Aesthetic Judgements of Abstract Dynamic Configurations

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Abstract

To date, aesthetic preference for abstract patterns has mainly been examined in the relation to static stimuli. However, dynamic art forms (e.g., motion pictures, kinetic art) are arguably more powerful in producing emotional responses. To start the exploration of aesthetic preferences for dynamic stimuli (stripped of meaning and context) we conducted four experiments. Symmetrical or random configurations were created. Each line element had a local rotation, and the whole configuration also underwent a global transformation (horizontal translation, rotation, expansion, horizontal shear). Participants provided explicit preference ratings for these patterns. As expected results showed a preference for dynamic symmetrical patterns over random. When global transformations were compared, expansion was the preferred dynamic transformation whilst participants liked the horizontal shear transformation the least. Overall, these results show that preference for symmetry persists and is enhanced for dynamic stimuli, and that there are systematic preferences for global transformations.

Keywords

Aesthetics, symmetry, visual preference, regularity, transformations, motion

1. Introduction

Dynamic stimuli can be very powerful in directing our attention and also in generating emotional responses. In this study, we explore what happens when the study of preference for abstract patterns is extended from static stimuli to moving configurations. We start by using symmetrical and random patterns, which are known to be differentially rated in terms of aesthetic judgements. To these patterns we add both a local motion of each element (a local rotation) and a global motion based on a transformation. In the next session we briefly review some of what is known about preference for symmetry.

1.1. Symmetry

Symmetry is prevalent in the world around us and evidence suggests that people have a preference for it. This has been observed in both the aesthetic appreciation of art (Arnheim, 1974; Washburn and Crowe, 1988) in the attractiveness of the human body (Cardenas and

Harris, 2006; Rhodes *et al*., 1998) and in rating of abstract stimuli (Bertamini *et al*., 2013a; Jacobsen and Höfel, 2002). Moreover, a preference for symmetry emerges in infants as young as four months old (Humphrey and Humphrey, 1989).

As symmetry can be processed efficiently (Barlow and Reeves, 1979) it has been described to be a good Gestalt (Koffka, 1935) and as one of the fundamental principles in aesthetics (Ramachandran and Hirstein, 1999). One explanation for the preference for symmetry is processing fluency. The fluency account proposes that efficient perceptual processing increases our preference towards that particular stimulus (Reber *et al*., 2004; Winkielman and Cacioppo, 2001). However, measuring ease of processing is not easy and other theories have suggested that preference may be generated by complex and challenging stimuli (Muth and Carbon, 2013), through previous exposure (Zajonc, 1968) or those that are most typical of their stimulus category (Halberstadt, 2006).

Preference for symmetry is typically studied using static stimuli either familiar like faces or abstract. However, kinetic art has been a major art movement since the 1950s and examines how things look when they move. Currently, little investigation has taken place into preference for dynamic abstract patterns. Previous research has mainly looked at preference to dynamic stimuli in the context of biological motion in both humans and animals (Daprati *et al*., 2009; Simion *et al*., 2008; Vallortigara *et al*., 2005). Cazzato *et al*. (2012) showed that moving (e.g., walking, running) body postures were liked more than static ones regardless of body shape size.

Some biological motions such as dance often contain symmetrical elements with these sequences liked more than asymmetrical ones (Brown *et al*., 2005; Orgs *et al*., 2013). Brown *et al*. (2005) found that there was a positive association between symmetrical dancing and liking. Participants watched clips of males dancing, with the more symmetrical dances being the most preferred. The amount of dynamic motion can also impact on aesthetic preference and beauty. Torrents *et al*. (2013) found that amplitude of movement was related to beauty. As part of an fMRI study, Calvo-Merino *et al*. (2008) found that participants preferred dance movements, which involved movement of the whole body with vertical displacement/jumping. Dance movements that were least preferred were those that involved simple single movements such as movements restricted to single limb movements, those without vertical changes and movement without significant movement of the torso.

