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COGS 190 Thesis
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Biological motion as a cue for attention

Abstract

During detection of biological motion, humans assess both the facing direction and motion direction. This study characterizes the role of these two biological cues, through use of a point-light walker, in regulating attention orientation through reaction times and accuracy ratings. We report here that the side of Gabor appearance and its tilt orientation are strongly linked through a mechanism of cued attention, consistent with the Posner paradigm. With only passive viewing, no evidence was found that facing direction or movement direction influenced reaction times or accuracy ratings. However, using active viewing, motion direction and Gaborside congruent trials (93.6%) showed significant effects at $p<0.001$ against incongruent trials (89.9%). Facing direction and Gaborside congruent trials (0.652 sec) showed significant effects at $p<0.05$ against incongruent trials (0.675 sec).

***Keywords*:** biological motion, attention, Gabor, facing direction, walking direction, central cues.

1. Introduction

Biological motion is a major source of social information for humans to quickly access and adapt for survival and social acceptance. Based on point-light displays, a set of dynamic dots can easily simulate the motions of the joints in a figure. This constellation of social movement patterns create perceptual characteristics of living animals [10], by which observers can recognize biological cues such as gender, emotion, action, and identity [1, 8, 7, 6]. Previous studies have shown that effects of biological motion continue to be salient despite having its constituent point-light dots masked or reallocated [3, 2]. Accordingly, observance of biological motion is sensitive in pinpointing not only locations of interest, but also social goals and intentions [16].

The exact behavioral processes of biological motion remain elusive. Support exists both for form-based information, including posture or facing direction, and motion-based information [11]. While form and motion may appear superficially as two distinct entities, separated by a clear temporal dimension, further studies have shown that form-based information also requires temporal integration over multiple frames in an appropriate time window to gather sufficient information for biological motion related tasks [12]. This conflict illustrates how the constituents of biological motion play crucial roles in modulating the effects of point-light displays on aspects of behavior. In the present study, we focus on how biological motion and the point-light model affect attention through the established Posner paradigm. The protocol of this visual attention paradigm presents a central cue proceeded by a peripheral target [15]. Subjects typically respond more rapidly to targets appearing on the congruent side of the cue, as a consequent effect of cued attention to the target location. To date, multiple biological features have been shown to impact the attention orienting system of the observer [9].

Previous studies have confirmed that a forward point-light walker efficiently models as a cue for the Posner paradigm and suggested movement is a salient cue in the attention orienting system, with participants showing higher accuracy ratings after presented with movement congruent cues [13]. This further provides evidence for the motion-based theory of biological motion processing. However, the previously mentioned study used strictly the forward walker, where the orientation in posture and movement direction of the cue always remained congruent; thus, it is difficult to assign the effects observed in accuracy ratings to either posture or movement.

Although point-light displays are simple and elegant, one major drawback is the inability to manipulate certain portions of the figure. A common occurrence in observed biology is when head orientation differs in direction from the overall motion of a figure. Point-light displays cannot account for this discrepancy, so we modeled this phenomenon with backward walking. We aim to disentangle form-based from motion-based information by incorporating both forward and backward point-light walkers. This in turn uncouples the two variables and allows us to individually analyze their effects on reaction time and accuracy ratings. The cue with greater influence on attention orientation is expected to produce faster response times with higher accuracy ratings for congruent than incongruent targets, an effect predicted to be significantly less pronounced in the less influential cue.

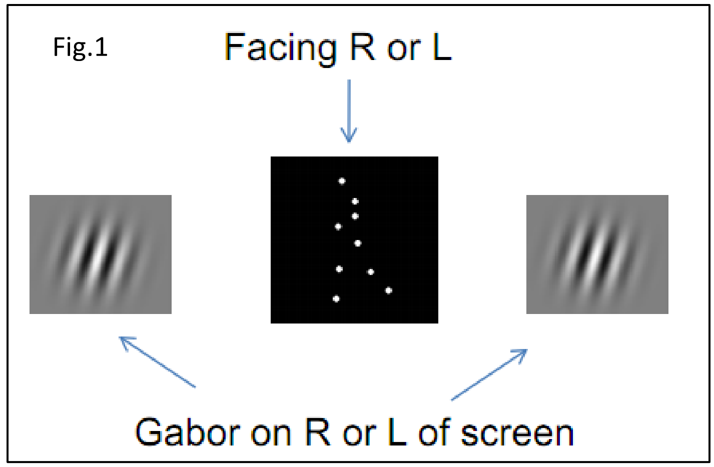
2. Methods

2.1 Subjects

A total of 38 (21 for Protocol 1, 17 for Protocol 2) student participants, ages 16-30, from the University of California, San Diego were tested. All were naive to the aims of the study, reported normal or corrected-to-normal visual acuity, and gave prior informed consent.

