MOTION ILLUSIONS CAUSED BY PAINTINGS OF OP ART DISTORT THE PERCEPTION OF TIME

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Abstract

Figurative static images implying human body movements observed for different durations (2-8 and 36 s) affected timing perception. This study examined whether images of static geometric shapes - juxtaposed lines causing visual motion illusions - would affect the perception of time. Undergraduate participants observed two optical paintings by Bridget Riley for 9 or 36 s seconds (G9 and G36 groups). The paintings implying different movements (2.0- and 6.0-point stimuli) were randomly presented. The prospective paradigm in the reproduction method to record the time estimations of the participants was used. Data analysis showed no time distortions in G9 group. In the G36 group the paintings were differently perceived: 2.0-point was estimated shorter than 6.0-point. Also, the exhibition time of the 2.0-point painting was underestimated, compared with the real time. These results show that optical illusion of movement in static images caused time distortions related to a long duration of exposure.

The Optical Art or Op Art can be considered as a generator of perceptual responses, having dynamic qualities which provoke illusions and sensations in the viewer (Rycroft, 2005). Some paintings of this artistic movement use perspective illusions or chromatic tension that lead to the perception of a flicker or movement in simple geometrical patterns (Zanker, 2004).

An important exponent of Op Art is Bridget Riley, whose works has been studied by several experimental studies on optical illusions and movement perception (Dodgson, 2008; Zanker, 2004; Zanker & Walker, 2004; Zeki & Lamb, 1994). According to Rycroft (2005), viewing a Riley painting was intended to be a physical, embodied experience that activated and exercised cognitive consciousness because of the visual movement perception of her paintings, e. g. *Fall* and *Current*, evoke on the viewers (see also Follin, 2004; Moorhouse, 2003).

Fall and *Current* artworks are composed of simple geometric patterns (curved lines) painted in black and white[1]. With the intention of explaining why these painting evoke visual illusions of movement, Zanker (2004) created digitalized images based on the Riley's painting (*Fall*) to identify movement indicators implicit in his images. The movement illusion caused by *Fall* on subjects occurs due to a relationship between these movement indicators and the saccadic eye movements (Zanker & Walker, 2004). Zanker, Hermens, and Walker (2010) found that the factors that intensify these illusion movements are the contrast and the wave frequency of the lines of the painting composition.

Op Art has often been portrayed as an art of high science, a rigorous, retinal art linked to theories of visual illusions and movement perception. However, other artistic movements have *represented* the movement in different ways. *Tension*, force lines, vector arrows, texture, and other technical strategies have been used by artists to represent the

[1] Digital reproduction of the painting *Fall* can be viewed on the site http://www.tate.org.uk/artworks/riley-fall-t00616.

movement in abstract paintings, drawings and photography (Arnheim, 2004; Cutting; 2002). According to the authors, the methods are not mutually exclusive and are often combined.

Kim and Blake (2007) used abstract paintings composed of stroboscopic images in a research on the perception of implied movement. They showed that abstract paintings of different artistic movements (Cubism and Futurism) were evaluated with more movement and activated the MT+ brain area more than other paintings that were not intended to evoke movement (Expressionism). Also, subjects with previous experience in abstract arts rated the "stroboscopic" paintings as having more movement than the non-experienced subjects. In a similar way, Riley's paintings were distinctly rated in respect to its evoked movement by untrained subjects in visual arts: *Fall* was rated as having more movement than *Chant 2* in a study that ranked artworks of Riley's from different periods (Giannetti, Nather, & Bueno, 2010)[2].

Similar ranking scales have explored movement perception of different figurative paintings and sculptures. Nather and Bueno (2006, 2008) used photographic reproductions of human-like objects and showed that subjects can recognize movement in these static images relating to different intensities of body movements for each one. Using pictures of sculptures of dancers by Edgar Degas, the authors showed that the perception of movement modulates the subjective time perception. Presented for 36 s, static dancers with lower movement scores were judged to have shorter duration than those with intermediary scores, and the dancers with intermediary scores were judged to be shorter than those with the highest scores (Nather & Bueno, 2011).

Dynamic balance criteria of movement representation could explain why the body postures of these Degas' ballerinas were rated differently. The relationships among the body parts (head, arms and legs) generated different visual asymmetries in artworks causing distinct movement perception (Cutting, 2002). Furthermore, Freedberg and Gallese (2007) hypothesized that an important element of aesthetic episodes consists of the activation of embodied mechanisms encompassing the simulation of actions and corporeal sensation that were being observed.

