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TITLE

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

RUNNING HEADER

Motion fluency and object preference

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KEY WORDS

Perceptual fluency; Affect; Preference; Learning; Memory

DATA AVAILABILITY

Data, assets, supplementary analysis and an additional experiment are available at https://osf.io/pjwht.

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

Perceptual processes extract information from the environment to facilitate action. Such processes have evolved to be as efficient as possible, where within a short period of time vision can identify targets and appropriate actions can begin to be evoked (e.g., Goodale & Milner, 1992; Simon, 1969; Tipper, Paul, & Hayes, 2006; Tucker & Ellis, 1998). Such highly efficient processes are necessary to enable organisms to survive in complex environments. Not only has evolution selected the most efficient perception-action systems, but fine tuning of the system continues through an organism's experiences. This fine tuning, where the most efficient processes are selected, could be supported by reinforcement, where positive affect is evoked when processing is more fluent (e.g., Reber & Schwarz, 2006; Winkielman, Schwarz, Fazendeiro, & Reber, 2003; Yue, Vessel, & Biederman, 2007). This is the principle behind the current work.

Evidence for the positive emotion associated with fluent perception and action has been obtained in a number of studies. For example, Reber, Winkielman, and Schwarz, (1998) showed that a number of perceptual properties that facilitated processing, such as contrast, priming and time of presentation, were capable of changing how much an individual liked an object. Similarly, symmetry has been shown to increases preference by facilitating processing in a variety of studies (e.g., Flavell, Tipper, & Over, 2017; Pecchinenda, Bertamini, Makin, & Ruta, 2014). In terms of action fluency, Cannon, Hayes, and Tipper (2010) observed positive emotional embodied states during fluent action and Hayes, Paul, Beuger, and Tipper (2008) demonstrated that merely observing another person's fluent actions evoked increased liking of acted upon objects. Importantly, such fluency effects can have real-world effects, as when more fluently named stocks increase in value, outperforming disfluently named stocks (e.g. Alter & Oppenheimer (2006).

This current work extends previous studies of perception-action fluency and engages with new issues. Previous work has shown that when assessing patterns of movement, some forms of motion are preferred (e.g., Stevanov, Spehar, Ashida, & Kitaoka, 2012; Wright & Bertamini, 2015; Zeki & Stutters, 2012). However, to our knowledge studies examining preference for objects' identity (rather than objects' motion) have only examined properties of static object displays. Little published research has investigated the effects of motion on object judgments in situations where the motion itself was irrelevant and not declared to be judged (i.e. where participants were only instructed to rate the object itself, rather than the motion property of the object). Motion, as a critical property of the environment, could be manipulated as a technique for shifting preference. Is it the case that the fluency and predictability of an object's motion influences an observer's judgements of the object itself?

The second issue to be engaged is whether there is learning of the association between an object's identity and its fluency of motion. In other words, does preference for an object increase/decrease following repeated exposures to that object always possessing fluent/disfluent motion? Such associative learning between an object and its motion can be considered similar to evaluative conditioning (for a review see De Houwer, Thomas, & Baeyens, 2001). That is, the neutral target property of identity can be considered as a conditioned stimulus (CS) property, while the associated pattern of fluent or disfluent movement can be considered as a positive or negative unconditioned stimulus (±UC) property.

A further issue is whether any learning of the object-motion association generalizes to other situations in which the object is not moving. That is, after repeated exposure to moving stimuli, are fluently associated objects preferred over disfluently associated objects when those objects are seen stationary with no cues to motion? Whether or not perceptual fluency effects on preference are confined to objects with their associated fluent/disfluent motion (as opposed to stationary objects) is an important issue. For broader effects where manipulated preference for stimuli can have real-world consequences, it will be necessary for fluency effects to be detected in different contexts. For example, a particular consumer product might be preferred within an experiment because it has greater movement fluency but can we demonstrate that this initial preference transfers to situations where the product may be encountered without the motion cue to fluency such as on a supermarket shelf? This generalization is clearly important for preference effects to reach beyond the laboratory setting where they may be initially demonstrated.

Therefore, in the presented experiments we aim to answer 3 questions. First, does the motion fluency of an object influence liking of that object? Second, if fluency effects exist, are object-motion associations learnt following repeated exposures or are they immediately evident following a single presentation? Finally, if fluency effects exist, do object-motion associations survive from moving to static presentations of object?

GENERAL METHODS

Elements common to each of our 8 experiments are described in General Methods. Experiments 1 to 4 feature traversing objects and are described in Part I. Experiments 5 to 8 feature rotating objects and are described in Part II. Details of each experiment are described in the relevant sections of each individual Method section.

Participants. All participants were recruited from the University of York's Department of Psychology participant recruitment system. Participants received either course credit (Department of Psychology students only) or financial compensation for participation. No participant completed more than one experiment. Participation numbers are provided in each experimental section. Exclusion criteria are described below in Data Exclusion and Analysis. Protocols were approved by the University of York's Psychology Departmental Ethics Committee and were in accord with the tenets of the Declaration of Helsinki. Participants gave written consent but were naïve to the purpose of the research until participation was complete.

Apparatus & Stimuli. Participants sat at a table in a dimmed room facing a 27" touch screen monitor (Iiyama (Tokyo, Japan) ProLite T2735MSC-B2, 1920×1080 pixels) at approximately 60 cm distance. A keyboard was positioned on the table between the participant and the screen. Participants and the keyboard response keys were position at the screen's horizontal centre (Figure 1). A PC (Dell (Round Rock, USA) XPS, Intel (R) Core (TM) i5-4430, 3 GHz CPU, 12 GB RAM, 64 bit Windows 7) generated stimuli and recorded responses. Stimuli were presented at 60 Hz in all experiments. Experimental stimuli are described later in Parts I and Part II. Image assets for each experiment are available at https://osf.io/pjwht.

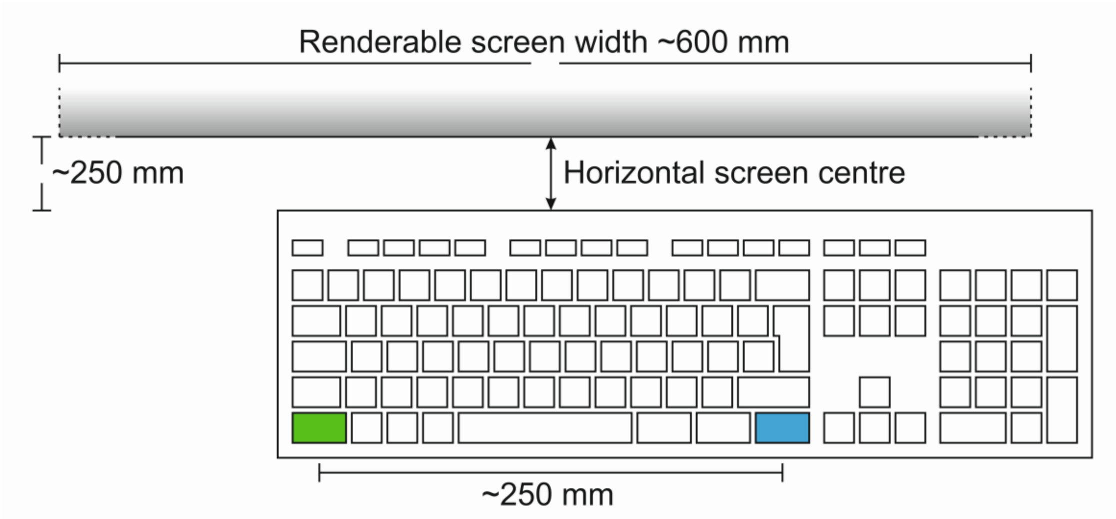

Figure 1. Schematic representation of the keyboard and screen. In response to changes in target appearance participants pressed the space bar (long lower key) in Experiments 1 to 7, or pressed left (green) and right (blue) response in Experiment 8. The control keys were coloured similarly on the actual keyboard.

