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Last but not least

A chimeric point-light walker

Abstract. Ambiguity has long been used as a probe into visual processing. Here, we describe a new dynamic ambiguous figure—the chimeric point-light walker—which we hope will prove to be a useful tool for exploring biological motion. We begin by describing the construction of the stimulus and discussing the compelling finding that, when presented in a mask, observers consistently fail to notice anything odd about the walker, reporting instead that they are watching an unambiguous figure moving either to the left or right. Some observers report that the initial percept fluctuates, moving first to the left, then to the right, or vice versa; others always perceive a constant direction. All observers, when briefly shown the unmasked ambiguous figure, have no difficulty in perceiving the novel motion pattern once the mask is returned. These two findings—the initial report of unambiguous motion and the subsequent 'primed' perception of the ambiguity—are both consistent with an important role for top – down processing in biological motion. We conclude by suggesting several domains within the realm of biological-motion processing where this simple stimulus may prove to be useful.

1 Introduction

Johansson's (1973, 1975) point-light displays have long proven to be a useful tool for exploring the processing of biological motion. In such displays, the details of the human form are reduced to small patches of light located at each of the major joints. When these points are set in motion, the spatiotemporal pattern they create can quickly and easily convey a wealth of information about the actor and/or the action being portrayed. Indeed, even when motion is only implied by the context, as in figure 1, a clear sense of a human

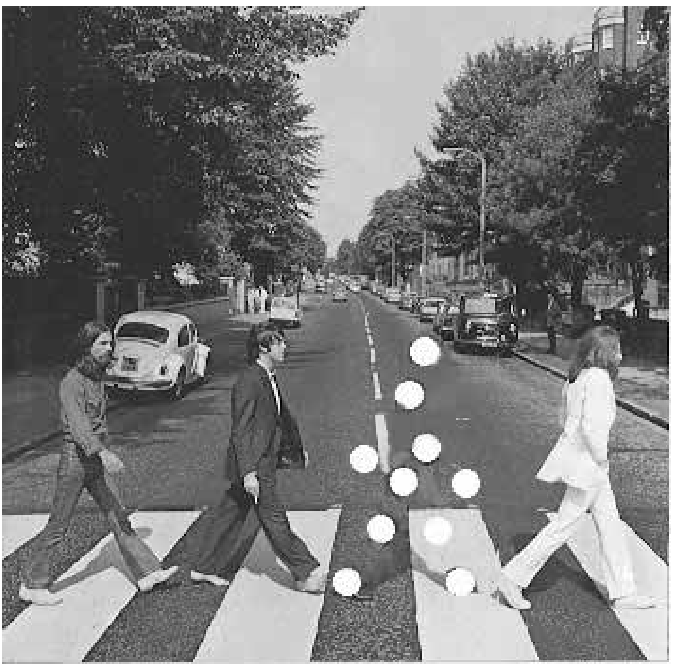

Figure 1. Point-light Ringo. The Beatles' Abbey Road album cover has been altered to demonstrate how a human form can easily be recovered from a few points of light when real or implied motion is present. (Original photograph by Iain MacMillan 1969, copyright Apple Corps Ltd; figure adapted from Thornton and Shiffrar 1996.)

form in action can still be obtained. Over the past 30 years, a number of researchers have employed point-light stimuli to explore the sensitivity of the visual system to objects and actions defined primarily by biological motion (eg Ahlström et al 1997; Bertenthal and Pinto 1994; Dittrich 1993; Kozlowski and Cutting 1977, 1978; Mather et al 1992; Pavlov and Sokolov 2000; Sumi 1984; Thornton et al 1998; Troje 2002; Verfaillie 1993).

Recently, Jan Vanrie and colleagues demonstrated that symmetric forms of these point-light figures are perceptually bistable. For instance, a figure walking towards an observer at 45°, travelling from 11 o'clock to 5 o'clock, can also be seen as a figure moving away from the observer at 45°, from 7 o'clock to 1 o'clock (Vanrie et al 2003). In other areas of vision research, relatively simple static ambiguous figures, such as the Necker cube (Gregory 1970; Necker 1832) and the hawk–duck illusion (Bernstein and Cooper 1997; Tinbergen 1939), as well as dynamic ambiguous displays, such as motion-defined rotating cylinders (eg Hiris and Blake 1996) and Ternus displays (Burt and Sperling 1981; Ternus 1926/1955), have long been used to explore the mechanisms of perception. Ambiguous point-light walkers are appealing as they may provide novel insights into the way we process biological motion.

