TIME ESTIMATION AND EYE-TRACKING MOVEMENTS IN HUMAN BODY STATIC IMAGES

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Abstract

According to Body Movement Ranking Scale (BMRS) same duration static images with 1.5 and 3.0-point stimuli were estimated as shorter than 6.0-point; 1.5 and 3.0-point were underestimated; 6.0-point were overestimated regarding real time by untrained participants. This study examined the eye-tracking movements to describe where and how often body parts in different positions were observed. Stimuli were photographic images of 3 Degas dancer sculptures ordered by BMRS geometric progression. Images were presented to participant groups untrained, dance trained and visual arts trained whose tasks were to observe the images and estimate the presentation time duration. Although image pattern observation was similar in 3 participant groups, most attention to arms and legs was observed in the sculpture with more movement and more attention to head and trunk to sculptures with less represented movement. Dance trained participants underestimated 6.0-point image; art trained participants estimated it as the same duration of real time.

In the dancer sculptures of Edgar Degas, the sculpted bodies in body positions with physical balance which is difficult to maintain for a long time can evoke in the observer the movement unfoldings which are about to happen (NATHER, 2007; NATHER; BUENO, 2009). It is possible that when observing these works the participant differentially processes represented movements due to the different asymmetries from the relations among the positions of body parts (CUTTING, 2002) of this important visual element.

Static images of the human body in implicit movements can induce dynamic mental representations related to the memory of recognizable movements (FREYD, 1983; SHIFFAR; FREYD, 1993; KOURTOSI; KANWISHER, 2000; BONNET, PAULOS; NITHART, 2005). According to Freedberg and Gallese (2007), the physical responses of the observer seem to be precisely located in those parts of the body that are being viewed in the images (pressured, constrained, destabilized etc.), because the brain can activate mirror neurons which reconstruct these actions by simply observing the *static pattern of a past action*.

There is increased activity in brain areas according to how learned and practiced dance movements are viewed (CALVO-MERINO *et al.*, 2005; CALVO-MERINO *et al.*, 2006) and to the participants ability to judge if they were able to imagine and perform dance movements recently learned (CROSS; HAMILTON; GRAFTON, 2006).

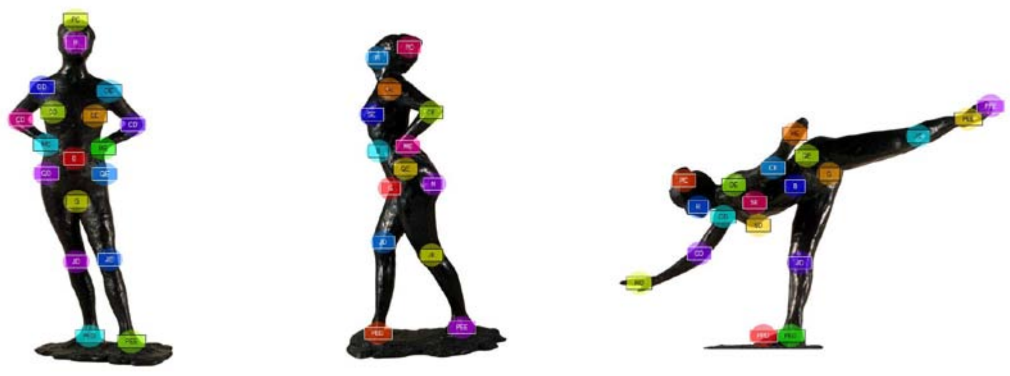
According to Duchowski (2007), the eye tracking methodology can be applied in many different studies of neuroscience and psychology. Eye-tracking studies are not only discussed in issues related to neuroscience of visual perception but also in attentional factors and psychological processes that relate these movements to the reading and scene perception of a visual art work (MANNAN; RUDDOCK; WOODING, 1997; WOODING, 2002).

The use of visual stimuli with different intensities of movement representation has been elucidating different temporal perception aspects in humans (NATHER; BUENO, 2006). According to Nather and Bueno (2008), images with equal durations ordered by BMRS's arithmetic or geometric progressions were estimated as different durations by untrained subjects: 1.5 and 3.0-point stimuli were estimated as shorter than 6.0-point ones; 1.5 and 3.0-point were underestimated, and 6.0-point were overestimated regarding real time.