Procedure. Every experiment consisted of a practice block, a task block and at least one rating block. Participants carried out a 'detection task' in the practice and task blocks with the former intended as rehearsal for the latter. The somewhat demanding detection task was to ensure that participants continuously attended to the presented objects. It required the participant to tap the space bar as soon as possible when they detected a temporary change in an object's pattern. For all experiments, the response window was the period when any portion of the changed object appearance was visible (~750 ms in Part I and 500 ms in Part II). Trials on which the object changed are referred to as 'catch trials' and those in which it didn't change are 'standard trials'. An object's changed pattern is referred to as its 'catch pattern' and its unchanged pattern is its 'standard pattern'. Participants were unaware whether the current trial was a catch until the object changed.

In the rating blocks, participants would rate each standard pattern object from the exposure block for liking. These measures of object liking were used to assess fluency effects. On a rating trial an object would be presented either as it would have appeared in the task trials or stationary in the centre of the screen (detailed in each Experiment section). The object would then disappear and there would be one second of blank screen before a 50 cm long Likert scale was presented horizontally in the centre of the screen for the participant to input their rating. The scale was a line with brackets at each end but no other demarcations. Instructions to '…rate how much you liked the object…' were presented on screen and verbally by the experimenter. Participants were told to tap the scale towards the right if they liked the object, towards the left if they didn't, with how far left or right they tapped indicating how much they did or didn't like the object. Details of all rating instructions are available at https://osf.io/pjwht.

Presentation order was randomised in every block. Participants could take short breaks before each block when the experimenter would provide instructions for the upcoming block and subsequently answer any questions. Details of practice and exposure blocks are provided in each experiment section presented later.

Data exclusion & analysis. Data were analysed using Matlab R2015a (The MathWorks Inc., Natick, USA). Participants who made errors on 25% of standard or 25% of catch trials in the task blocks were removed from the data set. An error on a standard trial is responding (pressing the space bar) at any point. An error on a catch trial is responding before or after the catch period, or failing to respond at all. Error rates are detailed in Results for each experiment section.

Liking ratings made on the Likert scale were converted to values between -100 (most extreme possible response to the left i.e. minimum liking rating) and 100 (most extreme possible response to the right i.e. maximum liking rating). Statistical tests were assessed with α of .05 throughout. The analysed liking ratings for each experiment and a brief discussion of data normality are available at https://osf.io/pjwht.

PART I: EXPERIMENTS 1 TO 4

Experiments 1 to 4 were executed using E-Prime 2.0 (Psychology Software Tools, Inc., Pittsburgh, USA). In each trial of the detection task (see Procedure earlier) an object moved across the screen either fluently or disfluently and passed behind black occluders en route (see Figure 2). Objects were scaled to fit into 60 mm square boxes.

Fluent movements were smooth and predictable whereas disfluent movements were less so in that they could make sudden direction changes whilst visible, and that it was not possible for participants to predict an object's re-emergence position following occlusion (further trajectory information and video examples of object movements are available at https://osf.io/pjwht). Object movements could be leftwards (as shown in Figure 2) or rightwards and inverted for either direction to give 4 fluent and 4 disfluent trajectories. The total movement time was always 5000 ms made up of alternating periods of visible motion (total 2500 ms) and occluded motion (total 2500 ms).

At the start of a trial, an object would appear and remain stationary for 500 ms before moving for 5000 ms. The object would remain stationary for 500 ms at the end of it's movement before disappearing. On a standard trial, the object would wear its standard pattern for the whole movement whereas, on a catch trial, the object would wear its standard pattern throughout apart from between one pair of adjacent occluders where it would wear its catch pattern (either between the first and second or between the second and third occluders; see Figure 3). The objects used are shown in Figure 4. Response errors were indicated to the participant by a short tone issued by the PC at the end of a trial.

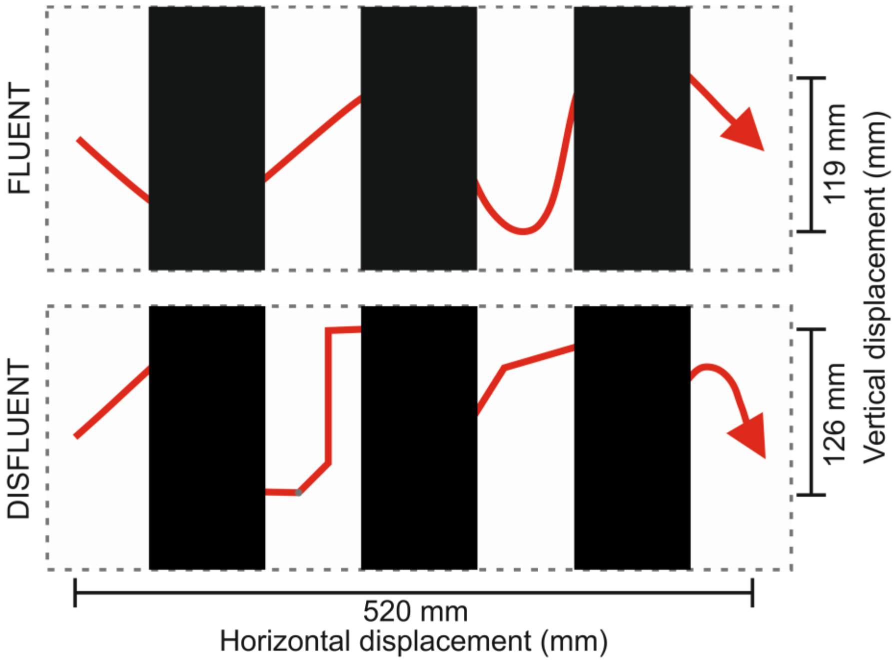

Figure 2. Schematic representations of object trajectories (red lines) in Experiments 1 to 4 in the fluent (top panel) and disfluent (bottom panel) conditions. Note that trajectory paths were not visible during the experiment and are provided here for illustrative purposes only.

