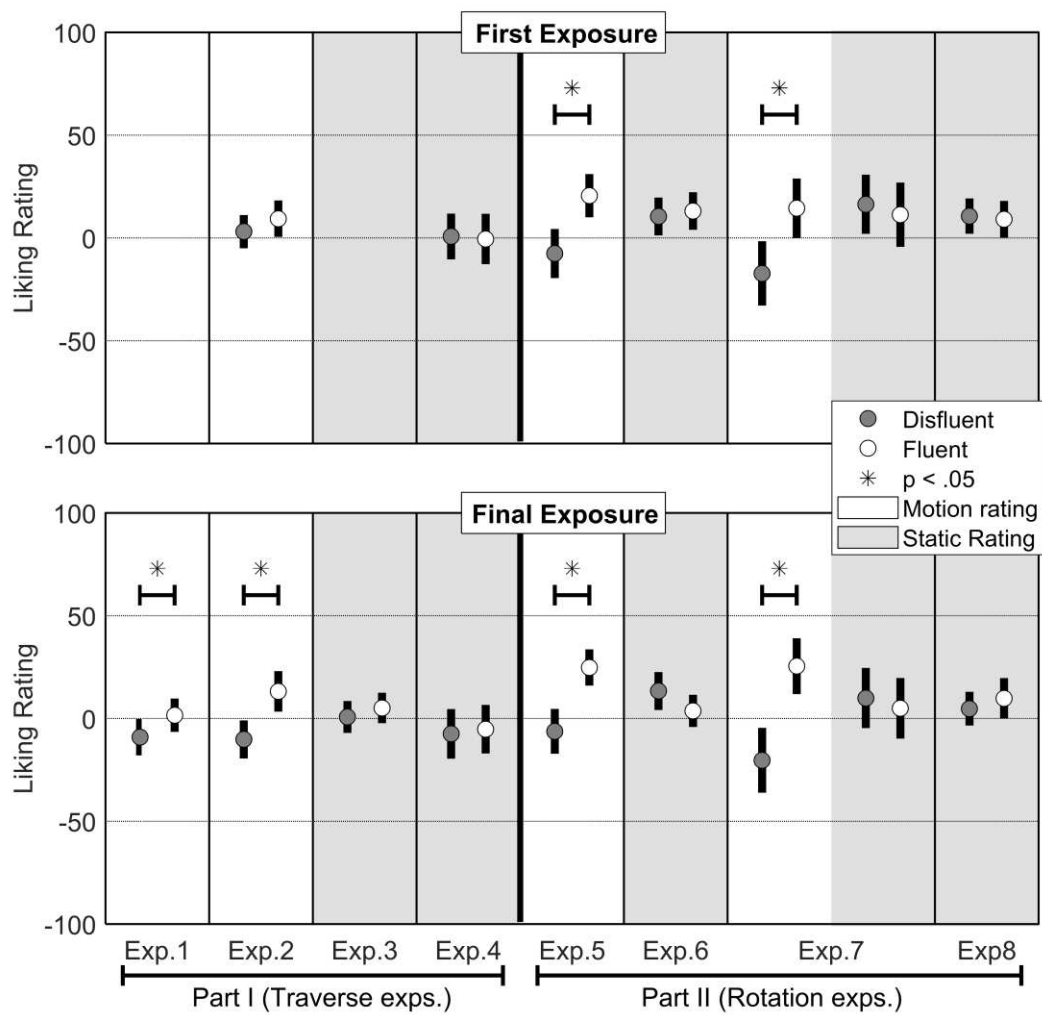
Figure 5. Mean (±95 confidence interval) for disfluent (dark grey dots) and fluent (pale grey dots) objects in each experiment. White panels indicate ratings made following exposure to moving objects and grey panels indicate ratings made following exposure to static objects. Ratings following the first exposure are shown in the top panel and ratings following the final exposure are shown in the bottom panel. Significant differences (p < .05) between fluency conditions are indicated with an asterix (*).

290

EXPERIMENT 2

292 Because motion fluency effects on object preference have not been reported previously,

293 it is important to replicate and extend our initial finding. Although Experiment 1

294 confirmed that motion fluency influences participants' liking of objects, it did not indicate

295 whether liking for an object is simply evoked by the last seen motion or instead is

296 developed following repeated exposure to fluent/disfluent pairings of motion and object

297 identity. In other words, it does not tell us whether there was any learning of the

298 association of motion fluency with an object.

299 Therefore, Experiment 2 exactly replicates Experiment 1 except that a rating block

300 was run at the start as well as at the end of the experiment. This provides two advantages.

301 First, it will reveal whether a single exposure is sufficient to evoke preference for fluent

302 objects or whether repeated exposures are necessary. Second, the contrast between the

303 first exposure rating and the final exposure rating after 10 intervening presentations,

304 may provide a more accurate measure of if/how preference is changed via learning. That

305 is, whether fluent object motion increases preference, disfluent object motion reduces

306 preference, or both (see Manssuer, Pawling, Hayes, & Tipper, 2016; Manssuer, Roberts, &

307 Tipper, 2015; Strachan, Kirkham, Manssuer, Over, & Tipper, 2017 for similar

308 approaches).

309

310 **Method.** Experiment 2 is a replication of Experiment 1 but with the addition of a first

311 exposure rating block before the practice block.

312

313   **Participants.** Forty-one participants were tested. One participant failed to complete the

314   experiment and was removed from the data set. None of the remaining participants erred

315   on more than 5 of 64 (mean ± SD = 1.5 ± 1.4) standard trials or on more than 3 of 16

316   (mean ± SD = 1.3 ± 0.8) catch trials. The remaining sample consisted of 40 participants

317   (8 male, age mean ± SD = 19.52 ± 1.92).

318

319   **Results & Discussion.** The liking ratings for fluent and disfluent objects are shown in

320   Figure 5. A 2 factor (first/final exposure × fluency) repeated measures ANOVA indicated

321   effects of object fluency ($F(1,39) = 8.307$, $p = .006$, η = .176) and the interaction of fluency

322   × first/final exposure ($F(1,39) = 5.914$, $p = .020$, η = .132) but not the main effect of

323   first/final exposure ($F(1,39) = 2.638$, $p = .112$). To break down the interaction we

324   conducted two-tailed paired samples t-tests on first and final exposure ratings.

325   First exposure ratings of disfluent and fluent objects did not differ significantly

326   ($t(39) = 1.368$, $p = .179$) but final exposure ratings of disfluent objects were significantly

327   less than those of fluent objects ($t(39) = 3.133$, $p = .003$, $d = .492$, Δ = 23). This indicates

328   that the influence of motion fluency on object liking via learning of object-motion

329   association requires more than a single exposure to disfluent/fluent motion and that it is

330   evident following 12 exposures (2 rating exposures and 10 task exposures).

331   Further analysis compared liking ratings at the start of the experiment with those

332   at the end. Note, that unlike previous similar designs (Manssuer et al., 2016; Strachan et

333   al., 2017), we do not have a true baseline in the current study as the initial ratings

334   possessed object fluency properties. Nevertheless, two-tailed paired samples t-tests

335   revealed a decline in liking of disfluent objects ($t(39) = 2.564$, $p = .014$, d = .405, Δ = 13),

336   but no change in liking of fluent objects ($t(39) = 0.996$, $p = .325$).