Subjective timing and experimental aesthetics literature (CUPCHICK; GEBOTYS, 1988) have already demonstrated that trained and untrained in visual arts participants presented distinct temporal estimations for different impressionist paintings. The aims of the present study were: a) To study the eye movements of subjects who observe photographs of Edgar Degas' dancer sculptures, b) To verify if the eye movements differ among groups of subjects trained in Visual Arts, trained in Classical Dance and not-trained, c) To verify among these groups the relation between eye movements and subjective time estimations of subjects who were exposed to images of bodies in different dance steps of classical ballet.

Method

Seventy students of psychology at the University of Bourgogne (France) participated in the experiment. The students were divided into 3 groups: 32 not-trained in Visual Arts and Classical Dance – NT (5 men and 27 women aged 18 to 21); 16 female students trained in Arts – TA (aged 18 to 20) and 22 female students trained in Dance - TD (aged 18 to 21).



1.5-point **3.0-point** **6.0-point**

Figure 1. The stimuli and AOIs used in the experiment: the joints of the body (as the scapular and pelvic girdle, elbows, wrists, knees and ankles) as well as parts of the thorax and abdomen (breasts, abdomen/umbilicus and pelvis region), face and head.

The time estimations were registered by *Wave Surfer* program installed in a HP Pavilion Notebook PC ZE5375. The prospective paradigm of time estimation with the reproduction method was used, and the total time of presentation of each stimulus was 36 seconds. Tobii Studio™ 1.1 was used to register the eye-tracking movements: *fixation time* and *observation count* parameters from areas of interest (AOIs) previously selected of "Civilian American and European Surface Anthropometry Resource" criteria (ROBINETTE *et al.*, 2002). Three photographs of dancer sculptures of Edgar Degas (Stimuli 1.5-point, 3.0-point and 6.0-point) in geometric progression of the "Body Movement Ranking Scale" - BMRS (NATHER; BUENO, 2008) were used as stimuli (Figure 1). The scanned photographs of sculptures went through a visual standardization processing in Adobe Photoshop 7.0 program. The final size of images on the screen of Tobii Studio was of approximately 30x40 cm in the resolution 1024x768 *dpi*. The pictures occupied the central position of the computer screen and the rest of the screen was filled with white color.

Each participant was individually led to the experimental room and asked to sit in his chair. Then the tasks were verbally explained: to observe each image, and after each observation to estimate its duration time. All participants were positioned facing the central region of the Tobii Studio screen at a fixed distance of 40 cm. The stimuli were presented randomly for the 3 groups of participants. A "Neutral" stimulus, the photograph of a dancer with 4.0-point according to BMRS, was used to train the subjects in the experimental tasks. The data were submitted to analyses of variance (ANOVA) and *Student's t Test*.

Results

Subjective Time Estimations: The results of the time reproductions of the stimuli in NT group showed that the presentation order of the images was statistically different for the 1.5-point stimulus. The analysis of time estimation values of the stimuli first presented in different experimental sequences showed that 30.54 s (1.5-point) and 32.55 s (3.0-point) were not statistically different, but they were significantly different from the 41.66 s (6.0-point); 1.5 and 3.0-point were estimated with lower temporal duration than 6.0-point stimulus. Moreover, when they were compared with 36 s of real time exposition, 1.5-point was underestimated and 6.0-point was overestimated; 3.0-point was estimated with the same duration time of real exposition ($p < 0.05$) (Table 1).

Table 1. Mean values and standard deviations of time reproductions of participants to 1.5, 3.0 and 6.0-point stimuli in not-trained (NT), trained in Visual Arts (TA) and trained in Dance (TD) groups. Values expressed in seconds

Group	1.5-point	3.0-point	6.0-point	N
NT	30,54 (±5,72)	32,55 (± 8,39)	41,66 (±8,22)	32
TA	38,10 (±12,08)	39,78 (±16,22)	36,72 (±12,31)	16
TD	33,47 (±9,84)	30,52 (±9,32)	30,55 (±7,38)	22

In the TA and TD groups, differences were not found in the order of the stimuli presentation, which allowed a grouped analysis of data from stimuli in different experimental sequences. Both in TA and TD groups differences statistical were not observed among stimuli. In the TA group, the stimuli presented similar values to the real time of exposition, but in the TD group, 30.52 s (3.0-point) and 30.55 s (6.0-point) values were underestimated (Table 1). In the 6.0-point stimulus, the value 41.66 s in NT group was statistically different from the value of 30.55 s TD group.