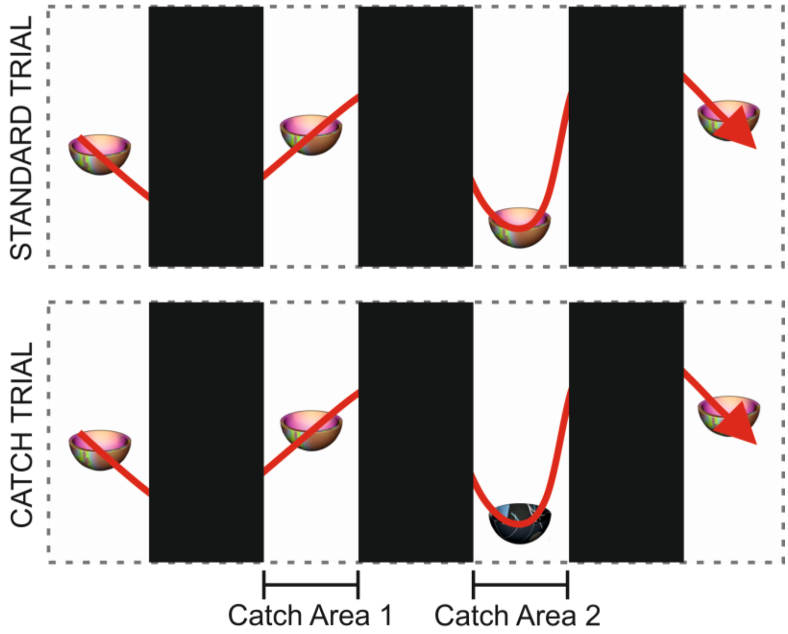

Figure 3. Schematic representations of standard and catch trials in the fluent condition. On a standard trial (top panel), the object would wear its standard pattern throughout the trial. On a catch trial (bottom panel), the object would wear its standard pattern apart from between one of two pairs of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

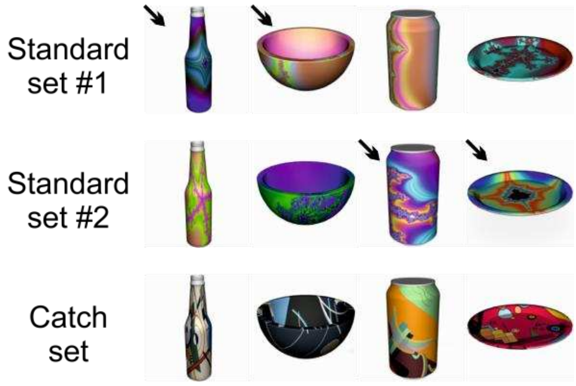

Figure 4. Standard (top two rows) and catch (bottom row) patterns for each object type in Experiments 1 to 4. Standard pattern set #1 and #2 featured in Experiments 1, 2 and 3. Only standard patterns marked with an arrow were used in Experiments 4. Participants rated only the standard pattern objects. Image assets are available at https://osf.io/pjwht

EXPERIMENT 1

The first experiment is a baseline study to verify that motion fluency does indeed influence object preference ratings.

Method. The experiment consisted of a practice block, then a task block and finally a rating block. Trials in the practice and task blocks were presented in a random order.

Objects in the practice block were a bottle, a bowl, a can and a plate, each with unique standard and catch patterns. We designed the patterned objects used throughout this article to be similar to artworks (interesting, distinctive and attractive) to ensure the object liking task had ecological validity – where everyday preference decisions are made based on such sensory properties. Two objects moved fluently (one in a standard trial and one in a catch trial) and two disfluently (one in a standard trial and one in a catch trial). Each object featured in a single trial.

The task block featured 8 objects of two standard patterns each for the bottle, bowl, can and a plate (see Figure 4). One set of standard patterns would always move fluently and the other disfluently. This was counterbalanced so that half of participants experienced standard pattern set #1 as fluent and standard pattern set #2 as disfluent, and the other half of participants experiencing the opposite pairing. Each object featured in 8 standard trials and 2 catch trials. This created 80 task trials (8 objects × 10 trials). The standard trials for a given object included two of every combination of rightwards/leftwards direction and standard/inverted orientation. The trajectory for a given object's catch trial was selected at random from the 8 possible combinations of direction, orientation and catch area (e.g. a trajectory might be rightwards, inverted and feature a catch pattern in catch area 2). Each catch trajectory was used only once for the fluent objects and once for the disfluent objects.

In the rating block, at the end of the experiment, the final exposure to each object was either fluent or disfluent as it would have been in the task block. Object assignment to a trajectory was otherwise random with the constraints that for both the fluent and disfluent sets: half of the objects moved rightwards and half leftwards, and half of each direction were inverted. Trial order in the rating block alternated between fluent and disfluent objects.

Further information on trajectory assignment in every block is available at https://osf.io/pjwht.

Determining power. A power analysis was conducted in RStudio (RStudio Team, Boston, MA) for a planned two-sided paired samples t-test with a target power of 0.8 and Cohen's *d* of 0.5. This yielded target samples of 34 but in an effort to maximise the robustness of our investigation we increased our target sample size to 40.

Participants. Forty participants were tested (6 males, age mean ± SD = 19.00 ± 1.43). No participant erred on more than 11 of 64 (mean ± SD = 1.8 ± 1.94) standard trials or on more than 4 of 16 (mean ± SD = 1.5 ± 1.0) catch trials.

Results & Discussion. The liking ratings for fluent and disfluent objects are shown in Figure 5. Note that due to technical error, two ratings were missing from different participants, one was for a fluent object rating, the other for a disfluent object rating. Due to balancing of fluent/disfluent ratings, we calculated each participant's means as normal. A two-tailed paired samples t-test indicated that liking of disfluent objects was significantly less than liking of fluent objects ($t(39) = 2.164$, $p = .037$, $d = .342$, $\Delta = 10.7$).

These results confirm our predictions concerning motion fluency and object preference, extending previous research by demonstrating that an object's motion path influences emotional responses which is reflected in the liking of that object. In Experiment 2 we seek to replicate this novel finding and investigate whether learning and memory processes mediate preference change.

