Direction perception of a translational point-light-walker

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Human observers exhibit a great sensitivity in identifying biological motion, even in a noised environment. In accordance with that, lights attached to the major joints of a human walking model are enough to recognize a human figure. This stimulus is called a point-light-walker (PLW). Until now, major experiments have been limited to studying this phenomena as if a person was walking on a treadmill. Here, in order to carry on a study in a more realistic situation, the PLW has been generated with a translational motion. The goal of the experiment is to compare the direction discrimination of a PLW with a non-biological stimulus having the same local motion signals (upside-down PLW). Results show that the direction discrimination threshold is lower for the biological condition. It means that supplementary cues of translation (expansion and common translational component) are not enough to offset the natural sensitivity for a biological stimulus. A better integration of each local motion signal in the canonical situation seems to explain the easier capacity of the subject to extract the common translational vector.

Introduction

In daily living we are seeing and interacting with lots of other people. Which makes the human being stimulus particularly singular in terms of frequency and social role. This observation has brought scientists to assume a specific cortical treatment of biological stimuli. So, a first question that has emerged is to know which processes a human observer uses to interpret the others' action. Following this interrogation, the second one is to discover if these processes are different than ones carry out to perceive a non-biological stimulus.

Several studies have demonstrated the impressive level of visual sensitivity to human movement (Johansson, 1973; Cutting & Kozlowski, 1977). For example, the recognition and orientation discrimination is higher for biological motion than a stimulus having the same local motion signals (Sumi, 1984; Pavlova & Sokolov, 2000; Beintema & Lappe, 2002). Furthermore, neurophysiological works describe the activation of some specific cortical areas (e.g., superior temporal sulcus and premotor cortex), following the presentation of a biological stimulus (Grossman et al. 2000; Saygin et al., 2004). All these results suggest a singular visual analysis of the biological entity.

However, one argument against these studies is, that they have been carried out in poor realistic conditions. Particularly, the translational component of the motion has been removed and, consequently, a fundamental cue to discriminate the direction of any stimulus has been absent. Therefore, the present study was targeted to find out if this approach might be scientifically justifiable. In order to know the role of the translational component of the motion in the direction perception of biological motion signals, it was analyzed the direction discrimination between two upside-right PLW (UR) versus two upside-down PLW (UD).

A previous study with a stationary walking figure showed a better discrimination of the UR than the UD condition (Troje, 2004). If the difference disappears in the presence of translation, it would mean that this cue cannot be neglect in a PLW motion study. Otherwise, it could be conclude that the addition of this variable is not enough to override the human being sensitivity for the biological motion.

Method

Point-light displays of translational walker in an upside-right and an upside-down position.

Display frequency: 30Hz

Stimulus duration: 2s

Number of walking cycles: 2

Number of illuminated joints: 13

PLW representation (sticks are not presented during experiment):

Upside-right

Upside-down (180º rotation according to the z-axis of the upside-right figure)

Task: Predict between 2 identical stimuli (UR/UR or UD/UD), presented in peripheral field of view (12.6º between each stimulus at the starting position), which one will go in front of the other.

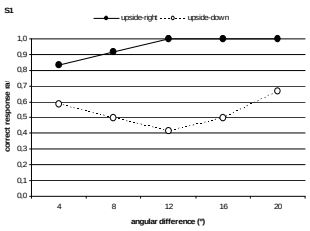
Translational motion: - PLW are displayed according to the z-axis of the screen (expansion motion).

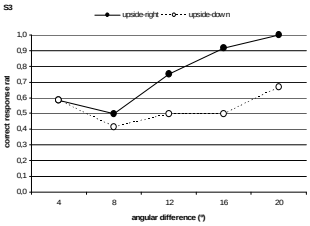
- Five differences of direction, between each PLW, have been tested: 4º, 8º, 12º, 16º, 20º.

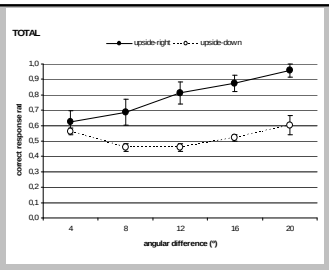
Design: 2 (conditions) x 5 (angles) x 12 (repetitions) = 120 trials

4 subjects

Results







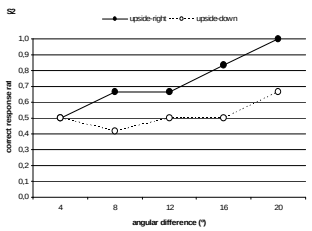
Statistics:

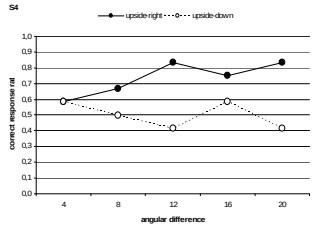
- total: F(1,3) = 30.84; p<.0115 *

- angle 4º: F(1,3) = 1.00; p<.3910 NS
- angle 8º: F(1,3) = 10.37; p<.0486 *
- angle 12º: F(1,3) = 14.69; p<.0313 *
- angle 16º: F(1,3) = 24.77; p<.0156*
- angle 20º: F(1,3) = 289.00; p<.0004 *

Commentaries:

- The discrimination of the motion direction is statistically better in UR position than in UD position [F(1,3) = 30.84; p<.0115].
- This analysis reveals a significant divergence in performance by 8º [F(1,3) = 10.37; p<.0486] with the UD PLW trials remaining significantly below the UR PLW trials for all angular differences beyond this point.





Discussion and perspectives

Results confirm the higher sensitivity of human observer for a canonical point-light-walker in comparison with a non-biological stimulus having the same local motion signals. Indeed, presence of an additional cue of motion direction (translation) does not nullify the difference between biological and non-biological motion.

According to psychophysical studies using an experimental paradigm of stimulus perception by a limited-lifetime technique (each point has a "limited lifetime" of one or few frames, after which it disappears and is redrawn in another randomly chosen position) or inside a random dot mask (plane of various randomly moving point lights), it seems that results can be explained by a better process of integration-segmentation of local signals in a biological configuration (Beintema & Lappe, 2002; Thornton et al., 1998). In these noised conditions, only a point arrangement according to a canonical view can be grouping in a global form in motion.

So, future work will be oriented to identify the mechanisms that support the perceptive construction of this gestalt. More specifically, in a first moment, it is scheduled a test to check if the promotion of the visual experience of an upside-down point-light walker can bring this grouping property.

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