Eye-Tracking Movements: Statistical analysis of *observation count* and *fixation time* values showed that the body parts were observed differently by the participants ($p < 0.01$) (Table 2, Annex). The grouped analysis of these data showed that the head at 1.5-point stimulus tends to be longer observed (*fixation time*) than the arms and legs in 3 experimental groups. The head was the most visited part of the body (*observation count*) by the eyes of this stimulus. In 3.0-point stimulus, the head was longer observed than the torso and arms, but the legs were observed in a similar duration of time as the head; in the NT and TD groups, the head was most often observed than the torso by the eyes, and in the TA group no part was visited with more frequency.

Contrary, in 6.0-point stimulus, the tendency of the body parts including the head being observed during similar times was verified, except in the TD group where the legs were longer observed than the head. This difference was also highlighted with the analysis of the number of visits made by the eyes which showed that the head at 6.0-point stimulus was less visited than the legs.

The torso tended to be shorter observed than the arms and legs in the 6.0-point stimulus in 3 experimental groups. In these cases, the torso was observed about 1.5 times shorter than the legs and almost 2 times shorter than the arms. The data from *observation count* showed that the legs (3.0 and 6.0-point stimuli in NT and TD groups, and 6.0-point stimulus in TA group) were 1.5 more times visited than the torso. In TD group, the arms were more frequently observed than the torso in 3.0 and 6.0-point stimuli. Significant differences between the number of observations of arms and legs were found only in 6.0-point stimulus at TD group: the legs were more often observed than the arms.

Discussion

The NT group values of time estimations reinforced those obtained by Nather and Bueno (2008), and also reinforced an order effect of image presentations caused by the intensity of represented movement in the sculptures (NATHER, 2007). The average time estimations in the NT can be explained by a combination of different models of subjective time, which relates to the storage-size (ORNSTEIN, 1969) and expectation (BOLTZ, 1989) generated by the different movements of the body. Thus, the 6.0-point stimulus (more movement) is more complex, creating the expectation of a movement that is not completed and causing major time estimations (temporal overestimations).

However, in the TD group the expectation of the represented movement in the 6.0-point stimulus is completed, since this ballet position ends a great dance step (NATHER; BUENO, 2008,2009). This explains why in the TD group this stimulus was underestimated. In TA group, the 6.0-point stimulus was similar to the real duration time of exposition and can be explained by different eye-tracking strategies adopted by this subject group. According to Vogt and Magnussen (2007), trained in arts subjects differ in the number of fixations and time spent looking at an image than not trained subjects.

The eye-tracking data showed that the 3 subject groups presented similar patterns of stimulus observations: the head was the body part most explored in the 1.5-point stimulus; in the 3.0-point stimulus it was similarly observed to the legs, and in the 6.0-point stimulus it was less explored than the legs mainly in the TD group. This suggests that in the stimulus with more represented movement more attention was focused on arms and legs, because these parts of the body really show the type of represented motion in function of different asymmetries they provide, depending on the dynamic mental representations related to the memory of recognizable movements, which activate brain areas related to visual perception and representation of different movements.

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References

Boltz, M. (1989). Time judgments of musical endings: effects of expectancies on the "filled interval effect". *Perception & Psychophsics*, 46(5):409-418.

Bonnet, C. ; Paulos, C.; Nithart, C. (2005). Visual representations of dynamic actions from static pictures. *Perception*, 34:835-846.

Calvo-Merino, B.; Glaser, D. E.; Grèzes, J.; Passingham, R. E.; Haggard, P. (2005). Action observation and acquired motor skills: an FMRI study with expert dancers. *Cerebral Cortex*, v. 15, p. 1243-1249.

Calvo-Merino, B.; Grèzes, J.; Glaser, D. E.; Passingham, R. E.; Haggard, P. (2006). Seeing or doing? Influence of visual and motor familiarity in action observation. *Current Biology*, 16 :1905-1910.

Cross, E. S.; Hamilton, A. F. D. C.; Grafton, S. T. (2006). Building a motor simulation de novo: observation of dance by dancers. *Neuroimage*, 31:1257-1267.

Cupchick, G. C.; Gebotys, R. (1988). The experience of time, pleasure, and interest during aesthetic episodes. *Empirical Studies of the Arts*, 6(1), 1-12.

Cutting, J. E. (2002). Representing motion in a static image: constraints and parallels in art, science, and popular culture. *Perception*, 31(10):165-1193.

Duchowski, A. (2007). *Eye tracking methodology: theory and practice*. London: Springer.

Freedberg, D.; Gallese, V. (2007). Motion, emotion and empathy in esthetic experience. *Trends in Cognitive Sciences*, 11(5):197-201.

Freyd, J. (1983). The mental representation of movement when static stimuli are viewed. *Perception & Psychophysics*, 33(6):375-381.