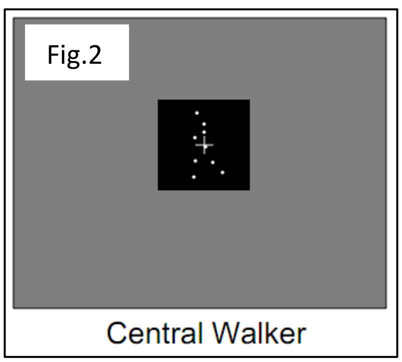
2.2 Stimuli and Apparatus

The study used a white point-light walker, Gabor, black fixation cross, and a continuous gray background. The point-light walker, facing either left or right, was represented by a sequence of 12 moving dots on an invisible body to simulate the figure and movement of a walking human through 20 frames. Backward walking was created by playing this sequence in reverse. Gabor is a circular patch of black and white grating with orientation tilted ±5 degrees of the vertical. Subjects were asked to fixate on the fixation cross throughout the experiment. MATLAB (Mathwords, Inc) with extensions from Psychophysics Toolbox [4, 14] generated all stimuli onto a CRT color monitor (1280x960 pixels spatial resolution; 90 Hz refresh rate).



*All background for Gabor and walker are always gray. Shown in false color for illustration purposes.

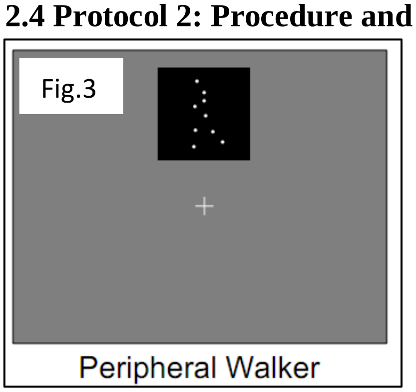
2.3 Protocol 1: Procedure and Design



Before starting the experiment, each individual subject was given verbal and printed instructions detailing the task. Testing occurred in a dimly illuminated room. Trials began with a continuous central fixation cross; after 100 ms, trials were presented with the central cue, either a forwards or backwards moving point-light walker for 500 ms. After the cue was an inter-stimulus interval for 100 ms, preceding the target of a tilted Gabor presented at either side of fixation for 100 ms. Subjects pressed a corresponding button to indicate perceived orientation of the Gabor before reaching an inter-trial interval prompting the participant to begin the next trial by pressing the spacebar. The session began with a practice of 19 trials, followed by two experimental blocks, each consisting 80 trials, separated by a 10 second break.

Protocol 1 established the effects on reaction time (RT) and accuracy rating (ACC), using a within-subject balanced order design with factors: left or right facing direction of the walker (FACE), forward or backward motion of the walker (WALK), left or right side of fixation Gabor appeared (GS), left or right orientation of the Gabor (GT), and the leftward or rightward motion of the walker (MOT). MOT was defined, from both FACE and WALK, as the overall movement of the walker. Facing right and walking backwards resulted in the same MOT as facing left and walking forward.

