

Local-to-global form interference in biological motion perception

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Abstract Point-light walkers have been useful to study the contribution of form and motion to biological motion perception by manipulating the lifetime, number, or spatial distribution of the light points. Recent studies have also manipulated the light points themselves, replacing them with small images of objects. This manipulation degraded the recognizability of biological motion, particularly for local images of human bodies. This result suggests an interference of body form information in the local images with the body form analysis necessary for global biological motion recognition at the global level. We further explored this interference with respect to its selectivity for body orientation and motion. Participants had to either discriminate the facing direction (left/right) or the walking direction (forward/backward) of a global walker composed of local stick figures that could face left or right and either stand still or walk forward or backward. Local stick figures interfered stronger with the facing direction task if they were facing in the same direction as the global walker. Walking (forward/backward/static) of the stick figures influenced neither the facing direction task nor the walking direction task. We conclude that the interference is highly specific since it concerns not only the category (human form), but even the facing direction.

Keywords Motion · Biological · Similarity · Reaction time methods

Biological motion perception is often investigated with point-light stimuli, very sparse representations of human movement by a set of moving dots attached to the joints of a moving person (Johansson, 1973). Although early studies have understood biological motion perception as a process of motion vector analysis of the point-light motion (Johansson, 1973; Hoffman & Flinchbaugh, 1982; Webb & Aggarwal, 1982; Mather, Radford, & West, 1992; Giese & Poggio, 2003), recent work has put more emphasis on the contribution of form analysis of the spatial pattern of point light distribution on the body (Beintema & Lappe, 2002; Beintema, Oleksiak, & van Wezel, 2006; Giese & Poggio, 2003; Hiris, 2007; Lange, Georg, & Lappe, 2006; Lange & Lappe, 2006; Reid, Brooks, Blair, & van der Zwan, 2009; Thirkettle, Scott-Samuel, & Benton, 2010; Thompson, Clarke, Stewart, & Puce, 2005; Thurman, Giese, & Grossman, 2010; Lu, 2010). Most evidence for the importance of form analysis in biological motion perception was gathered in studies in which the spatiotemporal content of the point-light stimuli was manipulated, either by destroying the point-light motion correspondence between frames (Beintema & Lappe, 2002; Beintema et al., 2006; Kuhlmann, de Lussanet, & Lappe, 2009) or the temporal order of the walking cycle (Lange & Lappe, 2007; Reid et al., 2009), or by focusing on particular phases of the walking cycle and the associated body postures (Thurman & Grossman, 2008; Thirkettle, Benton, & Scott-Samuel, 2009; Thurman et al., 2010).

Some studies have taken an alternative approach to destroying information in the point-light walker. They added signals that interfered with form or motion-based information processing. For example, using small Gabor patches instead of point lights interferes with recognition performance such that performance is higher if the orientation of the Gabor patches is consistent with the orientation of the limbs (Lu, 2010; Thirkettle et al., 2010).

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Replacing the point lights with random objects also interferes with biological motion recognition (Hunt & Halper, 2008). This interference is automatic and occurs even when participants are fully aware that the stimulus presents biological motion and that the objects are mere distractors (Wittinghofer, de Lussanet, & Lappe, 2010). We have argued that the interference occurs because biological motion analysis uses processes of object recognition to connect the point-lights to the global shape of a human figure. When natural objects are presented instead of the point lights, their recognition draws object recognition resources away from the global walker recognition process, limiting recognition capacity at the global level and increasing error rates and reaction times (RTs). In support of this explanation, we have found that the strength of interference depends on similarity between the local object category and the global walker. Interference is stronger when the point lights are replaced by pictures of humans than when they are replaced by pictures of other object categories such as animals, vegetables, or vehicles (Wittinghofer et al., 2010). The similarity explanation predicts that global biological motion perception should be especially disrupted if the local stimuli consist themselves of biological motion stimuli.