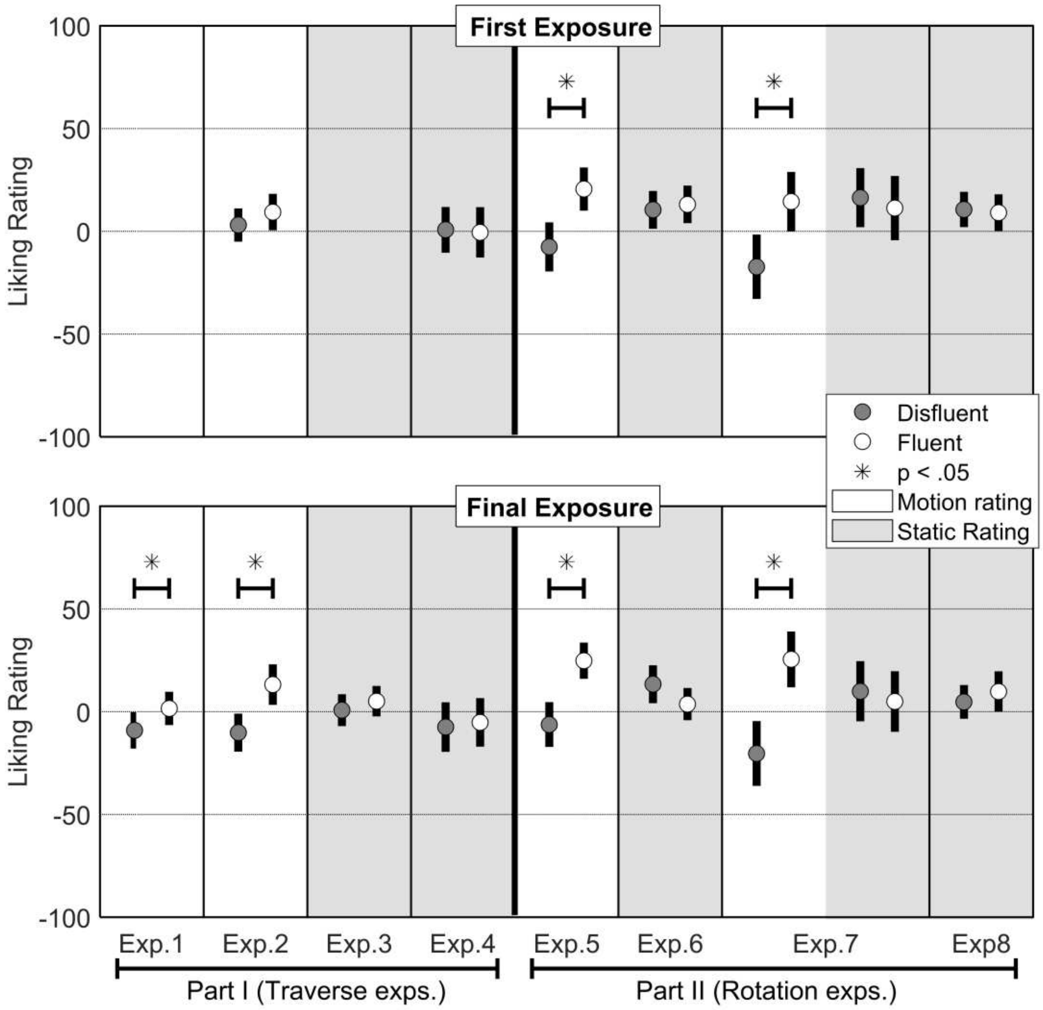

Figure 5. Mean (±95 confidence interval) for disfluent (dark grey dots) and fluent (pale grey dots) objects in each experiment. White panels indicate ratings made following exposure to moving objects and grey panels indicate ratings made following exposure to static objects. Ratings following the first 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 (*).

EXPERIMENT 2

Because motion fluency effects on object preference have not been reported previously, it is important to replicate and extend our initial finding. Although Experiment 1 confirmed that motion fluency influences participants' liking of objects, it did not indicate whether liking for an object is simply evoked by the last seen motion or instead is developed following repeated exposure to fluent/disfluent pairings of motion and object identity. In other words, it does not tell us whether there was any learning of the association of motion fluency with an object.

Therefore, Experiment 2 exactly replicates Experiment 1 except that a rating block was run at the start as well as at the end of the experiment. This provides two advantages. First, it will reveal whether a single exposure is sufficient to evoke preference for fluent objects or whether repeated exposures are necessary. Second, the contrast between the first exposure rating and the final exposure rating after 10 intervening presentations, may provide a more accurate measure of if/how preference is changed via learning. That is, whether fluent object motion increases preference, disfluent object motion reduces preference, or both (see Manssuer, Pawling, Hayes, & Tipper, 2016; Manssuer, Roberts, & Tipper, 2015; Strachan, Kirkham, Manssuer, Over, & Tipper, 2017 for similar approaches).

Method. Experiment 2 is a replication of Experiment 1 but with the addition of a first exposure rating block before the practice block.

Participants. Forty-one participants were tested. One participant failed to complete the experiment and was removed from the data set. None of the remaining participants erred on more than 5 of 64 (mean ± SD = 1.5 ± 1.4) standard trials or on more than 3 of 16 (mean ± SD = 1.3 ± 0.8) catch trials. The remaining sample consisted of 40 participants (8 male, age mean ± SD = 19.52 ± 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) = 8.307, p = .006, η = .176) and the interaction of fluency × first/final exposure (F(1,39) = 5.914, p = .020, η = .132) but not the main effect of first/final exposure (F(1,39) = 2.638, p = .112). To break down the interaction we conducted two-tailed paired samples t-tests on first and final exposure ratings.

First exposure ratings of disfluent and fluent objects did not differ significantly (t(39) = 1.368, p = .179) but final exposure ratings of disfluent objects were significantly less than those of fluent objects (t(39) = 3.133, p = .003, d = .492, Δ = 23). This indicates that the influence of motion fluency on object liking via learning of object-motion association requires more than a single exposure to disfluent/fluent motion and that it is evident following 12 exposures (2 rating exposures and 10 task exposures).

Further analysis compared liking ratings at the start of the experiment with those at the end. Note, that unlike previous similar designs (Manssuer et al., 2016; Strachan et al., 2017), we do not have a true baseline in the current study as the initial ratings possessed object fluency properties. Nevertheless, two-tailed paired samples t-tests revealed a decline in liking of disfluent objects (t(39) = 2.564, p = .014, d = .405, Δ = 13), but no change in liking of fluent objects (t(39) = 0.996, p = .325).

Finally, it should be noted that the final liking effects in Experiment 2 appear to be somewhat larger than those observed in Experiment 1 (see also Figure 5). The sole difference between these experiments is that of a first exposure rating in Experiment 2. It is possible that this prior consideration of the affective properties of objects had primed emotion/preference processes, producing more robust effects. To explore this, we compared the difference between fluent and disfluent ratings in these experiments using an independent samples t-test. There was no change in the difference between fluent and disfluent ratings from Experiment 1 to Experiment 2 ($t(78) = 1.410$, $p = .163$). Hence we cannot conclude that the effect was larger when an initial rating task was experienced by participants.

Though we have demonstrated repeated exposures are required for the association of an object identity with its motion fluency, we do not yet know whether the association survives a change in the context in which the objects are viewed. This is explored in Experiments 3 and 4.

EXPERIMENT 3

Experiment 2 provided evidence that there is learning of the association between an object's identity and the fluency of its motion. That is, after 12 exposures to an object's motion, liking of disfluently moving objects dropped significantly, resulting in a significant preference for fluently moving objects. We have shown fluency effects following repeated exposures, but it is unknown whether the association of prior motion fluency with an object's identity is robust enough to survive a change of context i.e. if the object is seen stationary rather than in motion. This critical issue of generalisation is little explored in fluency literature.

Embodied accounts of emotional memory encoding propose that visuomotor states are encoded during initial exposure to a stimulus (e.g., Niedenthal, 2007; Pawling, Kirkham, Hayes, & Tipper, 2017). That is, during episodic memory retrieval, sensory and motor neural processing states that were active at encoding are reactivated when the stimulus is encountered at a later time (e.g., Barsalou, 1999; Glenberg, 1997). In our previous experiments, the emotional reaction evoked by the fluent/disfluent motion was associated with object identity. Hence during later encounters with an object this prior embodied encoding of emotion was reactivated and influenced preference judgments.