Kourtzi Z.; Kanwisher, N. (2000). Activation in human MT/MST by static images with implied motion. *Journal of Cognitive Neuroscience*, 12:48-55.

Mannan, S. K.; Ruddock, K.H.; Wooding, D. S. (1997). Fixation patterns made during brief examination of two-dimensional images. *Perception*, 26(8):1059-1072.

Nather, F. C. (2007). *Movement perception and subjective time in the visual arts*. 182 p. Doctoral Thesis - Faculty of Philosophy Sciences and Letters of Ribeirão Preto, University of São Paulo, São Paulo, Brazil.

Nather, F. C.; Bueno, J. L. O. (2006). Effect of static images with different representations of movement under the subjective perception of time. *Psicologia Reflexão e Crítica* (*Psychology*), 19(2):217-224.

Nather, F. C.; Bueno, J. L. O. (2008). Movement ranking scale of human body static images for subjective timing estimation. *Proceedings of the 24th Annual Meeting of the Society for Psychophsics*, p. 185-190.

Nather, F. C.; Bueno, J. L. O. (2009, submitted). Timing perception in paintings and sculptures of Edgar Degas. *Kronoscope*.

Ornstein, R. E. (1969). *On the experience of time*. Harmondsworth U.K.: Penguin.

Robinette, K. M.; Balckwell, S.; Daanen, H.; Boehmer, M.; Fleming, S.; Brill, T.; Hoeferlin, D.; Beurnsides, D. (2002). *Civilian American and European Surface Anthropometry Resource* (CAESAR), Final Report, Volume I: Summary, United States Air Force Research Laboratory, Human Effectiveness Directorate.

Shiffrar, M.; Freyd, J. J. (1993). Timing and apparent motion path choice with human body photographs. *Psychological Science*, 4:379-384.

Vogt, S.; Magnussen, S. (2007). Expertise in pictorial perception: eye-movement patters and visual memory in artists and laymen. *Perception*, 36:91-100.

Wooding, D. (2002). Fixation maps: quantifying eye-movement traces. *Perception*, 31(10):1165-1193.

Annex. Table 2. Mean values of *observation count* and *fixation time* in 36 seconds of exposition to 1.5, 3.0 and 6.0-point stimuli in not-trained (NT), trained in Visual Arts (TA) and trained in Dance (TD) groups of participants. Respectively, N = 32, 16 and 22 subjects

	1.5-point			3.0-point			6.0-point		
AOIs	**NT**	**TA**	**TD**	**NT**	**TA**	**TD**	**NT**	**TA**	**TD**
Observation Count									
Head	63,89(±38,47)	69,93(±34,92)	61,47(±39,89)	44,85(±24,30)	50,31(±27,46)	50,55(±21,56)	41,26(±22,64)	45,63(±20,11)	37,95(±17,32)
Torso	47,22(±18,01)	51,06(±20,48)	55,32(±26,28)	23,63(±13,16)	31,13(±16,13)	23,90(±15,23)	40,00(±21,03)	36,69(±17,53)	36,36(±20,42)
Arms	34,70(±29,67)	33,50(±30,11)	25,95(±21,08)	35,04(±24,92)	42,13(±21,73)	36,86(±18,21)	53,96(±18,40)	54,06(±19,05)	58,73(±24,42)
Legs	28,78(±10,72)	28,19(±12,07)	31,91(±14,21)	40,41(±19,34)	44,63(±20,02)	40,82(±17,56)	61,81(±38,76)	79,40(±39,75)	80,95(±34,95)
Fixaton Time									
Head	5,68(±2,81)	6,33(±3,16)	5,76(±3,28)	4,66(±3,35)	3,37(±2,19)	3,91(±1,89)	3,08(±1,63)	3,35(±1,40)	3,25(±1,88)
Torso	3,49(±1,77)	3,17(±1,17)	3,37(±1,21)	1,88(±1,16)	1,86(±1,29)	1,32(±0,95)	2,54(±1,24)	2,22(±1,12)	2,40(±1,40)
Arms	1,99(±1,78)	1,90(±1,34)	1,66(±1,00)	2,16(±1,08)	2,35(±1,11)	2,22(±1,09)	4,17(±1,74)	4,07(±2,23)	4,06(±2,00)
Legs	2,35(±1,53)	1,98(±1,11)	2,56(±1,60)	3,83(±152)	3,21(±1,88)	4,25(±1,85)	4,01(±1,78)	4,71(±2,12)	5,91(±2,16)