1.2. Neural Activity to Dynamic Abstract Stimuli

Preference for abstract moving patterns produces activity in areas related to the experience of beauty. Zeki and Stutters (2012) examined the relationship between the preference for dot patterns in motion and activity in visual areas. All of the motion patterns produced activity in V1, V2, V3 and V5. However, increased neural activity positively correlated with aesthetic preference, as the kinetic patterns that were more preferred produced greater activity in V5 (MT+), V3 complex, parietal areas and field A1 in the medial orbito-frontal cortex (mOFC). The mOFC, although not involved in motion, has been reported to correlate with the experience of beauty (Ishizu and Zeki, 2011). Therefore not only can simple kinetic stimuli produce aesthetic responses, but the strength of these judgements can be related to neural activity.

With respect to global versus local processing of motion, it is known that in areas MT and MST there are cells selective for coherent expansion, rotation, or translation of dot patterns (Snowden et al., 1992; Tanaka et al., 1989), and that the channels responsible for responding to these types of transformations are independent (Freeman and Harris, 1992).

1.3. Summary of Experiments

We report a series of exploratory experiments to examine preference for dynamic stimuli. Alongside artworks, there are examples in everyday life of beauty being found in dynamic abstract stimuli many of which contain symmetry. For example, many screensavers consist of colourful patterns moving around the screen in various ways (Taylor and Sprott, 2008) whilst most people have an appreciation for the beauty of firework displays. To our knowledge, this is the first study of aesthetic preference for dynamic symmetrical patterns. We expect that the symmetrical patterns will be preferred to the random patterns. Symmetry is a good predictor of preference for abstract, geometrical patterns (Cardenas and Harris, 2006; Eisenman, 1967; Eysenk, 1941; Frith and Nias, 1974; Jacobsen and Höfel, 2002). Bilateral symmetry (reflection) is the most salient especially for a vertical axis and it is the easiest to be detected (Barlow and Reeves, 1979; Bertamini *et al*., 1997; for a review, see Wagemans, 1995, 1997).

We wanted our configurations to be as salient as possible, as this would help to keep participants interested whilst they viewed the stimuli. Our configurations had both vertical and horizontal axes of reflection, as double symmetry is more salient compared to single axis vertical symmetry (Palmer and Hemenway, 1978; Royer, 1981; Wagemans *et al*., 1991). We chose coloured line elements as along with symmetry, colour is considered important in aesthetic appreciation (Maffei and Fiorentini, 1995; Martindale and Moore, 1988) and adds interest and intensity to the configurations. Warm and cool colours were used in order to reduce the connotations that may have been attached to using a single colour. Furthermore, having our patterns consisting of line segments allowed us to have both global and local transformations, again increasing the saliency of the configurations and maximizing their dynamic behaviour.

In relation to the different transformations, it is expected that the more dynamic patterns will be preferred to those patterns that are less dynamic. Specifically we compared the following cases: no transformation (static), rotation, horizontal translation, horizontal shear, and expansion/contraction. These transformations were selected for two reasons. Firstly, they are all composites of affine transformations. In geometry, affine transformations map each point (x, y) in one space to a point in another (Snapper and Troyer, 1971). They map straight lines to straight lines and preserve collinearity and ratios of distance along straight lines (Silvester, 2001). However, they do not necessarily preserve angles and lengths. Shear occurs when either the x or y coordinates increase linearly. Rotation rotates each point in the plane about the origin by a specified amount. Translation moves each x and y point by a certain amount in the plane and expansion multiplies each point by a fixed amount.

Secondly, these transformations have previously been examined in terms of psychophysics (Bertamini and Proffitt, 2000) and neurophysiology (Tanaka *et al*., 1989; Snowden *et al*., 1992). These transformations consist of the elementary motion types and as such are involved in optical flow (Koenderink, 1986). Translation and rotation along the parallel plane to the observer provide in-plane motion whilst expansion/contraction and shear simulate in depth motion. The visual system seems to be particularly tuned to processing these motions. Evidence has shown that there are specialized detectors for radial, rotation and translation motions (Freeman and Harris, 1992; Morrone *et al*., 1995; Snowden and Milne, 1997). Many of the neurons located within the MT and the MST are direction-selective (Saito *et al*., 1986), with cells with large receptive fields tuned to expansion, rotation and translation motion (Duffy, 1998; Tanaka and Saito, 1989).