337   Finally, it should be noted that the final liking effects in Experiment 2 appear to be

338   somewhat larger than those observed in Experiment 1 (see also Figure 5). The sole

339   difference between these experiments is that of a first exposure rating in Experiment 2.

340   It is possible that this prior consideration of the affective properties of objects had primed

341   emotion/preference processes, producing more robust effects. To explore this, we

342   compared the difference between fluent and disfluent ratings in these experiments using

343   an independent samples t-test. There was no change in the difference between fluent and

344   disfluent ratings from Experiment 1 to Experiment 2 ($t(78) = 1.410$, $p = .163$). Hence we

345   cannot conclude that the effect was larger when an initial rating task was experienced by

346   participants.

347   Though we have demonstrated repeated exposures are required for the

348   association of an object identity with its motion fluency, we do not yet know whether the

349   association survives a change in the context in which the objects are viewed. This is

350   explored in Experiments 3 and 4.

351

352   **EXPERIMENT 3**

353   Experiment 2 provided evidence that there is learning of the association between an

354   object's identity and the fluency of its motion. That is, after 12 exposures to an object's

355   motion, liking of disfluently moving objects dropped significantly, resulting in a

356   significant preference for fluently moving objects. We have shown fluency effects

357   following repeated exposures, but it is unknown whether the association of prior motion

358   fluency with an object's identity is robust enough to survive a change of context i.e. if the

359   object is seen stationary rather than in motion. This critical issue of generalisation is little

360   explored in fluency literature.

361   Embodied accounts of emotional memory encoding propose that visuomotor

362   states are encoded during initial exposure to a stimulus (e.g., Niedenthal, 2007; Pawling,

363   Kirkham, Hayes, & Tipper, 2017). That is, during episodic memory retrieval, sensory and

364   motor neural processing states that were active at encoding are reactivated when the

365   stimulus is encountered at a later time (e.g., Barsalou, 1999; Glenberg, 1997). In our

366   previous experiments, the emotional reaction evoked by the fluent/disfluent motion was

367   associated with object identity. Hence during later encounters with an object this prior

368   embodied encoding of emotion was reactivated and influenced preference judgments.

369   Therefore, in the current and next experiment we explored whether prior motion

370   fluency can influence liking of an object even when that object no longer possesses a

371   motion property i.e. whether emotion associated with an object is activated when the

372   object is seen stationary rather than moving.

373

374   **Method.** Experiment 3 is a replication of Experiment 1, with the only change being that

375   the final exposure ratings are performed following exposure to a stationary image in the

376   centre of the screen (i.e. lacking any fluency properties) rather than following exposure

377   to a moving stimulus.

378

379   **Participants.** Forty-one participants were tested. One participant failed to complete the

380   experiment and was removed from the data set. None of the remaining participants erred

381   on more than 8 of 64 (mean±SD = 1.4 ± 1.6) standard trials or on more than 4 of 16 (mean

382   ± SD = 1.4 ± 1.0) catch trials. The remaining sample consisted of 40 participants (5 male,

383   age mean ± SD = 18.60 ± 0.67).

384

Results & Discussion. The liking ratings for fluent and disfluent objects are shown in Figure 5. A two-tailed paired samples t-test indicated that post-exposure ratings of disfluent and fluent objects did not differ significantly ($t(39) = 1.355$, $p = .183$).

Experiments 1 and 2 indicated that participants preferred fluently moving objects to disfluently moving objects after 12 exposures when assessments were made after seeing objects move. However, the current experiment demonstrates that this preference does not generalize to situations in which the object is assessed while it is stationary. Hence the association between object identity and its motion fluency may be weak and/or not easily retrieved. The fragility of such a retrieval process has been observed in other research where effects are not always observed. For example, Pawling et al. (2017) found that retrieval of prior emotional states following context change was possible whereas Kirkham, Hayes, Pawling, & Tipper, (2015) found that it was not. In Experiment 4, we continue to pursue the endurance of fluency effects following context change by reducing the number of objects to lessen memory load.

399

EXPERIMENT 4

Learning and retrieval of object-motion relationships was demonstrated in Experiment 2. However, in Experiment 3 that retrieval process was found not to survive a change in object viewing context. Persistence of fluency effects across contexts may be key to effect choice behaviour change in the real-world, so in the current experiment we continued to pursue this. In Experiment 4 a number of changes were made to the task block to facilitate

21

406   encoding of the object-motion relationship and thus allow easier retrieval when objects

407   are seen stationary.

408   First, Experiment 4 is modelled on that of Experiment 2 where ratings were made

409   at the start and end of the experiment. As we noted, although not statistically reliable,

410   there was a trend for final exposure effects to be larger in Experiment 2 than in

411   Experiment 1. Therefore, following the possibility that prior consideration of objects in

412   Experiment 2 might have subtly primed emotion/preference processes, we again opted

413   to use both a first exposure and a final exposure rating in the current experiment.

414   The second major change concerned the number of object-motion associations

415   (i.e. the number of unique standard objects in the experiment). Though incidental

416   associative learning has been demonstrated for 16 (e.g. Strachan et al., 2017) and even

417   40 face identities (e.g. Bayliss & Tipper, 2006), it is possible that the retrieval of prior

418   associative learning may be a limited capacity process for non-face stimuli, particularly

419   following a change in viewing context. Indeed the number of associations is often smaller

420   (e.g. Baeyens, Eelen, Crombez, & van den Bergh, 1992). The 8 object-motion associations

421   in the previous 3 experiments may have stretched that capacity so in the current

422   experiment we reduce the number of objects to 4.

423   The final change concerned the proportion of catch trials in the task block. Recall

424   that catch trials were to ensure that participants had to continuously attend to the

425   object's pattern (see Procedure earlier). In the previous 3 experiments, 20% of the task

426   block trials were such catch trials. In the current experiment we increase this to 50%,

427   with the aim of increasing attentional engagement with the objects and consequently

428   increasing affect encoding.

429

Method. Experiment 4 was a replication of Experiment 2 but with static objects in first and final-exposure rating blocks, a reduction from 8 to 4 objects (2 fluent and 2 disfluent), and an increase in the proportion catch trials to 50% for each object in the task block. Standard and catch patterns are shown in Figure 4.

Objects in the practice block were a bottle and a bowl each with unique standard and catch patterns. For even numbered participants the bottle was fluent and the bowl disfluent (vice versa for odd numbered participants). One fluent and one disfluent object featured in a catch trial with the other two featuring in standard trials (4 practice trials in total).

In the task block, each of the 4 objects featured in 4 standard trials and 4 catch trials to create a total of 32 experimental trials (4 objects × 8 trials). Half of participants experienced the bottle and bowl as fluent and the can and plate as disfluent, and the other half of participants experienced the opposite pairing. As in previous experiments, trajectory assignment was counterbalanced for standard and catch trials. Further information on trajectory assignment is available at https://osf.io/pjwht.

As in Experiment 3, objects were rated following a static presentation in the centre of the screen. The experiment protocol was otherwise as described for Experiment 2.