Nather, Bueno, Bigand and Droit-Volet (2011) showed that the exposure time of artworks is also a variable that affects time perception. Using the same Degas' dancers in a bisection paradigm, they showed that short exposures (0.4 to 1.6 s) of dancers with more or less implicit movement could affect subjective time perception more strongly than long exposures (2 to 8 s). They attributed these results to the embodiment mechanisms as the increased arousal levels were verified in body postures of dancers representing high intensity of movements.

Geometric shapes in motion observed for 6 to 18 s were estimated with longer duration than stationary squares and it was observed that the faster was the movement, the greater was the subjective time distortion (Brown, 1995). Similarly, figurative static images implying motion observed for different durations (0.4 to 1.6 and 36 s) modulated timing perception. The aims of the present study were to verify whether: (a) photographic reproductions of Bridget Riley's paintings rated with different intensities of movement affect time perception; and (b) their different time exposures (9 s and 36 s) differently affect the perception of time.

Method

The experiment was approved by the Ethics Committee of the University of São Paulo School of Philosophy, Sciences and Letters, at Ribeirão Preto, Brazil.

[2] *Chant 2* painting can be viewed on the site http://www.op-art.co.uk/op-art-gallery/bridget-riley/chant-2.

Forty-nine university students (23 men; 23.37±4.77 years of age) randomly invited from University of São Paulo, untrained in visual arts with normal or corrected-to-normal vision, participated in the experiment.

The experiment was performed in an isolated, soundproofed room at the central library of the University of São Paulo of Ribeirão Preto Campus. Indirect sunlight was used during the day, and artificial light was used by the night.

Digital photographs of three paintings by Bridget Riley (*Chant 2*, *Fall* and *Exposure*) having respectively 2.0-, 6.0-, and 5.5- points of implied movement were used as stimuli: A, B and Training Stimulus, respectively. As both *Fall* and *Exposure* are black and white paintings, *Chant 2* was modified to a black and white image, so that the colors wouldn't be an additional variable. These stimuli were obtained by using digital reproductions of 19 paintings by Bridget Riley which were scored (Likert 7-point scale) by participants who were untrained in arts.

Exposure of stimuli and recording of time estimations were done by the *Wave Surfer* program installed on an HP notebook. The tasks were orally explained to the participants. They were positioned facing the central region of the LG 19" monitor and were asked not to count time. The stimuli were exposed by pressing the "presentation" key and their time exposure were finalized after 9 s (Group G9) or 36 s (Group G36). At this moment, the monitor was filled with white color indicating that the participant could initiate time estimation. Then, immediately after each time observation the participant reproduced the presentation duration by pressing the "initiate" key. The experienced duration of each stimulus was finalized by pressing the "finished" key (reproduction method). The stimuli were presented randomly in two orders (A-B and B-A) to the participants. The Training Stimulus was presented first to the participants to make them familiar with these experimental tasks. This stimulus data were excluded from the analysis.

After the time estimations, the participants' task was to observe and judge the movement intensity of the paintings answering the Differential Semantic Scales for the locutions "Movement" and "Complexity". Subsequently, they answered questions about the characteristics of the paintings and personal information.

The temporal ratio (reproduced time/real time of exposure) was used in the analysis. The Two Way test (ANOVA) with no repeated measures and the Student-Newman-Keuls test for post-hoc comparisons were conduced individually for the G9 and G36 groups. Student *t* test analyses were conducted comparing the mean values of time ratios of the stimuli with the value 1.0, considering this value as an indication of no time distortion (under or overestimation).

Results

The mean values for temporal estimations (temporal ratio) are shown on Figure 1.

The analyses of variance showed that the order of the stimuli presentation did not affect time estimation of the participants in Group G9 (9 s of images exposure). Also, these analyses did not show differences between stimuli. The *t*-test analysis showed that the temporal estimations of A and B stimuli were not different of the actual duration of 9 s.

The analyses of variance of the G36 Group (36 s of exposure) did not show an effect of the order presentation of images but an effect between stimuli was observed: Stimulus A was estimated shorter than Stimulus B [$F(1, 38)=4.99$; $p<.05$]. The *t*-test analyses showed that the Stimulus A was underestimated in relation to the actual time of exposure of 36 s [$t(20)=-1.96$; $p<.05$].

The majority of participants of both G9 and G36 groups (59.3% and 68.2%, respectively) related that the images caused confusion and/or blurred vision.