These global transformations are also similar to Glass patterns (Glass, 1969). Glass patterns are randomly placed pairs of dots presented along a common path and tend to be radial, hyperbolic or parallel. These stimuli could be considered static counterparts of the dynamic stimuli we present participants. Threshold detection of glass patterns has shown that concentric patterns produced the lowest thresholds, followed by radial and hyperbolic, with parallel producing the highest. Glass patterns are generally presented static although implied motion can be induced through sequential presentation of the patterns (Ross *et al*., 2000). Glass patterns have been extensively used to study global form perception, although an aesthetic preference to these particular stimuli has not been examined.

In Experiment 1 we presented symmetrical and random patterns with five different dynamic transformations (static, expansion/contraction, rotation, horizontal shear, and horizontal translation). The total time of the presentation was either 12 s or 9.5 s. This variation in speed allowed us to examine the affect of speed on aesthetic preference. In Experiment 2 we introduced a completely static pattern in which there was no global or local motion. To distinguish it from the static condition, we use the label 'still'. In this experiment we decreased the time that the patterns were presented to 7.2 s. For Experiment 3, the same transformations were used but the configurations moved in a single direction (no cycles). Our choice of presentation times was dependent on the software used, the processing speed of the computer, and the screen refresh rate. As a consequence we were unable to have a simple linear reduction in duration across our three experiments.

2. Experiment 1

2.1. Method

2.1.1, Participants

Sixteen participants took part in the study (15 females; 14 right handed; mean age 19). Participants had normal or corrected-to-normal vision and some received course credit upon completion of the study. The study was approved by the Ethics Committee of the University of Liverpool and conducted in accordance with the Declaration of Helsinki (revised 2008).

2.1.2. Apparatus

Observers were seated approximately 57 cm from the monitor in a dark and quiet room. The presentation was controlled using some of the PsychoPy libraries (Peirce, 2007) with stimuli presented on a CRT monitor (resolution 1280 × 1024; 75 Hz) run by a Macintosh computer. Refresh rate was set at 75 Hz for the 12-s presentation trials and 85Hz for the 9.5-s presentations.

2.1.3. Design

The study had two within-subjects factors [regularity (symmetry, random)] × transformation (expansion/contraction, horizontal shear, rotation, horizontal translation, static) with 9 trials per condition for a total of 90 trials. Presentation time was a between-subjects factor (12 s, 9.5 s). The trials were presented in a randomised sequence for each participant.

2.1.4. Stimuli

Four global transformations (expansion/contraction, rotation, horizontal shear and horizontal translation) were used as well a transformation that only had local motion (static; see Fig. 1). Each pattern consisted of 32 elements that produced either a symmetrical or a random pattern that were presented on screen for 180 frames lasting either 12 s or 9.5 s. Each display consisted of a black background with the colour of the individual pattern elements randomly varying between 0 and 1 on the RGB spectrum. Each individual element of the pattern rotated 180 degrees.

Each pattern started and finished in the centre of the screen in a spherical area with a radius of 6.3º. The movement of the dynamic configurations were constrained to a spherical area of 10.6º. The total distance that each configuration moved around the screen varied between 9.9º and 10.2º. All of the patterns started and finished in the same configuration. The cycle of the rotation transformation consisted of a 90-degree clockwise turn followed by a 180-degree counter clockwise turn and then another 90-degree clockwise turn (see online supplementary video S1 and S2). For the horizontal shear transformation, the top half of the configuration stretched to the right whilst the bottom half stretched to the left this then reversed before the pattern returned to a vertical axis (see online supplementary video S3 and S4). The horizontal translation transformation moved to the right, then to the left and then to the right again and returned to the middle of the screen (see online supplementary video S5 and S6). The expansion transformation expanded to the edge of the spherical area then retracted before expanding again back to its original position (see online supplementary video S7 and S8). The static configuration contained no global motion transformation (see online supplementary video S9 and S10). All of the configurations also had local motion of the elements, which consisted of local rotation. A grey fixation cross also appeared at the centre of the screen prior to the start of the trial. Movies of the stimuli used in this experiment are available at http://www.liv.ac.uk/vp/projects/dynamic.html.