Human form information can be used in biological motion processing by a two-step procedure: template matching of the static information of a single snapshot from the walking cycle and subsequent analysis of the temporal sequence of template activation (Beintema & Lappe, 2002; Giese & Poggio, 2003; Lange et al., 2006; Lange & Lappe, 2006). Interference with object recognition should then occur mostly in the template matching stage. Previous work has used different tasks to focus on the template matching stage or on the sequence analysis stage. The recognition of the left- or right-facing direction of a point-light walker needs only template matching in computational studies (Lee & Wong, 2004; Lange et al., 2006; Lange & Lappe, 2006) and can be done from static (Beintema et al., 2006; Reid et al., 2009) or temporally scrambled (Lange & Lappe, 2007) displays. Discrimination of the facing direction is thus an appropriate task to investigate template-matching properties of biological motion perception. The discrimination between a forward-walking stimulus and a backward-walking stimulus, on the other hand, cannot be done from template matching alone but needs temporal analysis. Discrimination of the walking direction is thus an appropriate task to study motion aspects of biological motion.

To investigate the interference between object recognition and biological motion recognition for template matching and sequence analysis, we measured RTs to global walkers composed of local walkers in both tasks. We manipulated the similarity between the local and the global walkers by manipulating the facing and the walking of the local walkers. In Experiments 1 and 2, we used static local

stick figures of walking humans to investigate the interference of static form similarity on biological motion perception. In Experiments 3 and 4, we used moving local walkers to investigate any influence of movement similarity of the local walkers to the global biological motion recognition.

Experiment 1

Influence of static stick-figure orientation in a left-versus right-facing direction task

Previous work showed that static human figures cause large interference with biological motion perception. In the present study, we wanted to test whether the facing direction of the local human figures affects the performance in the facing direction task. Assuming that similarity between global and local stimuli makes the task more difficult, we hypothesized that the reaction speed decreases if global and local walkers are facing in the same direction.

Method

The participant sat in a dimly lit room, 57 cm in front of an Iiyama Vision Master 505 computer monitor (1,024 x 768 pixels, 120 hz). A point-light walker consisting of stick figures was presented on the middle of the screen (Fig. 1).

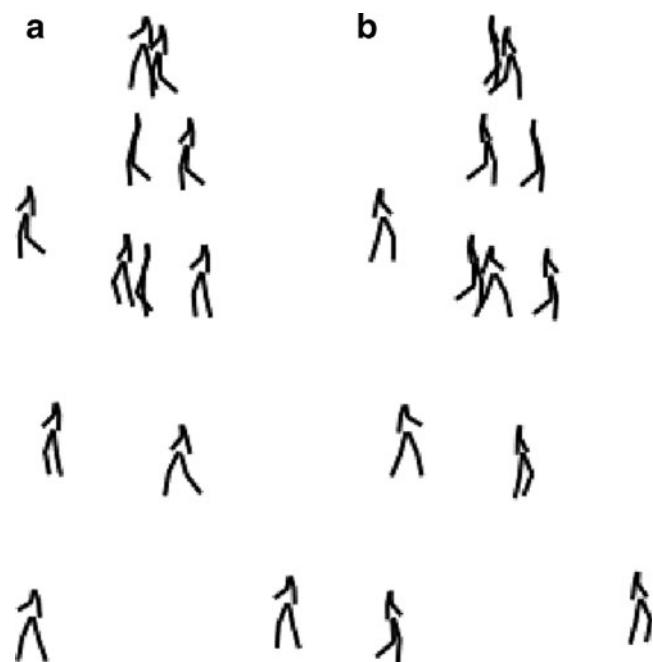


Fig. 1 Stimulus. In this example, both global walkers face to the left. Stimulus a: Global and local walkers facing in the same direction. Stimulus b: Global and local walkers facing in different directions. Notice that the global walker could also face to the left, and start phases of both levels were randomized in the experiment

The walker was based on motion-captured data of a walking human (Beintema et al., 2006). In the experiment, we showed the 12 positions representing the shoulders, hips, elbows, wrists, knees, and ankles. Horizontal translation was subtracted from the recorded walking, so that it looked like walking on a treadmill. The walker was presented from a side view, on a white background. The global walker could either face left or face right and walk forward or walk backward. The facing direction of the static local walkers could also be left or right. All stimulus conditions were randomly interleaved. The start phases of the walkers were randomly selected. The maximum dimensions of the global walker were 11.3 x 5.2 cm (11.2° x 5.2° viewing angle) in size. The local walkers were 1.6 x 0.9 cm (1.6° x 0.9° viewing angle) in size. This size for the local walkers was chosen to avoid overlapping between the local walkers while keeping them large enough to recognize them.