Participants. Forty-two participants were tested. Two participants failed to complete the experiment and were removed from the data set. None of the remaining participants erred on more than 3 of 16 (mean ± SD = 0.9 ± 0.9) standard trials or on more than 2 of 16 (mean ± SD = 1.0 ± 0.8) catch trials. The remaining sample consisted of 40 participants (10 male, age mean ± SD = 19.65 ± 1.96).

23

453

454 **Results & Discussion.** The liking ratings for fluent and disfluent objects are shown in

455 Figure 5. A 2 factor (first/final exposure × fluency) repeated measures ANOVA indicated

456 effects of first/final exposure ($F(1,39) = 4.925$, $p = .032$, $\eta = .112$, mean $\Delta = 6.444$) where

457 final exposure ratings were lower than first exposure ratings. However, there was no

458 effect of object fluency ($F(1,39) = 0.014$, $p = .906$, $\eta < .001$), or the interaction between

459 first/final exposure × fluency ($F(1,39) = 0.589$, $p = .448$, $\eta = .015$).

460 Again we found no evidence of fluency effects in ratings of static objects following

461 repeated exposures to each object's motion. This failure to detect an effect has now been

462 observed in 2 experiments, the latter of which employed a variety of manipulations aimed

463 at making the experiment more sensitive. Therefore, we are confident that the fluency

464 effects imparted by our current stimuli do not survive a change from moving to static

465 contexts.

466 However, although we demonstrate that objects that move fluently are preferred

467 over those that move disfluently in both Experiments 1 and 2, it is possible that our

468 motion fluency manipulation has a rather weak effect on emotional responses to a

469 moving object. Thus it may be the case that these weak effects cannot be retrieved when

470 transferred to static objects. Hence, in Part II we present a final set of experiments for

471 which we developed much more compelling motion fluency manipulations. We predict

472 that these new movements will produce stronger associations between an object's

473 identity and its repeated pattern of fluent/disfluent movement. Furthermore, to facilitate

474 such associative learning via a small number of associations, we again used only 4 objects.

475 In Part II, we first explore the effectiveness of these new motions before again attempting

476 to reveal motion fluency preference effects from stationary objects.

24

477

PART II: EXPERIMENTS 5 TO 8

479 Experiments 5 to 8 were executed using custom scripts and Psychtoolbox 3.0.11

480 (Brainard, 1997; Kleiner, Brainard, & Pelli, 2007; Pelli, 1997) operating within Matlab

481 R2015a (The MathWorks Inc., Natick, USA). The block protocol for experiments in Part II

482 was the same as that for Experiment 4 in Part I: a first exposure rating block, a practice

483 block, a task block, and lastly a final exposure rating block. The principle difference

484 between Part I and Part II was the object movement. Rather than traversing across the

485 screen, objects remained in the centre of the screen and changed size while rotating.

486 On trials in which an object moved, it would appear in the centre of screen and

487 remain stationary for 500 ms before moving for 2500 ms. The object would remain

488 stationary for 500 ms at the end of it's movement before disappearing. Objects could

489 either expand or contract, and rotated either clockwise or anti-clockwise resulting in four

490 possible movements. Fluent movements were a constant rate of change of size and

491 rotation (see the top panel in Figure 6). Disfluent movements were generated by dividing

492 a fluent movement into 5 equal length sections and then reordering them from [1-2-3-4-

493 5] to [1-4-3-2-5] (see bottom panel Figure 6). Further trajectory information and video

494 examples of object movements are available at https://osf.io/pjwht.

495 The objects used in the following experiments were a geometric shapes (see

496 Figure 7) to avoid implications of appropriate orientation and to more easily control

497 displayed object size. Just as in Part I, each object contained art patterns to provide

498 validity for the preference judgment task.

499   At the moment of appearance, an expanding object's area was 900 mm², and for a

500   contracting object it was 14400 mm². The final area was always 5625 mm². For example,

501   the length of one side of an expanding square would change from 30 mm to 75 mm, and

502   the length of one side of a contracting square would change from 120 mm to 75 mm. Just

503   as the final area of all objects was the same, the final orientation was too. All objects

504   rotated by 90° to the orientation shown in Figure 7 by the end of their movement.

505   The participants' role in the detection task (practice and task blocks) was the same

506   as Part I – press the space bar when the object's appearance changed. However, instead

507   of changing to a different pattern, objects would turn greyscale as shown in Figure 7. On

508   standard trials an object would wear its standard pattern throughout whereas on catch

509   trials the object would wear its standard pattern apart from in either block 2 or block 4

510   of the movement (see Figure 6) where it would wear its catch pattern. Participants were

511   not aware of catch trials until the object changed appearance.

512   Response errors (responding on standard trials, and failing to respond or

513   responding too early/late on catch trials) were indicated to the participant by a red

514   screen border from the moment of the error to 1500 ms after the object had disappeared.

515   Correct responses (pressing at the appropriate time on a catch trial or not pressing on a

516   standard trial) were indicated to the participant by a green screen border from the

517   moment of success to 1500 ms after the object had disappeared.

518   Just as in the Part I, during the object rating tasks, participants were asked to

519   assess how much they liked the object they saw. Object motion was never mentioned in

520   relation to rating. This meant that the focus of this task was on the object properties of

521   shape and pattern rather than with the object's motion, which was an irrelevant

522   background factor.

523

524
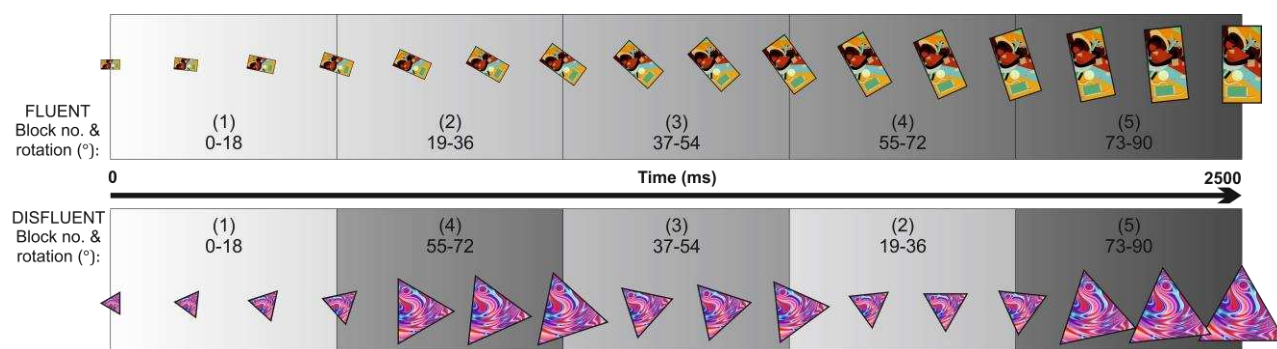
Figure 6. Schematic representations of object movements in experiments 5, 6 and 7 in the fluent (top panel) and disfluent (bottom panel) conditions. Note that the background colour in the experiments was a constant grey. In this figure the background varies to highlight the reordered sections in the disfluent condition.