2.1.5. Procedure

At the start of the trial, a fixation cross was presented in the centre of the screen for between 1 and 1.5 s. The dynamic configuration then appeared and once this had finished it remained on screen, and a rating scale was also then presented below it. Participants were asked to explicitly rate their preference for the dynamic pattern that they had just seen. This was done on a visual rating scale (0–100; 0 = dislike, 100 = like), which participants had to click on in the appropriate place in order to register their preference. Participants were allowed to take as long as they wanted to log a response.

Prior to the start of the main experiment, participants completed a practice block consisting of five trials. These were identical to the trials shown in the experiment. This practice block ensured that participants were able to familiarise themselves with the task and ask any questions that they may have.

2.2. Results

The mean aesthetic ratings for each of the symmetrical and random transformations are shown in Fig. 2. A within subjects ANOVA [regularity (symmetry, random) × transformation (expansion/contraction, horizontal shear, rotation, horizontal translation, static) was performed with an average computed across all trials in each condition per observer. There was a main effect of regularity [$F(1, 14) = 114.533$, $p < 0.001$, partial $\eta^2 = 0.891$] and for transformation [$F(4, 56) = 8.039$, $p < 0.001$, partial $\eta^2 = 0.365$]. There was a significant interaction between regularity and transformation [$F(4, 56) = 10.229$, $p < 0.001$, partial $\eta^2 = 0.422$]. The presentation time of each the patterns was a between-subjects factor. There was a non significant effect of presentation time [$F(1, 14) = 0.24$, $p = 0.879$, partial $\eta^2 = 0.002$]. Separate contrasts were run for symmetry and random. The static condition was used as the baseline. For symmetry there was a significant difference between static and expansion [$F(1, 15) = 9.889$, $p = 0.007$, partial $\eta^2 = 0.397$], as well as for static and horizontal shear [$F(1, 15) = 10.163$, $p = 0.006$, partial $\eta^2 = 0.404$]. For random there was a significant difference between static and expansion [$F(1, 15) = 5.304$, $p = 0.036$, partial $\eta^2 = 0.261$], static and rotation [$F(1, 15) = 6.736$, $p = 0.020$, partial $\eta^2 = 0.310$], as well as for static and horizontal shear [$F(1, 15) = 4.726$, $p = 0.046$, partial $\eta^2 = 0.240$].

2.3. Discussion

Experiment 1 revealed a greater preference to symmetrical dynamic patterns than random. Therefore we can conclude that our preference for symmetry persists even in dynamic patterns. For symmetrical patterns expansion and static were the most preferred transformations, whilst rotation and horizontal shear were the least preferred. For the random patterns, expansion and rotation were the most preferred, with horizontal translation and static being the least. The length of presentation time did not have a significant effect on aesthetic judgments.

3. Experiment 2

In this experiment we wanted to shorten the presentation time to reduce the possibility that aesthetic ratings were being modulated by boredom or a lack of attention to the stimuli. The same stimuli and procedure were used for Experiment 3 however the patterns were presented for 7.2 s. In addition, we added a further condition (still) in which the pattern had no motion either globally or locally, as the previous experiments did not contain a truly static stimulus to act as a control. When participants were required to give the aesthetics ratings, the configurations were no longer displayed, unlike in Experiment 1. This ensured that participants were providing preference ratings for the whole display including the dynamic transformation viewed. Previously in Experiment 1 as the ratings were displayed along with the global configuration there was the potential for participants to simply provide a preference on the pattern being symmetrical or random and not consider the transformation.