The participant had to decide as quickly as possible whether the global walker faced left or right and to respond by pressing the arrow keys of the keyboard connected to the operating computer (Apple MacBook Pro, OS X 10.5.6). Each stimulus was shown until the participant responded, but no longer than 5 s. Thereafter, the next trial started. The experiment comprised 80 trials for each participant. Since recognition of a walker composed of complex objects is a difficult task for naive subjects (Hunt & Halper, 2008), we preceded the data collection by a block of practice trials to achieve steady performance. The participants performed two blocks of practice trials before data collection started. We first presented some classical walker trials to make the participants familiar with the task in general, and after that, we presented additional practice trials to familiarize them with this unusual kind of stimulus. The practice trials were similar to the test trials except for the local objects. In the classical walker block, the local objects were just points (120 trials each), and in the other block, the local objects were inverted walkers (320 trials).

Twelve participants (five male) between 20 and 29 years old (average age of 24.5 years) participated in the experiment. All participants had normal or corrected-to-normal vision and were naive to the purpose of the experiment. Before the testing started, they were informed that they had to concentrate only on the task and to ignore the local walkers, because they were irrelevant.

Data analysis

We measured RTs for the recognition of the facing direction of the global walker. We compared data in conditions in which the local walkers faced in the same direction as the global walker with data in conditions in which the local walkers faced in the opposite direction as the global walker. There were 40 RT measurements for each participant per condition.

Statistical analysis of reaction time data Because RTs are not normally distributed but positively skewed, the mean does not represent the most likely RT, and the conditions for parametric statistical tests are not fulfilled. The RT data were therefore analyzed by transforming RTs to reaction speeds (1/RT) to yield an approximately symmetric distribution (van Zandt, 2002). This procedure avoids the use of outlier rejection and allows one to use the mean and associated statistical procedures (van Zandt, 2002). To make it easier for the reader to interpret our results, we reported RTs in the Results section as well.

Use of reaction time and accuracy The recognition of point-light walkers is very easy, even for inexperienced participants. It becomes more difficult if the classical point lights are replaced by complex objects (Hunt & Halper, 2008), but even in this case, participants are very accurate in deciding about the walking direction (Wittinghofer et al., 2010). Because we, therefore, expected ceiling effects in accuracy, we decided to measure RTs. Participants were explicitly instructed to answer as fast as possible.

The data showed that error rates were indeed very low. In order to verify that measured effects in reaction speed were not due to speed–accuracy trade-offs, we compared error rates for those conditions that showed significant reaction speed differences. A speed–accuracy trade-off predicts that error rates increase when RTs become shorter. Furthermore, we included both correct and incorrect responses in the reaction speed analysis to avoid biased data rejection (van Zandt, 2002). In addition, as a control, we calculated the same for the data excluding the error trials. We thus verified that the same statistical results occur if only correct trials are analyzed.

Results and discussion

To compare the reaction speeds, we computed a paired *t* test for the influence of facing direction. We grouped the trials into same and different facing on global and local level. Participants were very accurate in their responses and reached 94% correct responses on average.

For the left- and right-facing tasks, we found a significant effect for facing of the static stick-figures, $t(9) = -2.4$, $p = .038$). The same facing direction of global and local walkers led to lower performance (Fig. 2). The mean reaction speed for global and local walkers oriented to the same direction was 1.602 s^{-1} (RT = 0.62 s), and for different orientations, it was 1.723 s^{-1} (RT = 0.58 s). The mean error rate was 6.75% for same and 5.25% for different facing directions. This difference in error rates is inconsistent with a speed–accuracy tradeoff, which would predict higher error rates in the condition with faster RTs—that is, the "same"

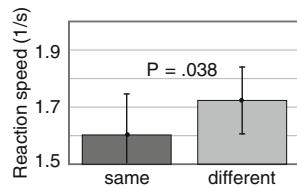


Fig. 2 Results of [Experiment 1](#). The bar charts show the reaction speeds and standard errors for the data of the facing direction task (left/right). The global walker was made up by static local stick figures. The data are split by the same- or different-facing direction of global and local walkers. If the facing direction of the local stimuli is the same as the facing direction of the global walker, then reaction speed is lower and it takes longer to decide whether the global walker faces left or right

condition. Thus, the significant difference in reaction speeds cannot be explained by a speed–accuracy trade-off.