529

530
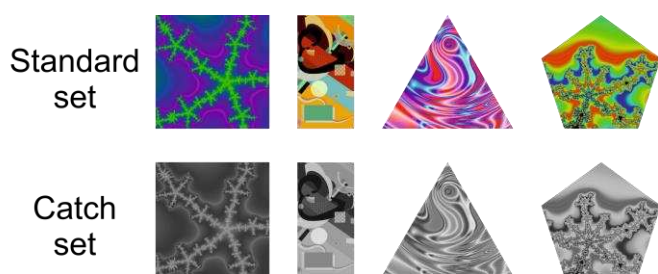
Figure 7. Standard (top row) and catch (bottom row) patterns for objects in experiments 5, 6 and 7. Participants rated only the standard patterns. Image assets are available at https://osf.io/pjwht

534

EXPERIMENT 5

In Part I we demonstrated that the learnt association of an object's motion fluency affects preference judgements only when the objects are seen moving. It is possible that preference transference to a static context did not occur because the fluency effects were not strong enough. As such, we developed a new and more compelling version of fluent/disfluent motion: rotation and size change. We aim to demonstrate fluency effects

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541   following exposure to these new motions (current experiment) before testing whether

542   the fluency effects evoked by our new motions are sufficient to survive a change in

543   context (next experiment).

544

545   **Method.** Participants completed a first exposure rating block, practice block, task block

546   and a final exposure rating block as in Experiments 2 and 4. Four objects were used (see

547   Figure 7). Even numbered participants experienced the square and pentagon as fluent

548   and the triangle and rectangle as disfluent (vice versa for odd numbered participants).

549   This was true for the practice and exposure blocks.

550   In the practice block, one fluent object and one disfluent object featured in catch

551   trials with the other two in standard trials (4 practice trials in total).

552   In the task block, each object featured in 16 trials (total 64 trials). Of those, 8 were

553   standard trials and 8 were catch trials. Half of each trial type expanded (the others

554   contracted) and half of those rotated clockwise (the others rotated anti-clockwise). This

555   meant that each object and trial type appeared the same number of times in each

556   movement.

557   In each rating block, every object was rated after being seen to move in its assigned

558   way (either fluently or disfluently). Movements in this block were always clockwise and

559   expanding.

560   Trial presentation was randomised by participant for every block. Further

561   information on trial assignment is available at https://osf.io/pjwht.

562

Participants. Forty-one participants were tested. One participant exceeded the error

threshold for catch trials by failing to respond on 7 of 16 catch trials and was removed

from the data set. None of the remaining participants erred on more than 3 of 32 (mean

± SD = 0.2 ± 0.6) standard trials or on more than 7 of 32 (mean ± SD = 2.4 ± 2.0) catch

trials. The remaining sample consisted of 40 participants (3 male, age mean ± SD = 19.48

± 1.92).

Results & Discussion. The liking ratings for fluent and disfluent objects are shown in

Figure 5. A 2 factor (first/final exposure × fluency) repeated measures ANOVA indicated

effects of object fluency ($F(1,39) = 16.94$, $p < .001$, ɳ = .303) where fluent objects were

preferred over disfluent objects (mean Δ = 29.602). There was no effect of first/final

exposure ($F(1,39) =.913$, $p = .345$, ɳ = .023) or of the interaction between fluency ×

first/final exposure ($F(1,39) = 0.297$, $p = .589$, ɳ = .008).

This experiment has confirmed that our new fluent and disfluent motions produce

very robust effects on liking judgments of moving objects. This is revealed in two key

findings. First, the effect of fluency on liking ratings at the final exposure were larger in

this experiment ($d = .691$, Δ = 31.1, [derived from a two sample t-test]) than in Experiment

1 ($d =.342$, Δ = 11) or Experiment 2 ($d = .492$, Δ = 23). Second, and more strikingly, fluency

effects in the current experiment were observed after only a single exposure to motion

(at the start of the experiment) whereas in Experiment 2 the object-motion associations

had to be learnt for fluency effects to be revealed.

EXPERIMENT 6

29

Having demonstrated clear fluency effects resulting from our new motions (rotation and size change), in the current experiment we test whether such fluency associations are preserved and retrieved following a change in context. That is, can fluency effects be detected when assessing static objects?

Method. Experiment 6 is a replication of Experiment 5, with the only change being that the objects are rated at the start and end of the experiment while they are static. The size and orientation of this static image was the final size and orientation in each trial in the task block.

Participants. Forty-one participants were tested. One participant exceeded the error threshold for catch trials by failing to respond on 7 of 16 catch trials and was removed from the data set. None of the remaining participants erred on more than 1 of 32 (mean ± SD = 0.2 ± 0.4) standard trials or on more than 6 of 32 (mean ± SD = 2.4 ± 1.9) catch trials. The remaining sample consisted of 40 participants (2 male, age mean ± SD = 18.80 ± 0.97).

Results & Discussion. The liking ratings for fluent and disfluent objects are shown in Figure 5. A 2 factor (first/final exposure × fluency) repeated measures ANOVA indicated that there were no effects of object fluency ($F(1,39) = .356$, $p = .554$, $\eta = .009$), or first/final exposure ($F(1,39) = 3.085$, $p = .087$, $\eta = .073$). However there was an interaction between fluency × first/final exposure ($F(1,39) = 7.369$, $p = .010$, $\eta = .159$). To break down the

30

608   interaction we conducted two-tailed paired samples t-tests on first and final exposure

609   ratings.

610   Ratings of disfluent and fluent objects did not differ significantly at the first (t(39)

611   = .429, p = .671) or final (t(39) = 1.515, p = .138) exposures. There was no change in the

612   liking ratings of disfluent objects (t(39) = 1.055, p = .298) but there was a significant

613   decrease in liking of fluent objects (t(39) = 3.055 p = .004, d = .483, Δ = 9).

614   The interaction was thus driven by a decline between first and final liking ratings

615   for objects associated with fluent motion. This is an unexpected result that we have not

616   observed before and that is opposite to our apriori predictions. However, most

617   importantly for our hypothesis concerning learned associations between patterns of

618   motion and object liking, in ratings at the end of the experiment there was no difference

619   in preference for static objects that had previously been viewed moving fluently or

620   disfluently.

621   The current experiment was a stronger test of fluency effect survival following

622   context change than those in Part I due to the potency of the new object motions.

623   However, we have again failed to detect fluency effects while judging static objects for

624   preference. Nevertheless, we felt it worthwhile to further replicate and extend our

625   findings in a further experiment.

626   Thus far our contrasts between assessing moving versus static objects have been

627   between participants in separate experiments. It is possible that requiring people to

628   assess both moving and static objects for liking within the same experiment might

629   increase sensitivity to the latter (see Poulton (1982), for influential companion effects).

630   Indeed, we found a trend for larger fluency effects in Experiment 2 than in Experiment 1

631   with the only difference being the addition of a first exposure rating that may have

increased participants' sensitivity to object motion. Therefore, the following experiment

replicates Experiments 5 and 6, but combines assessment of moving and static objects

into a within-participants design.

EXPERIMENT 7

Experiment 7 combined Experiments 5 and 6: objects always moved in the task trials

but in rating trials they were either stationary or moved as normal.