3.1. Method

3.1.1. Participants

Sixteen participants took part in this experiment (6 males; 15 right handed; mean age 26). Participants had normal or corrected-to-normal vision and some received course credit upon completion of the experiment. These participants had not taken part in the previous experiment. This experiment was approved by the Ethics Committee of the University of Liverpool and conducted in accordance with the Declaration of Helsinki (revised 2008).

3.2. Results

Figure 3 shows the aesthetics results of Experiment 2. A repeated measures ANOVA [regularity (symmetry, random) × transformation (expansion/contraction, horizontal shear, rotation, horizontal translation, static, still)] was conducted. For each participant an average aesthetic rating was generated across the nine trials per condition and this was entered into the ANOVA. There was a main effect of regularity, [$F(1, 15) = 31.160$, $p < 0.001$, partial $\eta^2 = 0.675$] as well as for motion, [$F(5, 75) = 9.314$, $p < 0.001$, partial $\eta^2 = 0.383$]. There was also a significant interaction between regularity and motion, [$F(5, 75) = 3.530$, $p = 0.013$, partial $\eta^2 = 0.190$]. Separate contrasts were run for symmetry and random with the static as the baseline. For symmetry there was a significant difference between static and rotation [$F(1, 15) = 5.572$, $p = 0.032$, partial $\eta^2 = 0.271$] as well as for static and still [$F(1, 15) = 11.636$, $p = 0.004$, partial $\eta^2 = 0.437$]. For random there was a significant difference between static and expansion [$F(1, 15) = 5.917$, $p = 0.028$, partial $\eta^2 = 0.283$] as well as for static and still [$F(1, 15) = 11.306$, $p = 0.004$, partial $\eta^2 = 0.430$].

3.3. Discussion

The results from Experiment 2 show that symmetrical patterns were preferred to random. Transformations also influenced aesthetic preference ratings, with still being one of the least liked for both symmetrical and random configurations. Overall, symmetrical patterns were liked most for the expansion and static transformations. The transformations least preferred for the symmetrical patterns were horizontal shear and still. For the random patterns, the most preferred were expansion and horizontal shear, whilst the least preferred were still and rotation.

4. Experiment 3

Although in the previous experiments single transformations had been used these had not contained one direction of motion. Therefore, for Experiment 3 we wanted to examine how a single direction of motion influenced aesthetic judgments. The expansion transformation cycle consisted of the pattern expanding out from the centre of the screen. For the horizontal translation transformation the configuration started at the centre of the screen and then moved to the right hand side. For the horizontal shear transformation the top half of the configuration stretched to the right hand side of the screen whilst the bottom half stretched to the left hand side. For the rotation transformation, the configuration did a 90-degree clockwise turn. Experiment 3 used the same transformations and procedure as Experiment 2. As the patterns moved in a single direction, presentation time was reduced to 1.8 s.

4.1. Method

4.1.1. Participants

Sixteen participants took part in the experiment (11 males; 15 right handed; mean age 22). They had normal or corrected-to-normal vision and some received course credit upon completion of the experiment. These participants had not previously taken part in the other experiments. This experiment was approved by the Ethics Committee of the University of Liverpool and conducted in accordance with the Declaration of Helsinki (revised 2008).