Therefore, in the current and next experiment we explored whether prior motion fluency can influence liking of an object even when that object no longer possesses a motion property i.e. whether emotion associated with an object is activated when the object is seen stationary rather than moving.

Method. Experiment 3 is a replication of Experiment 1, with the only change being that the final exposure ratings are performed following exposure to a stationary image in the centre of the screen (i.e. lacking any fluency properties) rather than following exposure to a moving stimulus.

Participants. Forty-one participants were tested. One participant failed to complete the experiment and was removed from the data set. None of the remaining participants erred on more than 8 of 64 (mean±SD = 1.4 ± 1.6) standard trials or on more than 4 of 16 (mean ± SD = 1.4 ± 1.0) catch trials. The remaining sample consisted of 40 participants (5 male, age mean ± SD = 18.60 ± 0.67).

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.

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 encoding of the object-motion relationship and thus allow easier retrieval when objects are seen stationary.

First, Experiment 4 is modelled on that of Experiment 2 where ratings were made at the start and end of the experiment. As we noted, although not statistically reliable, there was a trend for final exposure effects to be larger in Experiment 2 than in Experiment 1. Therefore, following the possibility that prior consideration of objects in Experiment 2 might have subtly primed emotion/preference processes, we again opted to use both a first exposure and a final exposure rating in the current experiment.

The second major change concerned the number of object-motion associations (i.e. the number of unique standard objects in the experiment). Though incidental associative learning has been demonstrated for 16 (e.g. Strachan et al., 2017) and even 40 face identities (e.g. Bayliss & Tipper, 2006), it is possible that the retrieval of prior associative learning may be a limited capacity process for non-face stimuli, particularly following a change in viewing context. Indeed the number of associations is often smaller (e.g. Baeyens, Eelen, Crombez, & van den Bergh, 1992). The 8 object-motion associations in the previous 3 experiments may have stretched that capacity so in the current experiment we reduce the number of objects to 4.

The final change concerned the proportion of catch trials in the task block. Recall that catch trials were to ensure that participants had to continuously attend to the object's pattern (see Procedure earlier). In the previous 3 experiments, 20% of the task block trials were such catch trials. In the current experiment we increase this to 50%, with the aim of increasing attentional engagement with the objects and consequently increasing affect encoding.

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).

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 first/final exposure ($F(1,39) = 4.925$, $p = .032$, $\eta = .112$, mean $\Delta = 6.444$) where final exposure ratings were lower than first exposure ratings. However, there was no effect of object fluency ($F(1,39) = 0.014$, $p = .906$, $\eta < .001$), or the interaction between first/final exposure × fluency ($F(1,39) = 0.589$, $p = .448$, $\eta = .015$).

Again we found no evidence of fluency effects in ratings of static objects following repeated exposures to each object's motion. This failure to detect an effect has now been observed in 2 experiments, the latter of which employed a variety of manipulations aimed at making the experiment more sensitive. Therefore, we are confident that the fluency effects imparted by our current stimuli do not survive a change from moving to static contexts.

However, although we demonstrate that objects that move fluently are preferred over those that move disfluently in both Experiments 1 and 2, it is possible that our motion fluency manipulation has a rather weak effect on emotional responses to a moving object. Thus it may be the case that these weak effects cannot be retrieved when transferred to static objects. Hence, in Part II we present a final set of experiments for which we developed much more compelling motion fluency manipulations. We predict that these new movements will produce stronger associations between an object's identity and its repeated pattern of fluent/disfluent movement. Furthermore, to facilitate such associative learning via a small number of associations, we again used only 4 objects. In Part II, we first explore the effectiveness of these new motions before again attempting to reveal motion fluency preference effects from stationary objects.

PART II: EXPERIMENTS 5 TO 8

Experiments 5 to 8 were executed using custom scripts and Psychtoolbox 3.0.11 (Brainard, 1997; Kleiner, Brainard, & Pelli, 2007; Pelli, 1997) operating within Matlab R2015a (The MathWorks Inc., Natick, USA). The block protocol for experiments in Part II was the same as that for Experiment 4 in Part I: a first exposure rating block, a practice block, a task block, and lastly a final exposure rating block. The principle difference between Part I and Part II was the object movement. Rather than traversing across the screen, objects remained in the centre of the screen and changed size while rotating.

On trials in which an object moved, it would appear in the centre of screen and remain stationary for 500 ms before moving for 2500 ms. The object would remain stationary for 500 ms at the end of it's movement before disappearing. Objects could either expand or contract, and rotated either clockwise or anti-clockwise resulting in four possible movements. Fluent movements were a constant rate of change of size and rotation (see the top panel in Figure 6). Disfluent movements were generated by dividing a fluent movement into 5 equal length sections and then reordering them from [1-2-3-4-5] to [1-4-3-2-5] (see bottom panel Figure 6). Further trajectory information and video examples of object movements are available at https://osf.io/pjwht.

The objects used in the following experiments were a geometric shapes (see Figure 7) to avoid implications of appropriate orientation and to more easily control displayed object size. Just as in Part I, each object contained art patterns to provide validity for the preference judgment task.

At the moment of appearance, an expanding object's area was 900 mm^2, and for a contracting object it was 14400 mm^2. The final area was always 5625 mm^2. For example, the length of one side of an expanding square would change from 30 mm to 75 mm, and the length of one side of a contracting square would change from 120 mm to 75 mm. Just as the final area of all objects was the same, the final orientation was too. All objects rotated by 90° to the orientation shown in Figure 7 by the end of their movement.

The participants' role in the detection task (practice and task blocks) was the same as Part I – press the space bar when the object's appearance changed. However, instead of changing to a different pattern, objects would turn greyscale as shown in Figure 7. On standard trials an object would wear its standard pattern throughout whereas on catch trials the object would wear its standard pattern apart from in either block 2 or block 4 of the movement (see Figure 6) where it would wear its catch pattern. Participants were not aware of catch trials until the object changed appearance.

Response errors (responding on standard trials, and failing to respond or responding too early/late on catch trials) were indicated to the participant by a red screen border from the moment of the error to 1500 ms after the object had disappeared. Correct responses (pressing at the appropriate time on a catch trial or not pressing on a standard trial) were indicated to the participant by a green screen border from the moment of success to 1500 ms after the object had disappeared.

Just as in the Part I, during the object rating tasks, participants were asked to assess how much they liked the object they saw. Object motion was never mentioned in relation to rating. This meant that the focus of this task was on the object properties of shape and pattern rather than with the object's motion, which was an irrelevant background factor.