The purpose of this brief report is to introduce a new form of dynamic ambiguous figure—the chimeric point-light walker. We begin by describing the new stimulus and detailing the simple technique used to create it. Next, we discuss how such figures, when combined with concurrent noise masks, provide a powerful demonstration of top–down processing of dynamic stimuli. In the remainder of the paper, we outline a number of potential research areas where we feel this stimulus could be applied, and briefly present some initial empirical findings.

2 The stimuli

Chimera are mythical creatures that typically contain body parts from several different animals. The first mention of them comes from Book VI of Homer's *Illiad*, where he describes a fire-breathing lion-goat-snake, a "savage monster", that was killed by Bellerophon with a little guidance from above (Homer, 800 BC, 1961). A modern and much less dangerous relative of this creature is shown in figure 2. The chimeric point-light walker is a composite of two walking figures, one facing and moving to the left, the other to the right.[(1)] Such a figure is potentially interesting for studying biological motion as it is both statically and dynamically ambiguous. That is, in the absence of translation cues (ie when it is moving on the spot, as if on a treadmill), the chimeric point-light walker simultaneously contains equal motion cues to the left and to the right.

Figure 2 shows how a chimeric point-light walker can be constructed in three simple stages.[(2)] First, two standard point-light figures are generated, one facing and

[(1)] We chose to call this stimulus a 'chimeric' point-light walker, rather than simply an ambiguous or bistable walker, to capture the general concept of putting two oppositely moving walkers together. As described in more detail below, the actual stimulus creation process also involves a good deal of averaging or blending dots from several body parts. Nevertheless, while such blending contributes to the figure's ambiguity, its potential for bistability comes mainly from the unaltered, combined parts of the two separate figures. Also, while we are not combining different species, as in the classical sense of chimera, in general usage the term can also refer to any figure composed of incongruous parts, and in the neuropsychological literature 'chimeric' faces made from the left and right side of different images have long proven to be a useful tool (eg Carbary et al 2001; Lior and Nachson 1999).

[(2)] These stages are illustrated for a single point in the gait cycle, and need to be repeated for each animation frame or time sample in order to create the dynamic walker. Furthermore, throughout this paper we have concerned ourselves with a simple 2-D version of the chimeric walker created by adapting Cutting's (1978) classic algorithm for synthetic gait patterns. Clearly other 2-D or 3-D methods for creating point-light stimuli, such as motion capture, computer animation, or video capture (see Dekeyser et al 2002, for a review) could also be adapted.