4.2. Results

The aesthetic ratings for each transformation are shown in Fig. 4. For each participant an average was generated across all trials in each condition then a within-subjects ANOVA [regularity (symmetry, random) × transformation (expansion/contraction, horizontal shear, rotation, horizontal translation, static, still)] was performed. This showed a significant main effect for regularity [$F(1, 15) = 21.271$, $p < 0.001$, partial $\eta^2 = 0.586$]. There was a main effect for motion [$F(5, 75) = 4.784$, $p = 0.010$, partial $\eta^2 = 0.242$]. There was a significant interaction between regularity and motion [$F(5, 75) = 7.826$, $p < 0.001$, partial $\eta^2 = 0.343$]. In order to examine further the differences in preferences between each transformation separate contrasts were run for symmetry and random with static as the baseline. For symmetry there was a significant difference between static and horizontal shear [$F(1, 15) = 6.280$, $p = 0.024$, partial $\eta^2 = 0.295$] as well as for static and still [$F(1, 15) = 5.805$, $p = 0.029$, partial $\eta^2 = 0.279$]. For random there was a significant difference between static and rotation [$F(1, 15) = 7.173$, $p = 0.017$, partial $\eta^2 = 0.324$], static and horizontal translation [$F(1, 15) = 5.878$, $p = 0.028$, partial $\eta^2 = 0.282$] as well as for static and still [$F(1, 15) = 11.265$, $p = 0.004$, partial $\eta^2 = 0.429$].

4.3. Discussion

In Experiment 3, symmetrical patterns were preferred to random patterns. For symmetrical patterns, horizontal translation and expansion were the most preferred transformations. The least preferred transformations were still and horizontal shear. For random patterns, horizontal translation and rotation were the most preferred whilst expansion and still were least preferred.

In this experiment for both symmetry and random the horizontal translation transformation was consistently preferred. Horizontal translation had a left-to-right direction and the preference for this transformation may be explained by individuals from a western culture having a preference for moving objects that have a left-to-right directionality (Freimuth and Wapner, 1979; Gaffron, 1950; McLaughlin and Cramer, 1998; Mead and McLaughlin, 1979). The preference for this directionality is said to result from reading patterns being from the left-to-right (Fredrich *et al*., 2014).

5. General Discussion

This is the first investigation into the effect of dynamic motion on the aesthetic appreciation of abstract symmetrical and random patterns. The experiments were exploratory in that we wanted to establish the general pattern of preference rather than try parametric comparisons. We focused on making the patterns as rich and engaging as possible, while at the same time keeping them geometrical and with no semantic content. Aesthetic ratings were obtained for dynamic symmetrical and random configurations. Each configuration had a local motion of the elements and a global transformation. It was expected that symmetry would produce higher aesthetic ratings than random. We also expected that patterns with less dynamic changes (e.g., still) would produce lower aesthetic ratings. This would be consistent with results from Calvo-Merino *et al*. (2008). They found that symmetrical dance movements with less motion were liked the least. Note, however, that Calvo-Merino *et al*. examined biological motion sequences rather than abstract patterns.

Overall, we found a preference for symmetrical patterns over random. This is consistent with the literature on symmetry (Cardenas and Harris, 2006; Frith and Nias, 1974; Jacobsen and Höfel, 2002), which has shown it to be the best predictor of aesthetic judgments and high in Gestalt goodness (Wertheimer, 1923). This goodness has been linked to economy in perceptual processing and information load (Koffka, 1935; Leeuwenberg, 1971), which in turn has led to the idea that a preference for symmetry is mediated by perceptual fluency (Reber *et al*., 2004; Winkielman *et al*., 2003). As we did not measure fluency it is difficult to say if the preference observed in our results was influenced by this factor. However, our results strengthen the claim that symmetry is an important predictor of aesthetic judgments.

For symmetrical patterns, expansion was the most liked transformation for the first two experiments (For Experiment 3 it was the second most liked transformation). The preference for the expansion transformation is not just specific to symmetry as the random configurations also produced high liking ratings in the first two experiments. Familiarity could play a role in the preference for this transformation and so may be linked to the mere exposure effect (Zajonc, 1968), which states that preference is increased for stimuli that have previously been encountered. Expansion is often experienced when moving forward through an environment in the form of the objects image on the retina expanding. The rate the image expands corresponds to the individual's forward motion speed and the time to contact. As a result the human visual system appears specially adapted to processing expansion, with cells in the dorsomedial region of the medial superior temporal having a strong bias for this particular type of motion (Saito *et al*., 1986; Tanaka and Saito, 1989; Tanaka *et al*., 1989).