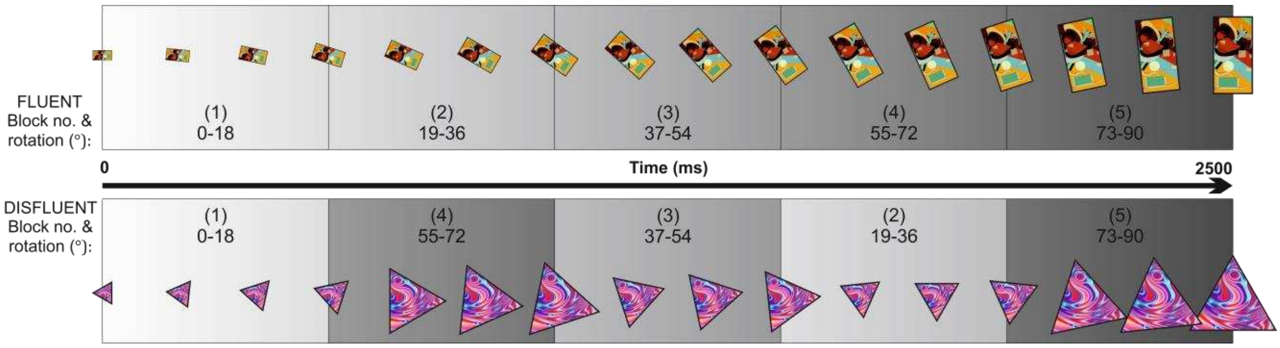

Figure 6. Schematic representations of object movements in experiments 5, 6 and 7 in the fluent (top panel) and disfluent (bottom panel) conditions. Note that the background colour in the experiments was a constant grey. In this figure the background varies to highlight the reordered sections in the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

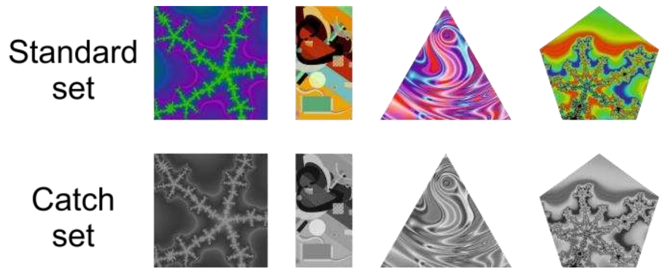

Figure 7. Standard (top row) and catch (bottom row) patterns for objects in experiments 5, 6 and 7. Participants rated only the standard patterns. Image assets are available at https://osf.io/pjwht

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 following exposure to these new motions (current experiment) before testing whether the fluency effects evoked by our new motions are sufficient to survive a change in context (next experiment).

Method. Participants completed a first exposure rating block, practice block, task block and a final exposure rating block as in Experiments 2 and 4. Four objects were used (see Figure 7). Even numbered participants experienced the square and pentagon as fluent and the triangle and rectangle as disfluent (vice versa for odd numbered participants). This was true for the practice and exposure blocks.

In the practice block, one fluent object and one disfluent object featured in catch trials with the other two in standard trials (4 practice trials in total).

In the task block, each object featured in 16 trials (total 64 trials). Of those, 8 were standard trials and 8 were catch trials. Half of each trial type expanded (the others contracted) and half of those rotated clockwise (the others rotated anti-clockwise). This meant that each object and trial type appeared the same number of times in each movement.

In each rating block, every object was rated after being seen to move in its assigned way (either fluently or disfluently). Movements in this block were always clockwise and expanding.

Trial presentation was randomised by participant for every block. Further information on trial assignment is available at https://osf.io/pjwht.

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 ($F(1,39) = 16.94$, $p < .001$, $\eta = .303$) where fluent objects were preferred over disfluent objects (mean $\Delta = 29.602$). There was no effect of first/final exposure ($F(1,39) = .913$, $p = .345$, $\eta = .023$) or of the interaction between fluency × first/final exposure ($F(1,39) = 0.297$, $p = .589$, $\eta = .008$).

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 ($d = .691$, $\Delta = 31.1$, [derived from a two sample t-test]) than in Experiment 1 ($d = .342$, $\Delta = 11$) or Experiment 2 ($d = .492$, $\Delta = 23$). 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

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

Ratings of disfluent and fluent objects did not differ significantly at the first ($t(39) = .429$, $p = .671$) or final ($t(39) = 1.515$, $p = .138$) exposures. There was no change in the liking ratings of disfluent objects ($t(39) = 1.055$, $p = .298$) but there was a significant decrease in liking of fluent objects ($t(39) = 3.055$ $p = .004$, $d = .483$, $\Delta = 9$).

The interaction was thus driven by a decline between first and final liking ratings for objects associated with fluent motion. This is an unexpected result that we have not observed before and that is opposite to our apriori predictions. However, most importantly for our hypothesis concerning learned associations between patterns of motion and object liking, in ratings at the end of the experiment there was no difference in preference for static objects that had previously been viewed moving fluently or disfluently.

The current experiment was a stronger test of fluency effect survival following context change than those in Part I due to the potency of the new object motions. However, we have again failed to detect fluency effects while judging static objects for preference. Nevertheless, we felt it worthwhile to further replicate and extend our findings in a further experiment.

Thus far our contrasts between assessing moving versus static objects have been between participants in separate experiments. It is possible that requiring people to assess both moving and static objects for liking within the same experiment might increase sensitivity to the latter (see Poulton (1982), for influential companion effects). Indeed, we found a trend for larger fluency effects in Experiment 2 than in Experiment 1 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 ($F(1,39) = 9.143$, $p = .004$, $\eta = .190$) but not first/final exposure ($F(1,39) = .129$, $p = .722$, $\eta = .003$) or motion/static rating

($F(1,39) = 2.363$, $p = .132$, $\eta = .057$). There was a significant interaction between fluency × motion/static rating ($F(1,39) = 8.303$, $p = .006$, $\eta = .176$). There were no interactions between first/final exposure × fluency ($F(1,39) = 2.056$, $p = .160$, $\eta = .050$), first/final exposure × motion/static rating ($F(1,39) = 3.342$, $p = .075$, $\eta = .079$) or between first/final exposure × fluency × motion/static rating ($F(1,39) = 1.567$, $p = .218$, $\eta = .039$). To breakdown the fluency × motion/static rating interaction we carried out separate 2 × 2 repeated measures ANOVAs on liking ratings made of moving objects and on liking ratings made of static objects.

Replicating the results of Experiment 5, when objects were seen moving during ratings, the ANOVA indicated a highly significant main effect of fluency ($F(1,39) = 17.842$, $p < .001$, $\eta = .314$), but no main effect of first/final exposure ($F(1,39) = .720$, $p = .401$, $\eta = .018$). Interestingly, the interaction between first/final exposure and object fluency ($F(1,39) = 4.505$, $p = .040$, $\eta = .104$), was significant, as observed in Experiment 2, suggesting a role for learning in these object-motion association processes. However, even though the fluency effect was smaller at the start of the experiment, nevertheless the effect was significant at the first ($t(39) = 3.473$, $p = .001$, $d = .549$, $\Delta = 32$) and final ($t(39) = 4.426$, $p = .001$, $d = 0.670$, $\Delta = 46$) exposures. Further analysis indicated no change in ratings of disfluent objects ($t(39) = .500$, $p = .620$) but an increase in ratings of fluent objects between the first and final exposure ($t(39) = 2.068$, $p = .044$, $r = .330$, $\Delta = 11$).

In contrast, and again replicating our prior results (Experiment 6) the analysis of ratings of static objects detected no main effect of fluency ($F(1,39) = .272$, $p = .605$), no main effect first/final exposure ($F(1,39) = 2.452$, $p = .125$) and no interaction between first/final exposure and fluency ($F(1,39) < 0.001$, $p = .992$).