Methods. All protocols were identical to those in Experiments 5 and 6 apart from the

assignment of objects to fluency and rating blocks. Again two objects were fluent and two

were disfluent but now one fluent object and one disfluent objects were always rated

following a moving presentation (as in Experiment 5) with the others rated following a

static presentation (as in Experiment 6). Four versions of the experiment were run to

counterbalance these conditions (further information at https://osf.io/pjwht).

Participants. Forty participants were tested (18 male, age mean ± SD = 20.65 ± 1.48). No

participant erred on more than 2 of 64 (mean±SD = 0.3±0.6) standard trials or on more

than 5 of 16 (mean±SD = 1.5±1.4) catch trials.

Results and Discussion. The liking ratings for fluent and disfluent objects are shown in

Figure 5. A 3 factor (first/final exposure × fluency × motion/static rating) repeated

measures ANOVA indicated main effects of fluency ($F(1,39) = 9.143$, $p = .004$, η = .190)

but not first/final exposure ($F(1,39) = .129$, $p = .722$, η = .003) or motion/static rating

32

655   ($F_{(1,39)}$ = 2.363, p = .132, ɳ = .057). There was a significant interaction between fluency

656   × motion/static rating ($F_{(1,39)}$ = 8.303, p = .006, ɳ = .176). There were no interactions

657   between first/final exposure × fluency ($F_{(1,39)}$ = 2.056, p = .160, ɳ = .050), first/final

658   exposure × motion/static rating ($F_{(1,39)}$ = 3.342, p = .075, ɳ = .079) or between first/final

659   exposure × fluency × motion/static rating ($F_{(1,39)}$ = 1.567, p = .218, ɳ = .039). To

660   breakdown the fluency × motion/static rating interaction we carried out separate 2 × 2

661   repeated measures ANOVAs on liking ratings made of moving objects and on liking

662   ratings made of static objects.

663   Replicating the results of Experiment 5, when objects were seen moving during

664   ratings, the ANOVA indicated a highly significant main effect of fluency ($F_{(1,39)}$ = 17.842,

665   p < .001, ɳ = .314), but no main effect of first/final exposure ($F_{(1,39)}$ = .720, p = .401, ɳ =

666   .018). Interestingly, the interaction between first/final exposure and object fluency

667   ($F_{(1,39)}$ = 4.505, p = .040, ɳ = .104), was significant, as observed in Experiment 2,

668   suggesting a role for learning in these object-motion association processes. However,

669   even though the fluency effect was smaller at the start of the experiment, nevertheless

670   the effect was significant at the first ($t_{(39)}$ = 3.473, p = .001, d = .549, Δ = 32) and final

671   ($t_{(39)}$ = 4.426, p = .001, d = 0.670, Δ = 46) exposures. Further analysis indicated no change

672   in ratings of disfluent objects ($t_{(39)}$ = .500, p = .620) but an increase in ratings of fluent

673   objects between the first and final exposure ($t_{(39)}$ = 2.068, p = .044, r = .330, Δ = 11).

674   In contrast, and again replicating our prior results (Experiment 6) the analysis of

675   ratings of static objects detected no main effect of fluency ($F_{(1,39)}$ = .272, p = .605), no

676   main effect first/final exposure ($F_{(1,39)}$ = 2.452, p = .125) and no interaction between

677   first/final exposure and fluency ($F_{(1,39)}$ < 0.001, p = .992).

678   Therefore, this final experiment again confirms our findings of clear effects of

679   visuomotor fluency on liking when assessing moving objects, but when the objects are

680   static no preference effects can be detected.

681   We have been surprised by the consistent failure to detect fluency effects when

682   assessing static objects. Associative learning/evaluative conditioning would have

683   predicted that such effects exist due to the CS of object identity being repeatedly

684   associated with the US± of motion fluency. Two reviewers suggested that the apparent

685   lack of association may be due to object identity being ignored. This could be because the

686   detection of, and response to, object appearance change is a somewhat low-level

687   transient signal that potentially results in a low-level of engagement, shallow encoding

688   and, consequently, weaker memories (e.g., the levels of processing theory of Craik &

689   Lockhart, 1972). Weak/absent associations between affect induced by motion and the

690   object identity may mean that participants are primarily influenced by the currently

691   observed motion (or lack of) when rating objects.

692   With this in mind, we designed a new experiment (Experiment 8) in which we

693   endeavoured to engage participants more directly with target appearance. Participants

694   were required to actively attend to and identify each object as this determines which key

695   press response would be appropriate if the target pattern changed to greyscale.

696

697   **EXPERIMENT 8**

698   In Experiments 5, 6 and 7 fluency effects were apparent when objects were rated

699   following a moving presentation but not when they were rated following a static

700   presentation. In Experiment 8 we attempted once more to elicit preference for fluent

34

701   motion in a static rating condition by increasing participant engagement with target

702   shape/pattern. Experiment 8 is replication Experiment 6 but rather than tapping the

703   space bar when the object turned to greyscale, participants were required to tap either

704   the left control key for one fluent and one disfluent object, or the right control key for the

705   other fluent and disfluent objects. This would require explicit encoding of object-shape

706   and rapid detection of object-pattern change to produce the appropriate key-press

707   response.

708

709   **Method.** Experiment 8 is a replication of Experiment 6 (static object presentation for

710   ratings) with changes to the response key used in the task and practice blocks, the

711   composition of the practice block, and the object-condition assignments.

712   In all of our previous experiments, participants were required to press the space

713   bar when they detected a change in target appearance. However, in the current

714   experiment participants were instead required to press either the left or right control

715   keys depending on the presented object (see Figure 1). The left control key was covered

716   with a green sticker and the right with a blue sticker (referred to henceforth and in the

717   experiment as the green and blue keys). Four versions of the experiment were run to

718   counterbalance   fluency   and   key   assignment   for   each   object   (details   at

719   https://osf.io/pjwht).

720   This new two-key task was much more demanding than the one-key task of

721   previous experiments so three practice blocks were run to slowly introduce object-key

722   assignments rather than the single block used in all previous experiments. The first

723   practice block included only the two objects assigned to the green key and the second

724   practice block included only the two objects assigned to the blue key. The third practice

725   block included all four objects. Every object in each practice block featured in one

726   standard and one catch trial to yield 4 trials each in blocks 1 and 2, and 8 trials in block 3.

727   Each of these blocks began with instructions given verbally by the experimenter and

728   presented on the screen. The objects in the upcoming trials along with their assigned

729   colour key were also shown on the screen. Verbal and displayed reminders of key

730   assignments were also given before the task block. Reminders would also be displayed

731   after a trial if the participants made a response error on that trial. Examples of

732   instructions and reminders are available at https://osf.io/pjwht.

733

734   **Participants.** Forty-two participants were tested. Two participants exceeded the error

735   threshold for catch trials by failing to respond on 9 and 10 of 16 catch trials. They were

736   removed from the data set. None of the remaining participants erred on more than 1 of

737   32 (mean ± SD = 0.15 ± 0.36) standard trials or on more than 8 of 32 (mean ± SD = 2.75 ±

738   2.18) catch trials. The remaining sample consisted of 40 participants (13 male, age mean

739   ± SD = 20. 26 ± 3.25, one participant did not disclose their age).