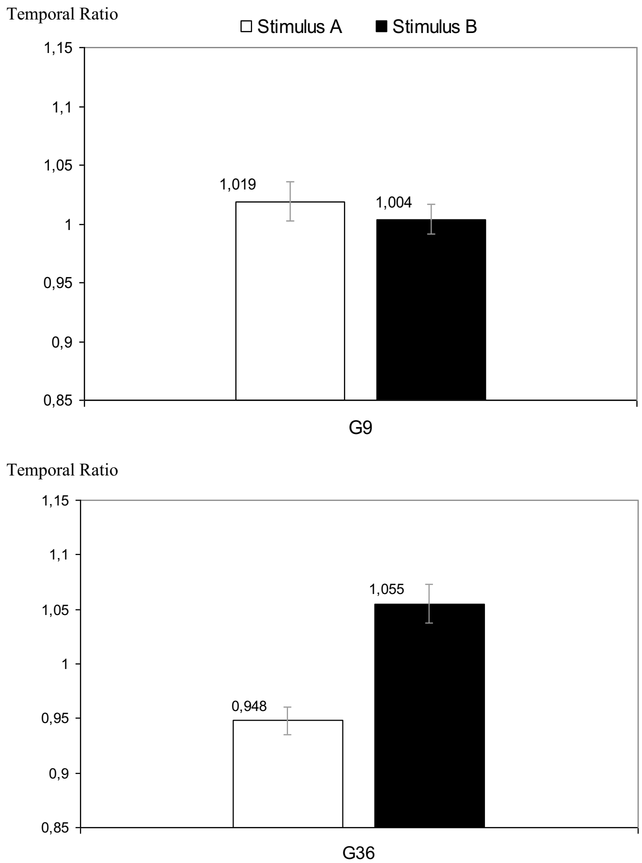

Figure 1: Temporal ratio of the mean values of time estimations: Stimuli A (less movement) and Stimuli B (more movement) in G9 and G36 groups.

Discussion

This study showed that time perception was affected by abstract paintings inducing different intensities of motion illusions. However, this time distortions were observed when the paintings were exposed for 36 s. This result is consistent with previous studies that used figurative images of Degas' sculptures representing different body movements that were presented for the same duration: static dancers with lower movement were judged to have shorter duration than those dancers with the highest movement (Nather & Bueno, 2006, 2011).

On the other hand, time estimations for 9 s of exposure did not cause time distortions between the paintings. This result was not totally in agreement with Nather, Bueno, Bigand, and Droit-Volet (2011) which showed that time distortions between the images were strong for 0.4 to 1.6 s (short) of exposure while the same was not verified for 2 to 8 s (long) of exposure. Further, this result for long durations was not in agreement with those that used stationary and geometric shapes in motion presented for 6 to 18 s (Brown, 1995).

In this sense, the results pointed out that the duration of stimuli is a relevant variable in studies that use static images – artworks representing different abstract and figurative movements – to understand aspects underlying the subjective time perception. Recently, Nather and Bueno (2012) used a behavioral measure allowing the viewer to freely observe (visual exploration) the same images of Degas' dancers and then record this self-observation. They verified that participants observe for a mean of 18 s the different artworks but the time distortions were less marked.

Different methodologies for time estimation with, for example, changes in time exposure and tasks have been used to examine different aspects and processes related to the perception of time (Fraisse, 1984; Block, 1990). From this perspective, it is possible to discuss the different results found between 9 and 36 s of exposure by relating them to the effects of the implicit effects (motion illusions) of Riley's paintings caused on subjects.

According to Rycroft (2005), the aesthetical experience of seeing Riley's paintings such as *Fall* was not corporeally limited to the eye and the mind of the viewer but embodied. It was internalized as a changing set of physical responses and realizations. This can explained why, for example, people related physical states of dizziness and general disorientation when viewing the paintings for an extended time in a museum. In this study the majority of the participants - 60% and 70% (G9 and G36 respectively) - declared that the paintings caused confusion and/or blurred vision.

From this perspective, it is possible to infer that the different duration exposures interact with the effects of motion illusions causing the distinct time distortions in the G36 group. Thereby, not only the visual perception of movement but the body sensations contribute in the process of time perception. According to Rycroft (2005), viewing a Riley painting was intended to be an embodied experience that activated different cognitive processes involved in visual motion experience and eye movements (see Zanker & Walker, 2004; Zanker, Hermens, & Walker, 2010).

The effects of embodiment on these time estimations are also important to be considered. Nather et al. (2011) associated time distortions to embodiment mechanisms as they observed increased arousal levels in short exposures (0.4 to 1.6 s) of images implying human body movements of more intensity. As the arousal levels decayed after 2-3 s of exposure of images with emotional contents (Angrili, Cherubini, Pavese, & Manfredini; 1997), they explain why 2 to 8 s of exposure caused less time distortions. This could explain why 9 s of exposure of Bridget Riley's paintings did not affect time estimations as was observed when these paintings were exposed for 36 s.

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