Therefore, this final experiment again confirms our findings of clear effects of visuomotor fluency on liking when assessing moving objects, but when the objects are static no preference effects can be detected.

We have been surprised by the consistent failure to detect fluency effects when assessing static objects. Associative learning/evaluative conditioning would have predicted that such effects exist due to the CS of object identity being repeatedly associated with the US± of motion fluency. Two reviewers suggested that the apparent lack of association may be due to object identity being ignored. This could be because the detection of, and response to, object appearance change is a somewhat low-level transient signal that potentially results in a low-level of engagement, shallow encoding and, consequently, weaker memories (e.g., the levels of processing theory of Craik & Lockhart, 1972). Weak/absent associations between affect induced by motion and the object identity may mean that participants are primarily influenced by the currently observed motion (or lack of) when rating objects.

With this in mind, we designed a new experiment (Experiment 8) in which we endeavoured to engage participants more directly with target appearance. Participants were required to actively attend to and identify each object as this determines which key press response would be appropriate if the target pattern changed to greyscale.

EXPERIMENT 8

In Experiments 5, 6 and 7 fluency effects were apparent when objects were rated following a moving presentation but not when they were rated following a static presentation. In Experiment 8 we attempted once more to elicit preference for fluent motion in a static rating condition by increasing participant engagement with target shape/pattern. Experiment 8 is replication Experiment 6 but rather than tapping the space bar when the object turned to greyscale, participants were required to tap either the left control key for one fluent and one disfluent object, or the right control key for the other fluent and disfluent objects. This would require explicit encoding of object-shape and rapid detection of object-pattern change to produce the appropriate key-press response.

Method. Experiment 8 is a replication of Experiment 6 (static object presentation for ratings) with changes to the response key used in the task and practice blocks, the composition of the practice block, and the object-condition assignments.

In all of our previous experiments, participants were required to press the space bar when they detected a change in target appearance. However, in the current experiment participants were instead required to press either the left or right control keys depending on the presented object (see Figure 1). The left control key was covered with a green sticker and the right with a blue sticker (referred to henceforth and in the experiment as the green and blue keys). Four versions of the experiment were run to counterbalance fluency and key assignment for each object (details at https://osf.io/pjwht).

This new two-key task was much more demanding than the one-key task of previous experiments so three practice blocks were run to slowly introduce object-key assignments rather than the single block used in all previous experiments. The first practice block included only the two objects assigned to the green key and the second practice block included only the two objects assigned to the blue key. The third practice block included all four objects. Every object in each practice block featured in one standard and one catch trial to yield 4 trials each in blocks 1 and 2, and 8 trials in block 3. Each of these blocks began with instructions given verbally by the experimenter and presented on the screen. The objects in the upcoming trials along with their assigned colour key were also shown on the screen. Verbal and displayed reminders of key assignments were also given before the task block. Reminders would also be displayed after a trial if the participants made a response error on that trial. Examples of instructions and reminders are available at https://osf.io/pjwht.

Participants. Forty-two participants were tested. Two participants exceeded the error threshold for catch trials by failing to respond on 9 and 10 of 16 catch trials. They were removed from the data set. None of the remaining participants erred on more than 1 of 32 (mean ± SD = 0.15 ± 0.36) standard trials or on more than 8 of 32 (mean ± SD = 2.75 ± 2.18) catch trials. The remaining sample consisted of 40 participants (13 male, age mean ± SD = 20. 26 ± 3.25, one participant did not disclose their age).

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) = .075, p = .785, η = .002), or first/final exposure (F(1,39) = .953, p = .335, η = .024), or the interaction between fluency × first/final exposure (F(1,39) = 1.696, p = .200, η = .042).

This experiment has again failed to detect the fluency effects when rated objects are presented stationary. This is surprising as we felt that the much deeper encoding resulting from attention focused on both the object's shape identity and it's pattern throughout the experiment would result in stronger memories for affect induced by experience, which in turn would influence assessments of static objects (e.g., Craik & Lockhart, 1972).

The results of all our previous experiments using static objects (Experiments 3, 4, 6, 7 and 8) challenge, to some extent, the idea that associative learning is an automatic process that takes place in all situations. There certainly appear to be limits in the context of perceptual fluency effects on liking.

FURTHER ANALYSIS

Cross-experiment analysis. We performed two additional analyses on the combined final exposure ratings from the 4 experiments where moving objects were assessed (Experiments 1, 2, 5 & 7) and from the 5 experiments where static objects were assessed (Experiments 3, 4, 6, 7 & 8). These were 2-way repeated measures ANOVAs with a between-subjects factor of experiment and provided high levels of power (160 participants for moving assessments and 200 participants for static assessments) to assess the fluency effects following presentation of moving and static objects.

The analyses confirmed all of our previous findings on fluency effects. Objects that moved fluently were preferred over disfluent objects when ratings followed a moving presentation ($F(1,156) = 51.631$, $p < .001$, $\eta = .249$) but not when they followed a static presentation ($F(1,195) = .038$, $p = .845$). For the moving rating analysis, there was also an interaction between fluency and experiment ($F(3,156) = 3.614$, $p = .015$, $\eta = .065$) which likely resulted from the greater efficacy of object motions in Part II of the study. There was no interaction between fluency and experiment in the static rating analysis ($F(4,195)$

= .926, *p* = .450). The mean liking ratings for fluent and disfluent objects from all experiments are shown in Figure 8.

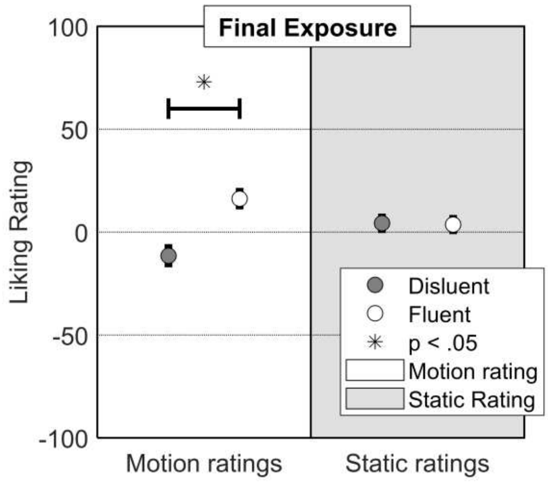

Figure 8. Mean (±95 confidence interval) for final exposure disfluent (dark grey dots) and fluent (pale grey dots) object ratings in all experiments. White panels indicate ratings made following exposure to moving objects and grey panels indicate ratings made following exposure to static objects. Significant differences (p < .05) between fluency conditions are indicated with an asterix (*).

Bayesian analysis. Following discussions with reviewers we also ran Bayesian analyses on the aggregate data described above using JASP v0.9.0.1 (JASP-Team, 2018). The Bayesian 2-way repeated measure ANOVA (between-subjects factor of experiment) strongly suggest that presentation of an object in motion influences rating (BF_{10} = 1.160e+10, $p(H_1|Data) > .999$) and that presentation of a stationary object does not influence rating (BF_{10} = .112, $p(H_1|Data) = .101$). These models and Bayesian paired samples t-tests (which also support our conclusions) are available at https://osf.io/pjwht.