740

741   **Results & Discussion.** The liking ratings for fluent and disfluent objects are shown in

742   Figure 5. A 2 factor (first/final exposure × fluency) repeated measures ANOVA indicated

743   that there were no effects of object fluency ($F(1,39) = .075$, $p = .785$, $\eta = .002$), or first/final

744   exposure ($F(1,39) = .953$, $p = .335$, $\eta = .024$), or the interaction between fluency ×

745   first/final exposure ($F(1,39) = 1.696$, $p = .200$, $\eta = .042$).

746   This experiment has again failed to detect the fluency effects when rated objects

747   are presented stationary. This is surprising as we felt that the much deeper encoding

748 resulting from attention focused on both the object's shape identity and it's pattern

749 throughout the experiment would result in stronger memories for affect induced by

750 experience, which in turn would influence assessments of static objects (e.g., Craik &

751 Lockhart, 1972).

752 The results of all our previous experiments using static objects (Experiments 3, 4,

753 6, 7 and 8) challenge, to some extent, the idea that associative learning is an automatic

754 process that takes place in all situations. There certainly appear to be limits in the context

755 of perceptual fluency effects on liking.

756

757 **FURTHER ANALYSIS**

758 **Cross-experiment analysis.** We performed two additional analyses on the combined final

759 exposure ratings from the 4 experiments where moving objects were assessed (Experiments 1,

760 2, 5 & 7) and from the 5 experiments where static objects were assessed (Experiments 3, 4, 6,

761 7 & 8). These were 2-way repeated measures ANOVAs with a between-subjects factor of

762 experiment and provided high levels of power (160 participants for moving assessments and

763 200 participants for static assessments) to assess the fluency effects following presentation of

764 moving and static objects.

765 The analyses confirmed all of our previous findings on fluency effects. Objects that

766 moved fluently were preferred over disfluent objects when ratings followed a moving

767 presentation ($F(1,156) = 51.631$, $p < .001$, $\eta = .249$) but not when they followed a static

768 presentation ($F(1,195) = .038$, $p = .845$). For the moving rating analysis, there was also an

769 interaction between fluency and experiment ($F(3,156) = 3.614$, $p = .015$, $\eta = .065$) which

770 likely resulted from the greater efficacy of object motions in Part II of the study. There

771 was no interaction between fluency and experiment in the static rating analysis ($F(4,195)$

772   = .926, *p* = .450). The mean liking ratings for fluent and disfluent objects from all

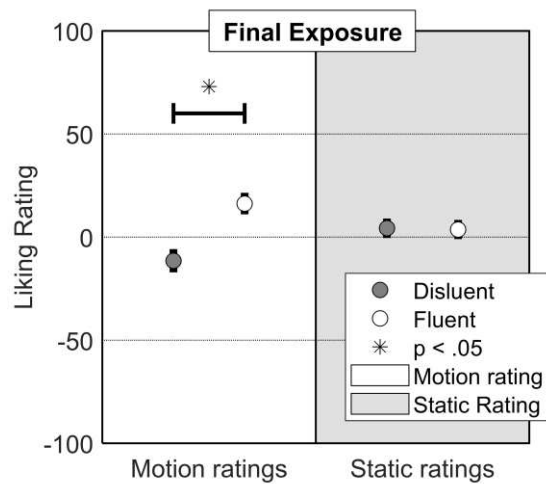773   experiments are shown in Figure 8.

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775

776   Figure 8. Mean (±95 confidence interval) for final exposure disfluent (dark grey dots) and

777   fluent (pale grey dots) object ratings in all experiments. White panels indicate ratings

778   made following exposure to moving objects and grey panels indicate ratings made

779   following exposure to static objects. Significant differences (p < .05) between fluency

780   conditions are indicated with an asterix (*).

781

782   **Bayesian analysis.** Following discussions with reviewers we also ran Bayesian analyses

783   on the aggregate data described above using JASP v0.9.0.1 (JASP-Team, 2018). The

784   Bayesian 2-way repeated measure ANOVA (between-subjects factor of experiment)

785   strongly suggest that presentation of an object in motion influences rating (BF_{10} =

786   1.160e+10, $p(H_1|Data) > .999$) and that presentation of a stationary object does not

787   influence rating (BF_{10} = .112, $p(H_1|Data) = .101$). These models and Bayesian paired

788   samples t-tests (which also support our conclusions) are available at

789   https://osf.io/pjwht.

790

791

GENERAL DISCUSSION

793 In a series of 8 experiments we investigated three questions: (1) does motion fluency

794 influence object liking?; (2) are object-motion associations learnt following repeated

795 exposures?; and (3) do object-motion associations transfer from moving to static

796 presentations of objects? Before commenting on possible mechanisms and future

797 directions we first provide brief answers to these questions.

798   First, in Experiments 1, 2, 5 and 7 we demonstrated that liking of objects is

799 influenced by the motion patterns associated with them: when objects move disfluently

800 (unpredictable movement) they are liked less than objects that move more fluently

801 (predictable movements).

802   Second, the association between an object's identity and its pattern of motion

803 (fluent or disfluent) can, to some extent, be learned. In Experiment 2 liking ratings did

804 not differ between fluently and disfluently moving objects after one presentation but they

805 did following repeated presentations. And, in Experiment 7, the learned fluency effect

806 was larger after repeated exposures to the moving objects. Of course the interaction was

807 not observed in Experiment 5, so whilst associative learning of motion fluency can occur,

808 with sufficiently powerful stimulus motions it may not always be necessary since ceiling

809 effects can be reached immediately.

810   Finally, and most surprisingly, the association between an object's identity and the

811 affect evoked by its motion fluency did not transfer to situations where that object was

812 no longer moving. The lack of effect when rating static objects for liking was observed in

813 Experiments 3, 4, 6, 7 & 8 ($n = 40$ in each) and in the combined analysis ($n = 200$) on those

814 data. In our attempts to detect transfer from moving to static displays we have tested:

815 reducing numbers of objects to alleviate cognitive load; increasing proportions of catch

816   trials to encourage engagement with objects; using highly potent object motions that

817   were shown to yield fluency effects even following a single moving presentation; and

818   modifying the response task to encourage deeper levels of encoding.

819   Our initial prediction that learning of visuomotor properties would influence

820   object preference judgements, even when context changed, was motivated by embodied

821   or grounded accounts of cognition. In these, memory consists of visuomotor information

822   from different modalities in distributed systems and when encountering an object at a

823   later time, such visuomotor properties are retrieved (e.g., Barsalou, 2008; Glenberg,

824   1997). We expected such learning and retrieval to take place and that this would lead to

825   evocation/retrieval of motion evoked affect. However, this consistently appeared not to

826   be the case in our experiments. It is important to note that we are not questioning such

827   embodied/grounded accounts of cognition, and indeed we have previously provided

828   evidence for such learning and retrieval processes (e.g., Pawling et al., 2017; Rogers et al.,

829   2014). Rather, our current results, and those of Canits et al. (2018) and Quak et al. (2014)

830   who also failed to show any effects of action fluency on later retrieval from memory,

831   provide important boundary conditions where visuomotor fluency when processing

832   objects may not always influence processing when later encountering an object in a

833   different context.