For the symmetrical patterns the least preferred transformation was the horizontal shear. In all three experiments it ranked in the two least liked transformations. A lack of liking for this transformation appears specific to symmetry, as it was not disliked as much when the patterns were random. This can be explained by the observation that the horizontal shear transformation, unlike the other transformations, not only does it skew the symmetry but it also distorts it in the image. Gartus and Leder (2013) found that even a small decrease of symmetry resulted in a decrease in liking.

In Experiment 1, presentation time was found not to have a significant effect on aesthetic judgments. Reber *et al.* (1998) showed that people have a preference for stimuli that are presented for longer durations. They presented stimuli for 100, 200, 300 or 400 ms. In our experiment the difference in presentation times was much greater than that used by Reber *et al.* (1998) and our stimuli were also dynamic. It could be that our presentation times were too long (our shortest presentation time was 1.8 s) to make a significant difference to aesthetic ratings. As visual preference to a stimulus can take as little as 50 ms (Lindgaard *et al*., 2006), it may be that all the information required to make a judgment had been taken in within the first few hundreds of a second and the further viewing time then had no substantial effect on liking. In addition, the finding that presentation time is linked to liking remains unclear, especially for longer time periods. Brieber *et al*. (2014) showed that there was a relationship between viewing time and appreciation during the free viewing of art in an exhibition. Alternatively, Heidenreich and Turano (2011) failed to found a significant correlation between aesthetic judgments and viewing time.

Another interest aspect of the findings is the difference in preference ratings between Experiment 1 and Experiments 2 and 3. For Experiment 1, which did not have a still condition, preference ratings were much higher for symmetry than random. This would appear to support the claim that symmetry is a salient aspect of stimuli. In Experiments 2 and 3, which did have a ‘still’ condition, this condition is rated as the least liked for both the symmetry and random configurations. Therefore whether the pattern is in motion is also a salient aspect of stimuli.

A number of limitations of these experiments should be considered. Using dynamic stimuli has a number of inherent limitations. Firstly, the distance at which the patterns moved was not constant for all of the elements. For some of the transformations the elements moved at different speeds. This is an inherent feature of a rigid expansion. As a result of this the speed was not consistent for all of the pattern elements. Although our aim was to present stimuli that were salient but also semantic free, our transformations have a physiognomic quality that can naturally affect their saliency (Funkenstein, 2007). Bartram and Nakatani (2010) found that small simple motions can produce certain attributes which could be grouped into positive, negative and calm. These attributes could then be strongly influenced by the shape, position and speed of the motion. Thus, the differences in preferences for our transformations across the experiments may be the result of participants inferring qualities onto the stimuli. Aesthetic judgments also are difficult to examine and as a result there are issues with using explicit ratings to examine preference to visual stimuli. For example, explicit judgments can be influenced by experience and expectation, which may affect aesthetic responses (Makin *et al*., 2012). Despite this, explicit aesthetic judgments have been measured in numerous studies, for example, Jacobsen and Höfel (2002), Kawabata and Zeki, (2004), and Lindgaard *et al*. (2005).

These experiments aimed to provide an exploration of how global motion influences aesthetic preference. With respect to the stimuli, future studies could match motion energy, and with respect to the dependent variable future studies could explore implicit preference through the implicit association test or affective priming. The implicit association test has been shown to expose automatic affective responses to visual stimuli (Bertamini *et al*., 2013b; Makin *et al*., 2012). We also restricted ourselves to looking at preference for reflection however other types of symmetry such as translation or rotation could also be investigated. This would be particularly interesting and provide a greater understanding of preference to Gestalts both static and dynamic as well as for local and global transformations.

In conclusion, we examined aesthetic preference to dynamic symmetrical and random stimuli in a series of exploratory experiments. Participants rated their preference for symmetrical and random patterns that had local and global motion. Our findings add to the literature on aesthetics by showing that our preference for symmetry is maintained even when the patterns are presented in motion; with dynamic symmetrical patterns preferred to random dynamic patterns. Different transformations can also influence aesthetic preferences. Expansion produced the highest aesthetic preference whilst horizontal shear produced the least. Also, presentation time did not have a significant influence on the aesthetic judgments.