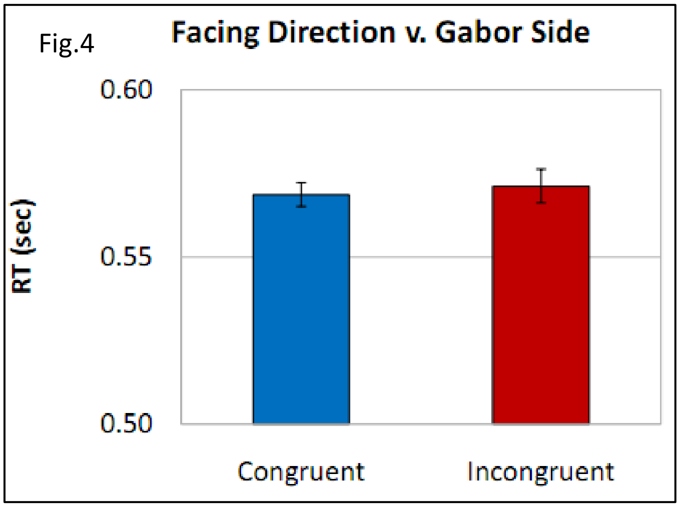
2.4 Protocol 2: Procedure and Design

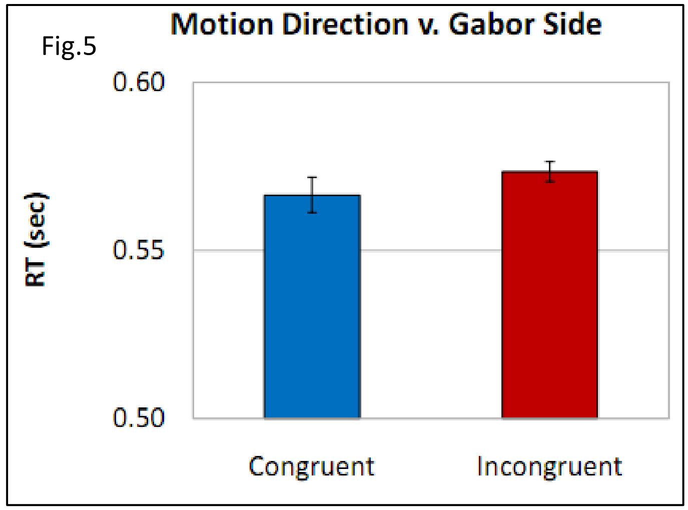


Protocol 2 is identical to Protocol 1 (see 2.2), with the addition of scrambled walkers. The session began and ended with two blocks, each with 160 randomized trials. Orders of test conditions were balanced between subjects. Effects of central figures versus peripheral figures were also tested. Protocol 2 modified Protocol 1 by presenting scrambled figures in half of the total trials. Scrambled figures contained two random dots (central figure) or five random dots (peripheral figure) in the point-light figure that were displaced with a Gaussian frequency, but retained the original movement vector. Participants were instructed to press a corresponding key upon seeing the scrambled figure. All other intact figures followed Protocol 1.

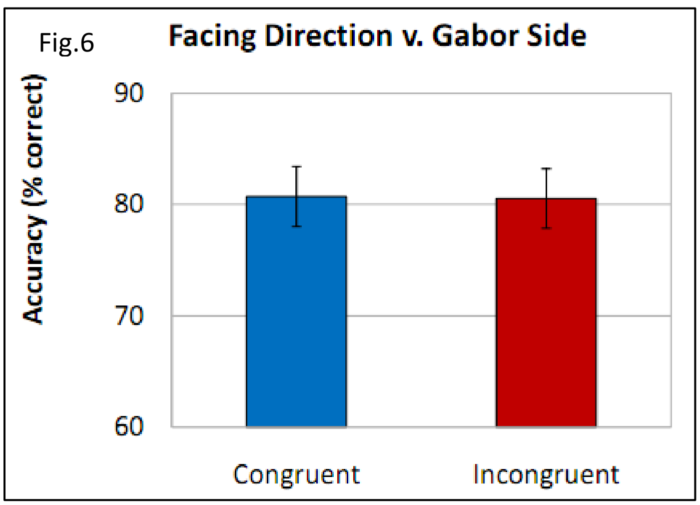
3. Results

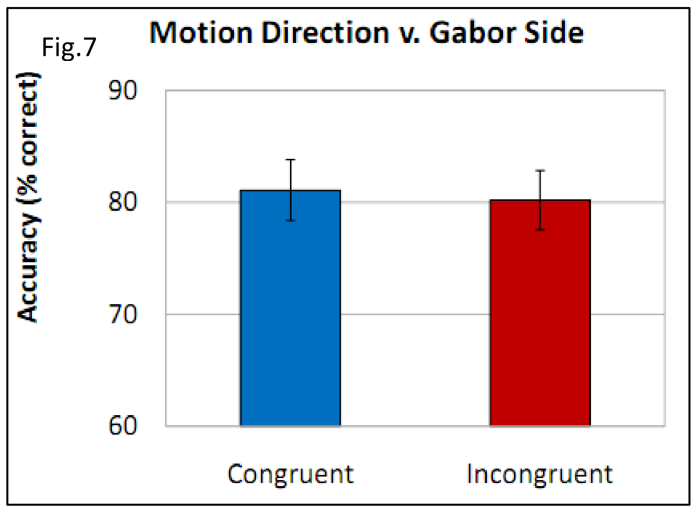
3.1 Protocol 1





The study identified the impact of facing direction (FACE) as a cue using a 2 (FACE) x 2 (WALK) x 2 (GS) x 2 (GT) repeated-measures analysis of variance (ANOVA) to evaluate mean reaction times and accuracy ratings. To assess the impact of walking direction as a cue, a 2 (MOT) x 2 (WALK) x 2 (GS) x 2 (GT) ANOVA was used. ANOVA results revealed that GS significantly correlated with GT in both reaction time (RT) and accuracy (ACC), ($p<0.005$; $p<0.05$). No significant interactions of RT or ACC involving FACE or MOT were consistently reflected in the dataset. See Fig. 4-7.