834   As noted previously, our task is a form of evaluative conditioning. In such tasks a

835   neutral conditioned stimulus (CS, e.g. an apple), when associated with a positive

836   unconditioned stimulus (US, e.g. a pleasant background), takes on positive properties and

837   is liked more subsequently. Such associations can develop following a small number of

838   pairings (e.g., 6) and may go unnoticed by participants (e.g. Walsh and Kiviniemi, 2014).

839   As typical in associative learning tasks, in our tasks participants were not explicitly

840   instructed to learn the object-motion associations but they nevertheless had to

841   continuously and carefully attend to the objects (to achieve the detection task) which may

842   have facilitated learning. Furthermore, that the CS (object identity) and US±

843   (fluent/disfluent motion) were elements of the same object might also be assumed to

844   facilitate learning of the association between CS and US. We expected evaluative

845   conditioning be the mechanism of association between objects and affect in our

846   experiments. Indeed, Experiments 2 and 7 provide some evidence for such associative

847   learning, in that the liking effects were larger after repeated exposures to the CS-US

848   pairings

849   Statistical learning might be the way in which participants learn object-motion

850   associations. Statistical leaning is, broadly speaking, a general mechanism that operates

851   by mere-exposure to extract structure from the environment. In this way, specific

852   environment properties that are to be learned do not need attention and awareness

853   directed towards them. Rather spatial and temporal structures are extracted incidentally.

854   This learning process is general, being observed across species, development and

855   domains (see Aslin and Newport (2012) for review). Of particularly relevance for the

856   current work, temporal (N. Z. Kirkham, Slemmer, & Johnson, 2002; Nissen & Bullemer,

857   1987) and spatial regularities (Fiser & Aslin, 2001) embedded in a scene can be extracted

858   in this way. In our tasks, participants continuously attended to objects to detect

859   occasional brief pattern changes and, whilst irrelevant to that task, a given object's

860   motion was consistently either fluent or disfluent. So similar to the studies above,

861   statistical learning that an object is always associated with a particular fluent/disfluent

862   motion property would be incidental. It should be noted that these incidental learning

863   studies show improved performance <u>within</u> the task. We have investigated such within

864   task effects (moving rating experiments) and, in sharp contrast, investigated whether

865   fluency effects might generalize to different contexts (stationary rating experiments).

866   Whilst retrieval within-task contexts appear to be robust and may even show learning

867   after a single trial, we consistently found that generalization may not always be possible.

868   In other words, retrieval might be context dependent.

869   This failure to detect retrieval of associations when static objects were assessed

870   would appear to be an important boundary condition for the learning of visuomotor

871   fluency effects on preference. And indeed it is in agreement with some recent challenges

872   to the idea that associative learning is automatic and often not accessible to awareness.

873   For example, (Högden, Hütter, & Unkelbach, 2018) recently examined the classic eye-

874   blink conditioning studies. They demonstrated that such conditioning only takes place

875   when participants are initially informed that one CS predicts the air-puff and they can

876   explicitly report the contingencies. Furthermore, the role of explicit awareness of

877   contingencies in evaluative conditioning has also been noted (e.g., Högden et al., (2017)

878   and Kattner (2012); also see Hofmann, De Houwer, Perugini, Baeyens, & Crombez (2010)

879   for meta-analysis review and Weidemann, Satkunarajah, & Lovibond (2016).

880   Although somewhat tangential, there have been recent debates concerning

881   positive publication bias in psychology (e.g., Kicinski, 2014; Rothstein, Sutton, &

882   Borenstein, 2005), where experiments that produce null results are not always published

883   (i.e., the 'file drawer' problem). However, we feel that demonstrating where effects are no

884   longer detected provides critical boundary conditions to understanding the underlying

885   mechanisms in many cognitive systems. In the current research programme, our initial

886   assumptions, based on embodied memory and evaluative conditioning theories and our

887   own previous empirical work, were that there would be learning of prior associations

888   between an object's identity and its repeated pattern of motion, and that this would

889 generalize to other situations (i.e., static displays). That such effects were never detected

890 in a series of 5 experiments with a variety of approaches makes clear that our predictions

891 were not supported.

892   This lack of transfer from moving to static displays has important practical

893 implications. For example, it might be possible to bias liking of consumer products or a

894 food type by manipulating patterns of motion in advertising or, to generate greater user

895 engagement, a computer game. However, it is critical that such preferences are robust

896 enough to be detected in a different context for effective behaviour change. For example,

897 imagine trying to increase a child's consumption of fruit relative to some other food they

898 like equally well. In a game, fruit would be continuously paired with fluent movement and

899 the other food with disfluent movement. Our results show that fruit would be preferred

900 within the game but that outside of the game (i.e. out of context, perhaps at the dinner

901 table) this is unlikely to be the case.

902   In summary, our current results suggest that visuomotor fluency could be highly

903 effective in changing preference but that more work is needed to establish preference in

904 contexts other than those in which fluency associations are learnt. Our future research,

905 such as further investigating the role of levels of processing (e.g. Craik & Lockhart, 1972)

906 and combining different forms of fluency, will continue to seek techniques that enable

907 visuomotor fluency to influence preference more broadly.

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909   **REFERENCES**

910   Alter, A. L., & Oppenheimer, D. M. (2006). Predicting short-term stock fluctuations by

911   using processing fluency. *Proceedings of the National Academy of Sciences*, *103*(24),

912   9369–9372.

913   Aslin, R. N., & Newport, E. L. (2012). Statistical learning: From acquiring specific items to

914   forming general rules. *Current Directions in Psychological Science*, *21*(3), 170–176.

915   Baeyens, F., Eelen, P., Crombez, G., & van den Bergh, O. (1992). Human evaluative

916   conditioning: Acquisition trials, presentation schedule, evaluative style and

917   contingency awareness. *Behaviour Research and Therapy*, *30*(2), 133–142.

918   Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*(4),

919   577–609.

920   Barsalou, L. W. (2008). Grounded Cognition. *Annual Review of Psychology*, *59*(1), 617–

921   645.

922   Bayliss, A. P., & Tipper, S. P. (2006). Predictive Gaze Cues and Personality Judgments:

923   Should Eye Trust You? *Psychological Science*, *17*(6), 514–520.

924   Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision*, *10*, 433–436.

925   Canits, I., Pecher, D., & Zeelenberg, R. (2018). Effects of grasp compatibility on long-term

926   memory for objects. *Acta Psychologica*, *182*(January 2017), 65–74.

927   Cannon, P. R., Hayes, A. E., & Tipper, S. P. (2010). Sensorimotor fluency influences affect:

928   Evidence from electromyography. *Cognition and Emotion*, *24*(4), 681–691.

929   Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory

930   research. *Journal of Verbal Learning and Verbal Behavior*, *11*, 671–684.

931   De Houwer, J., Thomas, S., & Baeyens, F. (2001). Associative Learning of Likes and

932   Dislikes: A Review of 25 Years of Research on Human Evaluative Conditioning.

933   *Psychological Bulletin*, *127*(6), 853–869.

934   Fiser, J., & Aslin, R. N. (2001). Unsupervised Statistical Learning of Higer-Order Spatial

935   Structures from Visual Scenes. *Psychological Science*, *12*(6), 499–504.

936   Flavell, J. C., Tipper, S. P., & Over, H. (2018). Preference for Illusory Contours: Beyond

937   Object Symmetry, Familiarity, and Nameability. *Emotion*, *18*(5), 736–738.

938   Glenberg, A. M. (1997). What memory is for. *The Behavioral and Brain Sciences*, *20*(1), 1-

939   19; discussion 19-55.