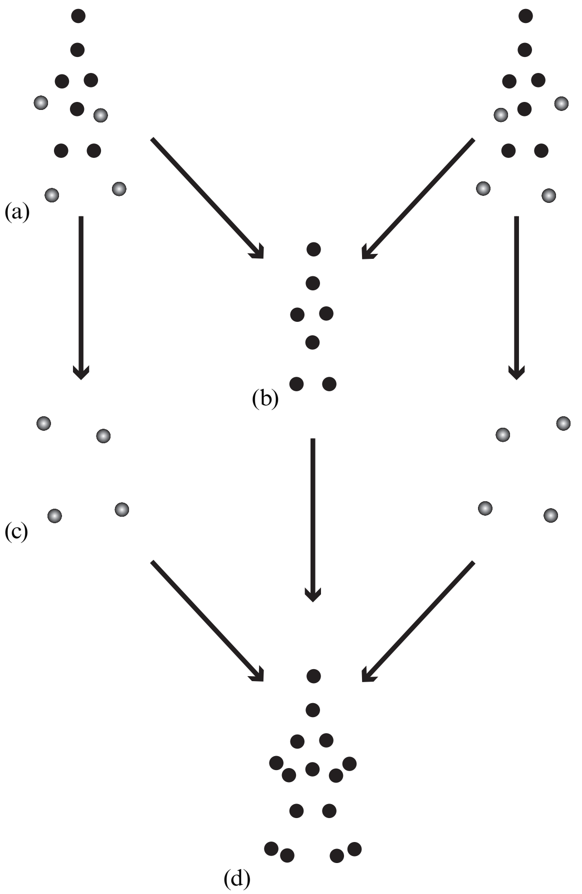

Figure 2. Making a chimeric point-light walker: (a) Two unambiguous point-light figures are generated, one facing to the left, the other to the right. The wrist and ankle dots are highlighted for illustrative purposes. (b) Corresponding head, shoulder, elbow, hip, and knees dots from the two walkers are averaged to produce a single, common frame for the ambiguous figure. (c) The two sets of ankle and wrist dots are added to the common frame. (d) The resulting chimeric figure (centre) is completely ambiguous, containing equal motion to the left and right.

moving to the left, and one facing and moving to the right (figure 2a). These unambiguous figures each consists of 11 points (head, forward shoulder, forward hip, two elbows, two wrists, two ankles, and two knees) and are animated without occlusion cues. Conceptually, the next step is simply to spatiotemporally superimpose the two unambiguous figures. However, as unambiguous walkers typically contain body tilt, this process is achieved in two further steps in order to remove slight mismatches between the positions of most of the dots. Specifically, the x and y positions of the head, shoulder, hip, elbow, and knee dot pairs are first averaged to produce a single common body frame (figure 2b). The unmodified ankle and wrist dots from the two unambiguous figures are then added to this new composite body frame (figure 2c). When the 2 wrist and 2 ankle dots from each of the unambiguous component walkers are present, the chimeric walker contains equal motion to the left and to the right (figure 2d). To view a dynamic version of the chimeric walker, visit http://www.kyb.tuebingen.mpg.de/links/chimericwalker.html.

3 The mask

While the chimeric point-light walker contains equal motion to the left and to the right, the subjective impression of the basic figure is not of walking at all, but rather of some complex, non-directional, novel action. This impression changes dramatically when the figure is placed in a concurrent noise mask, a technique commonly used in studies of biological motion (eg Bertenthal and Pinto 1994; Cutting et al 1988). That is, when the chimeric walker is embedded in a field of additional moving elements, observers no longer perceive the ambiguous novel action, but instead report the presence of a single, unambiguous walking figure facing either to the left or to the right. For most observers, the directional percept is quite stable; others report that the walker seems to change direction, flipping from left to right or vice versa after taking a number of steps.[3]

This complete failure of observers to spontaneously perceive the ambiguous nature of the display is quite compelling. So far, in the laboratory and at symposia, we have shown this masked figure to upwards of 200 people. None has ever initially noticed that there is anything odd about the walking figure he/she reports seeing. When pressed to examine the figure more closely, some observers suggest that there may be something strange about the ankles or wrists, but they typically continue to see a uniquely directional figure. This finding is similar to that reported by Bülthoff et al (1998) for depth-scrambled walking figures. In their study, individual dots were placed at different depth planes from each other, although the x and y positions were consistent with a normal walker. When shown such displays, observers appeared to be completely unaware of any depth conflict in resolving and reporting a coherent point-light walker.

Interestingly, in our work, as soon as an observer is shown the basic, unmasked figure, he/she has no difficulty in retaining the impression of the complex, novel action once the mask is returned. This observation, that a brief exposure or priming with a target stimulus can help to resolve perceptual conflict, is reminiscent of findings from the perceptual learning literature (eg Furmanski and Engel 2000; Poggio et al 1992) and is consistent with Cavanagh's notion of "attentional sprites" (Cavanagh 1999; Cavanagh et al 2001). This notion suggests that complex motion perception can be mediated via the top – down influence of dynamic templates (Ullman 1984) which help parse the world according to prior experience.