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Figure 1. Examples of each transformation. (A) Expansion/contraction. The pattern initially expanded before retracting and then expanding again to return to the centre of the screen. (B) Horizontal shear. The top half of the pattern stretched to the right hand side of the screen, whilst the bottom half stretched to the left hand side. The top and bottom halves then changed direction and stretched to the opposite sides of the screen. (C) Rotation. The pattern rotated 90-degrees to the right then 180-degrees to the left before performing a 90-degree rotation to the right in order to return to its original position. (D) Horizontal translation. The pattern started off at the centre before moving to the right hand side of the screen. It then moved to the left hand side of the screen before returning to the centre. (E) Static. The pattern remained in the centre of the screen however, each of the individual elements rotated.

Figure 2. Mean aesthetic ratings for each of the transformations in Experiment 1. Red bars represent transformations for symmetrical patterns whilst blue represent random patterns. * $p < 0.05$; ** $p < 0.01$ with static used as a baseline. This figure is published in colour in the online version.

Figure 3. Mean aesthetic ratings for each of the transformations in Experiment 2. Red bars represent transformations for symmetrical patterns whilst blue represent random patterns. * $p < 0.05$; ** $p < 0.01$ with static used as a baseline. This figure is published in colour in the online version.

Figure 4. Mean aesthetic ratings for each of the transformations in Experiment 3. Red bars represent transformations for symmetrical patterns whilst blue represent random patterns. * $p < 0.05$; ** $p < 0.01$ with static used as a baseline. This figure is published in colour in the online version.

Queries to authors

1.1. Symmetry

p. 3, l 1: rating of abstract stimuli (Bertamini *et al*., 2013; Which Bertamini *et al*. (2013) was intended? Please differentiate between the two and make sure both are mentioned in the text (also p 18, l 16) Corrected

p 3, l 8: Reber *et al*., (2004); Same query (also p 16, l 2) Corrected

p 3, l 18: Simion *et al*., (2007) Reference list gives 2008; please make sure the correct date is given (should be 2008 – corrected)

1.3. Summary of Experiments

p 5, l 17: Martindale and Moore (1998) Reference list gives 1988; please make sure the correct date is given (Should be 1988)

p 6, l 19: Duffy (1998) Not mentioned in the references; please amend (Reference has been added)

2.1.2. Apparatus

p 8, l 2: Pierce, 2007 Pierce or Peirce, as in the References? Corrected.

5. General Discussion

p 16, l 10: Zajonc, 2001 Not mentioned in the references; please amend Corrected

p 18, l 10-11: Kawabata and Zeki, (2002) Reference list gives 2004; please make sure the correct date is given (Corrected – 2004); Lingaard *et al*. (2005) Lindgaard intended? (Corrected –Lindgaard)

References

Bartram, L. and Nakatani, A. (2010). Please give editors (?) and place of publication (Corrected)

Mead, A. M. and McLaughlin, J. P. (1992) This reference is the same as M & M, 1979, except initials; please correct (also in the text, where necessary) (should be M + M 1992).

Silvester, J.R. (2001) Please provide place of publication (Added)

Winkielman, P., Schwarz, N., Fazendeiro, T. A. and Reber, R. (2003) Corrected

The following references are not mentioned in the text; please amend.

Berlyne, D. E. (1970); Cannon, P. R., Hayes, A. E. and Tipper, S. P. (2010); Franconeri, S. L. and Simons, D. J. (2003); Jakesch, M. and Leder, H. (2009); Lin, J. Y., Franconeri, S. and Enns, J. T. (2008); Mastandrea, S., Bartoli, G. and Carrus, G. (2010); Mead, A. M. and McLaughlin, J. P. (1992)—initials for this reference OK (cf. M & M 1979); Topolinski, S. (2010); Zeki, S. (1980). These have been removed