940   Goodale, M. A., & Milner, D. A. (1992). Separate visual pathways for perception and action.

941   *Trends in Neurosciences*, *15*(1), 20–25.

942   Hayes, A. E., Paul, M. A., Beuger, B., & Tipper, S. P. (2008). Self produced and observed

943   actions influence emotion: The roles of action fluency and eye gaze. *Psychological*

944   *Research*, *72*(4), 461–472.

945   Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative

946   Conditioning in Humans: A Meta-Analysis. *Psychological Bulletin*, *136*(3), 390–421.

947   Högden, F., Hütter, M., & Unkelbach, C. (2018). Does Evaluative Conditioning Depend on

948   Awareness? Evidence From a Continuous Flash Suppression Paradigm. *Journal of*

949   *Experimental Psychology: Learning Memory and Cognition*, *Advance on*.

950   JASP-Team. (2018). JASP (Version 0.9)[Computer software].

951   Kattner, F. (2012). Revisiting the relation between contingency awareness and attention:

952   Evaluative conditioning relies on a contingency focus. *Cognition and Emotion*, *26*(1),

953   166–175.

954   Kicinski, M. (2014). How does under-reporting of negative and inconclusive results affect

955   the false-positive rate in meta-analysis? A simulation study. *BMJ Open*, *4*(8), 1–9.

956   Kirkham, A. J., Hayes, A. E., Pawling, R., & Tipper, S. P. (2015). Facial mimicry and emotion

957   consistency: Influences of memory and context. *PLoS ONE*, *10*(12), 1–18.

958   Kirkham, N. Z., Slemmer, J. a, & Johnson, S. P. (2002). Visual statistical learning in infancy:

959   Evidence for a domain-general learning mechanism. *Cognition*, *83*, 35–42.

960   Kleiner, M., Brainard, D., & Pelli, D. (2007). What's new in Psychtoolbox-3? *Perception*,

961   *36*(ECVP Abstract Supplement).

962   Manssuer, L. R., Pawling, R., Hayes, A. E., & Tipper, S. P. (2016). The role of emotion in

963   learning trustworthiness from eye-gaze: Evidence from facial electromyography.

964   *Cognitive Neuroscience*, *7*(1–4), 82–102.

965   Manssuer, L. R., Roberts, M. V., & Tipper, S. P. (2015). The late positive potential indexes

966   a role for emotion during learning of trust from eye-gaze cues. *Social Neuroscience*,

967   *10*(6), 635–650.

968   Niedenthal, P. M. (2007). Embodying emotion. *Science*, *316*(5827), 1002–1005.

969   Nissen, M. J., & Bullemer, P. (1987). Attentional requirements of learning: Evidence from

970   performance measures. *Cognitive Psychology*, *19*(1), 1–32.

971   Pawling, R., Kirkham, A. J., Hayes, A. E., & Tipper, S. P. (2017). Incidental retrieval of prior

972   emotion mimicry. *Experimental Brain Research*, *235*(4), 1173–1184.

973   Pecchinenda, A., Bertamini, M., Makin, A. D. J., & Ruta, N. (2014). The pleasantness of visual

974   symmetry: Always, never or sometimes. *PLoS ONE*, *9*(3).

975   Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: transforming

976   numbers into movies. *Spatial Vision*.

977   Poulton, E. C. (1982). Influential companions: Effects of one strategy on another in the

978   within-subjects designs of cognitive psychology. *Psychological Bulletin*, *91*(3), 673–

979   690.

980   Quak, M., Pecher, D., & Zeelenberg, R. (2014). Effects of motor congruence on visual

981   working memory. *Attention, Perception & Psychophysics*, *76*(7), 2063–2070.

982   Reber, R., & Schwarz, N. (2006). Perceptual fluency, preference, and evolution. *Polish

983   Psychological Bulletin*, *37*(January 2006), 16–22.

984   Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of Perceptual Fluency on Affective

985   Judgments. *Psychological Science*, *9*(1), 45–48.

986   Rogers, R. D., Bayliss, A. P., Szepietowska, A., Dale, L., Reeder, L., Pizzamiglio, G., … Tipper,

987   S. P. (2014). I want to help you, but i am not sure why: Gaze-cuing induces altruistic

988   giving. *Journal of Experimental Psychology: General*, *143*(2), 763–777.

989   Rothstein, H. R., Sutton, A. J., & Borenstein, M. (Eds.). (2005). *Publication Bias in Meta-

990   Analysis: Prevention, Assessment and Adjustments*. Chichester, England: Wiley.

991   Simon, S. R. (1969). Reactions towards the source of stimulation. *Journal of Experimental

992   Psychology*, *81*, 174–176.

993   Stevanov, J., Spehar, B., Ashida, H., & Kitaoka, A. (2012). Anomalous Motion Illusion

994   Contributes to Visual Preference. *Frontiers in Psychology*, *29*.

995   Strachan, J. W. A., Kirkham, A. J., Manssuer, L. R., Over, H., & Tipper, S. P. (2017). Incidental

996   learning of trust from eye-gaze: Effects of race and facial trustworthiness. *Visual

997   *Cognition*, *25*(7–8), 802–814.

998   Tipper, S. P., Paul, M., & Hayes, A. E. (2006). Vision-for-action: the effects of object

999   property discrimination and action state on affordance compatibility effects.

1000   *Psychonomic: Bulletin & Review*, *13*(3), 493–498.

1001   Tucker, M., & Ellis, R. (1998). On the relations between seen objects and components of

1002   potential actions. *Journal of Experimental Psychology: Human Perception and*

1003   *Performance*, *24*, 830–846.

1004   Walsh, E. M., & Kiviniemi, M. T. (2014). Changing how i feel about the food: Experimentally

1005   manipulated affective associations with fruits change fruit choice behaviors. *Journal*

1006   *of Behavioral Medicine*, *37*(2), 322–331.

1007   Weidemann, G., Satkunarajah, M., & Lovibond, P. F. (2016). I Think, Therefore Eyeblink:

1008   The Importance of Contingency Awareness in Conditioning. *Psychological Science*,

1009   *27*(4), 467–475.

1010   Winkielman, P., Schwarz, N., Fazendeiro, T. a, & Reber, R. (2003). The hedonic marking of

1011   processing fluency: Implications for evaluative judgment. In J. Musch & K. C. Klauer

1012   (Eds.), *The psychology of evaluation: Affective processes in cognition and emotion.* (pp.

1013   189–217). Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

1014   Wright, D., & Bertamini, M. (2015). Aesthetic Judgements of Abstract Dynamic

1015   Configurations. *Art and Perception*, *3*(3), 283–301.

1016   Yue, X., Vessel, E. A., & Biederman, I. (2007). The neural basis of scene preferences.

1017   *NeuroReport*, *18*(6), 525–529.

1018   Zeki, S., & Stutters, J. (2012). A brain-derived metric for preferred kinetic stimuli. *Open*

1019   *Biology*, *2*(2), 120001–120001.

1020