3.2 Protocol 2

ANOVA revealed significant effects of accuracy ratings between MOT and GS congruencies ($p<0.001$). Congruent trials showed accuracy values were at 93.6% and incongruent were at 89.9%. Significant results were also observed between FACE and GS congruencies ($p<0.05$) in terms of reaction time. Congruent trials showed reaction times at 0.652 sec and incongruent were at 0.675 sec. Other interactions of RT or ACC involving FACE or MOT showed no evidence of significance in the ANOVA test. See Fig 8-9.

Fig.8

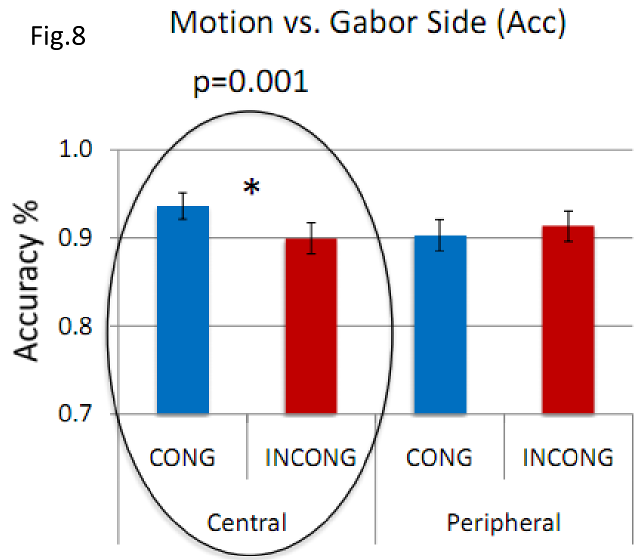
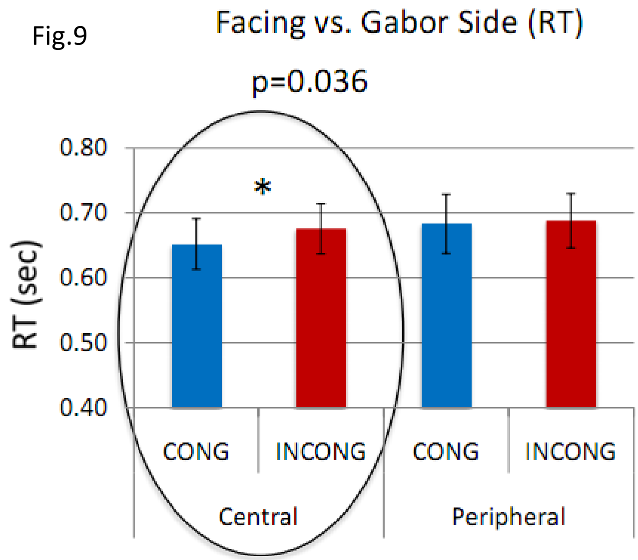


Fig.9



4. Discussion

The experiments described in the present study were designed to investigate the roles of a facing direction and motion direction, in mediating attention through the use of a point-light walker.

In Protocol 1, the data shows no indication that either FACE or MOT cued attention. ANOVA results of reaction times and accuracy ratings showed no significance difference between the congruent and incongruent sides. The results of Shi *et al*. (2010) were not replicated in Protocol 1, suggesting an underlying deviation in the participants' task in the testing conditions. We believe this discrepancy to be attributed mostly to the passive cue. As a passive cue, the point-light walker was not explicitly linked to the task. The data suggests that when passively viewed, biological motion is too subtle as a cue for the Posner paradigm.

Controlled for active viewing, Protocol 2 introduced scrambled point-light walkers to ensure active viewing by placing attention demand at every cue. In reviewing the results, congruency significances were observed between MOT and GS for accuracy ratings and between FACE and GS for reaction times. MOT and GS congruent trials showed higher accuracy ratings than its incongruent trials, suggesting that when the direction of motion and the side of the Gabor are congruent, this secures the accuracy of the response by directing of cognitive attention to the target side. In contrast, FACE and GS congruent trials exhibited significantly faster response times than its incongruent trials. This shows that the facing direction of the point-light figure directs attention to the side of the Gabor with the least amount of time when the cue and target are congruent.

This raises an interesting question on the possible interaction between these two sets of congruencies. We propose a two-layer independent stratification in the process of orienting attention with congruency to GS. The facing direction congruency is the primary and elicits a fast response. The motion direction congruency, seen over multiple time frames, is the secondary and supports attention through accuracy. An alternative explanation is that the two variables are dependent of each other where the more accurate trials were completed with slower response times. A more detailed analysis is integral in understanding the mechanisms behind orienting attention, possibly an aim for future studies.

Acknowledgments

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