GENERAL DISCUSSION

In a series of 8 experiments we investigated three questions: (1) does motion fluency influence object liking?; (2) are object-motion associations learnt following repeated exposures?; and (3) do object-motion associations transfer from moving to static presentations of objects? Before commenting on possible mechanisms and future directions we first provide brief answers to these questions.

First, in Experiments 1, 2, 5 and 7 we demonstrated that liking of objects is influenced by the motion patterns associated with them: when objects move disfluently (unpredictable movement) they are liked less than objects that move more fluently (predictable movements).

Second, the association between an object's identity and its pattern of motion (fluent or disfluent) can, to some extent, be learned. In Experiment 2 liking ratings did not differ between fluently and disfluently moving objects after one presentation but they did following repeated presentations. And, in Experiment 7, the learned fluency effect was larger after repeated exposures to the moving objects. Of course the interaction was not observed in Experiment 5, so whilst associative learning of motion fluency can occur, with sufficiently powerful stimulus motions it may not always be necessary since ceiling effects can be reached immediately.

Finally, and most surprisingly, the association between an object's identity and the affect evoked by its motion fluency did not transfer to situations where that object was no longer moving. The lack of effect when rating static objects for liking was observed in Experiments 3, 4, 6, 7 & 8 (n = 40 in each) and in the combined analysis (n = 200) on those data. In our attempts to detect transfer from moving to static displays we have tested: reducing numbers of objects to alleviate cognitive load; increasing proportions of catch trials to encourage engagement with objects; using highly potent object motions that were shown to yield fluency effects even following a single moving presentation; and modifying the response task to encourage deeper levels of encoding.

Our initial prediction that learning of visuomotor properties would influence object preference judgements, even when context changed, was motivated by embodied or grounded accounts of cognition. In these, memory consists of visuomotor information from different modalities in distributed systems and when encountering an object at a later time, such visuomotor properties are retrieved (e.g., Barsalou, 2008; Glenberg, 1997). We expected such learning and retrieval to take place and that this would lead to evocation/retrieval of motion evoked affect. However, this consistently appeared not to be the case in our experiments. It is important to note that we are not questioning such embodied/grounded accounts of cognition, and indeed we have previously provided evidence for such learning and retrieval processes (e.g., Pawling et al., 2017; Rogers et al., 2014). Rather, our current results, and those of Canits et al. (2018) and Quak et al. (2014) who also failed to show any effects of action fluency on later retrieval from memory, provide important boundary conditions where visuomotor fluency when processing objects may not always influence processing when later encountering an object in a different context.

As noted previously, our task is a form of evaluative conditioning. In such tasks a neutral conditioned stimulus (CS, e.g. an apple), when associated with a positive unconditioned stimulus (US, e.g. a pleasant background), takes on positive properties and is liked more subsequently. Such associations can develop following a small number of pairings (e.g., 6) and may go unnoticed by participants (e.g. Walsh and Kiviniemi, 2014). As typical in associative learning tasks, in our tasks participants were not explicitly instructed to learn the object-motion associations but they nevertheless had to continuously and carefully attend to the objects (to achieve the detection task) which may have facilitated learning. Furthermore, that the CS (object identity) and US± (fluent/disfluent motion) were elements of the same object might also be assumed to facilitate learning of the association between CS and US. We expected evaluative conditioning be the mechanism of association between objects and affect in our experiments. Indeed, Experiments 2 and 7 provide some evidence for such associative learning, in that the liking effects were larger after repeated exposures to the CS-US pairings

Statistical learning might be the way in which participants learn object-motion associations. Statistical leaning is, broadly speaking, a general mechanism that operates by mere-exposure to extract structure from the environment. In this way, specific environment properties that are to be learned do not need attention and awareness directed towards them. Rather spatial and temporal structures are extracted incidentally. This learning process is general, being observed across species, development and domains (see Aslin and Newport (2012) for review). Of particularly relevance for the current work, temporal (N. Z. Kirkham, Slemmer, & Johnson, 2002; Nissen & Bullemer, 1987) and spatial regularities (Fiser & Aslin, 2001) embedded in a scene can be extracted in this way. In our tasks, participants continuously attended to objects to detect occasional brief pattern changes and, whilst irrelevant to that task, a given object's motion was consistently either fluent or disfluent. So similar to the studies above, statistical learning that an object is always associated with a particular fluent/disfluent motion property would be incidental. It should be noted that these incidental learning studies show improved performance <u>within</u> the task. We have investigated such within task effects (moving rating experiments) and, in sharp contrast, investigated whether fluency effects might generalize to different contexts (stationary rating experiments). Whilst retrieval within-task contexts appear to be robust and may even show learning after a single trial, we consistently found that generalization may not always be possible. In other words, retrieval might be context dependent.

This failure to detect retrieval of associations when static objects were assessed would appear to be an important boundary condition for the learning of visuomotor fluency effects on preference. And indeed it is in agreement with some recent challenges to the idea that associative learning is automatic and often not accessible to awareness. For example, (Högden, Hütter, & Unkelbach, 2018) recently examined the classic eye-blink conditioning studies. They demonstrated that such conditioning only takes place when participants are initially informed that one CS predicts the air-puff and they can explicitly report the contingencies. Furthermore, the role of explicit awareness of contingencies in evaluative conditioning has also been noted (e.g., Högden et al., (2017) and Kattner (2012); also see Hofmann, De Houwer, Perugini, Baeyens, & Crombez (2010) for meta-analysis review and Weidemann, Satkunarajah, & Lovibond (2016).

Although somewhat tangential, there have been recent debates concerning positive publication bias in psychology (e.g., Kicinski, 2014; Rothstein, Sutton, & Borenstein, 2005), where experiments that produce null results are not always published (i.e., the 'file drawer' problem). However, we feel that demonstrating where effects are no longer detected provides critical boundary conditions to understanding the underlying mechanisms in many cognitive systems. In the current research programme, our initial assumptions, based on embodied memory and evaluative conditioning theories and our own previous empirical work, were that there would be learning of prior associations between an object's identity and its repeated pattern of motion, and that this would generalize to other situations (i.e., static displays). That such effects were never detected in a series of 5 experiments with a variety of approaches makes clear that our predictions were not supported.

This lack of transfer from moving to static displays has important practical implications. For example, it might be possible to bias liking of consumer products or a food type by manipulating patterns of motion in advertising or, to generate greater user engagement, a computer game. However, it is critical that such preferences are robust enough to be detected in a different context for effective behaviour change. For example, imagine trying to increase a child's consumption of fruit relative to some other food they like equally well. In a game, fruit would be continuously paired with fluent movement and the other food with disfluent movement. Our results show that fruit would be preferred within the game but that outside of the game (i.e. out of context, perhaps at the dinner table) this is unlikely to be the case.

In summary, our current results suggest that visuomotor fluency could be highly effective in changing preference but that more work is needed to establish preference in contexts other than those in which fluency associations are learnt. Our future research, such as further investigating the role of levels of processing (e.g. Craik & Lockhart, 1972) and combining different forms of fluency, will continue to seek techniques that enable visuomotor fluency to influence preference more broadly.

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