4 Possible uses

Our hope is that the chimeric point-light walker will prove to be a useful tool for exploiting ambiguity in the context of biological motion. One obvious application area concerns the role of bottom – up (Giese and Poggio 2003; Johansson 1973, 1975; Mather et al 1992; Webb and Aggarwal 1982) versus top – down (Bertenthal and Pinto 1994; Bülthoff et al 1998; Dittrich 1993; Thornton et al 2002) processing of biological motion. The chimeric point-light walker is an ideal stimulus to explore the relationship between these two types of mechanism. For example, top – down contributions to the processing of biological motion could be examined by priming or cueing (Shiffrar and Pinto 2002; Verfaillie 1993, 2000) the expectations of an observer towards a particular direction

[3] For masking a chimeric point-light walker, dot density needs to be quite high, typically 10 or more additional points for each element in the figure. Also, we have found that adding a translational component to the mask greatly increases its effectiveness. We have mainly used two types of mask, a transparent motion mask, and a translating limb mask. The former simply contains two random fields of dots which translate in opposite directions. Adding a slight sinusoidal jitter to the individual dots can also be effective. This mask has the advantage that naïve observers can quickly locate the global figure, but the disadvantage that for some observers the mask can give rise to the perception of a rotating 3-D sphere, whose apparent, unambiguous direction of motion could influence the perceived direction of the target walker. The limb mask contains two fields of randomly positioned limbs, again translating in opposite directions. This mask does not give rise to a 3-D percept, but its complexity makes the presence of any global target that much harder to detect.

without having to change the physical stimuli. The impact of such top–down manipulations could then be examined across a range of display types where low-level parameters, such as mask type and density (Cutting et al 1988), mask direction (Fujimoto and Sato 2002), or motion quality (Mather et al 1992; Thornton et al 1998) compete for influence over the perceived direction.

The exploration of directional preferences (Chokron and Agostini 2000; Gaffron 1950; Levy 1976; McBeath et al 1992) or canonical viewpoints (Blanz et al 1999; Palmer et al 1981) for biological motion is another area where the chimeric walker could be quite useful. Of interest here is whether observers have an internal bias to favour some views of walkers over others. While previous studies have explored general questions of view invariance (Bülthoff and Bülthoff 2003; Verfaillie 1993, 2000), the impact of picture plane rotation (eg Pavlova and Sokolov 2000; Sumi 1984), changes in view height (Bülthoff and Bülthoff 2003), and the effects of forward-versus-backward articulation (Pavlova et al 2002), there is still little work that directly explores the issue of representational biases.

Recently, Vanrie et al (2003) demonstrated that observers have a marked preference for selecting approaching versus receding interpretations of a 3-D ambiguous point-light walker, even though the information in the display was unbiased in this respect. The chimeric point-light walker provides a similar opportunity to explore left–right directional preferences. As noted above, when shown in a mask, observers report seeing an unambiguous figure facing in one direction or the other. In one preliminary experiment we showed the chimeric walker embedded in a random mask of transparently translating, jittering dots, and asked observers to report the direction in which the figure appeared to face and move. All thirty-four observers saw an unambiguous figure, with thirteen reporting leftward motion and twenty-one reporting rightward motion. These proportions do suggest a slight rightward bias ($\chi_1 = 5.54$, $p < 0.05$) and this bias appeared to be independent of reported handedness, mask interpretation (2-D or 3-D pattern), or mask direction, although clearly these are only initial observations.

Finally, the chimeric walker may prove useful as a direction-neutral baseline or control stimulus for a number of tasks, such as priming (eg Shiffrar and Pinto 2002; Verfaillie 1993, 2000), interference (Thornton et al 2001), and visual search (Cavanagh et al 2001) which have recently been used to explore biological motion. For example, we have used a dynamic variant of the classic Eriksen interference paradigm (Eriksen and Eriksen 1974) to explore the impact that task-irrelevant flanking figures have on responses to a central target walker (Thornton et al 2001). Typically, direction discrimination responses to a central target are slower when the flankers face in a direction opposite to the target (incongruent condition) than when they face in the same direction (congruent condition). However, without a complexity-matched baseline, it is hard to know whether this pattern of reaction times arises owing to interference during incongruent trials, facilitation during congruent trials, or some combination of both. As the chimeric point-light walker simultaneously contains both left-facing and right-facing motion—ie is directionally neutral—it should provide a very useful baseline control condition against which to compare the speed of congruent and incongruent trials. In an initial study, chimeric control trials ($M = 470$ ms) were indistinguishable from congruent trials ($M = 470$ ms), while incongruent trials ($M = 484$ ms) were reliably slower ($t_{11} = 3.3$, $p < 0.01$), suggesting that interference rather than facilitation is the main factor in these flanker studies.

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