As was expected, a greater similarity between global and local figures led to slower reactions. If the facing direction of the interfering local stimuli is the same as the facing direction of the global walker, it takes longer to decide whether the global walker faces left or right. This confirms the similarity explanation put forward in our previous study (Wittringhofer et al., 2010) and extends the similarity to the facing direction (i.e., orientation) of the walker. It suggests that the interference takes place in a representation that is specific for the orientation of the stimulus, such as the template level proposed in recent modeling work (Lange et al., 2006; Lange & Lappe, 2006).

Experiment 2

Influence of static stick-figure orientation in a forward- versus backward-walking task

Method

In [Experiment 2](#), we used the same stimuli and procedures as in [Experiment 1](#). However, participants were now requested to discriminate whether the global walker walked forward or backward. Hence, the factor of interest (same or different facing direction) was not related to response categories of the task.

Ten participants (two male) between 19 and 28 years old (average age of 22.1 years) participated in the experiment. All of the participants had normal or corrected-to-normal vision and were naive to the purpose of the experiment.

Results and discussion

Reaction speeds of trials in which the facing direction of the local stimuli was the same as the facing direction of the global stimulus were compared to those of trials in which

local and global facing directions were different. The comparison showed no significant differences in reaction speeds between those two conditions [Fig. 3, $t(11) = 2.0, p = .072$]. The mean reaction speed for trials in which global and local walkers faced same direction was 1.37 s^{-1} (RT = 0.73 s), and for different directions, it was 1.31 s^{-1} (RT = 0.76 s). Participants reached 97.8% correct responses, on average.

These results suggest that the facing direction of the local stimuli did not interfere with the discrimination between forward and backward walking at the global level. This is surprising, because earlier work using the forward/backward task had shown that replacing the dots of a point-light walker with stick figures in general interferes with the reaction’s speed in the forward/backward discrimination. For example, participants were faster in forward/backward discrimination if the global walker consisted of inverted stick figures as compared with upright stick figures (Wittringhofer et al., 2010). Taken together, these two results suggest that the presence of local human figures interferes with the forward/backward discrimination but does so independently of the facing direction of the figures.

Experiment 3

Influence of walking stick figures in a left- versus right-facing direction task

In [Experiments 1](#) and [2](#), we showed that the orientation of the local stick figures influenced RT in the facing direction task but not in the walking direction task. In the next two experiments, we tested whether the walking direction of the local walkers influenced RTs in those tasks when the local walker was set into walking motion. We first investigated how walking local stick figures (with translational motion subtracted) interfere with global facing discrimination. For this, we determined the influence of both the facing and the walking directions of the local stick figures on the global facing task.

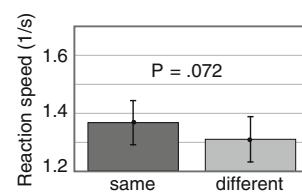


Fig. 3 Results of [Experiment 2](#). The bar charts show the data of the walking direction task (forward/backward) with static local stick figures. As in Fig. 2, the data are split by the same or different orientation. The comparison showed no significant differences in reaction speeds between those two conditions

Method

In [Experiment 3](#), we used the same stimuli and procedures as in [Experiment 1](#), with the exception that the stick figures walked forward or backward (with translational motion subtracted). Because two local walking directions were used, the number of trials was 160. Global as well as local walkers could face left or right and walk forward or backward. The participants had to report whether the global walker faced left or right by pressing the arrow keys.

Ten participants (two male) between 19 and 28 years old (average age of 22.1 years) participated in the experiment. All of the participants had normal or corrected-to-normal vision and were naive to the purpose of the experiment. Before the testing started, they were informed that they had to concentrate only on the task and to ignore the local walkers, because they were irrelevant.

Results and discussion

Because the stimuli in [Experiment 3](#) had not only a facing but also a moving direction, we calculated reaction speeds for three different comparisons.

First, we compared same- and different-facing directions (left/right) between local and global walkers. Reaction speeds showed a significant effect of facing direction, $t(9) = -2.7, p = .024$. Participants were slower in deciding whether the global walker faced to the left or to the right, when local and global walkers faced in the same direction ([Fig. 4a](#)). The mean reaction speed for global and local walkers facing in the same direction was 1.62 s^{-1} (RT = 0.62 s) and for different facing directions it was 1.75 s^{-1} (RT = 0.57 s). Participants were very accurate in their responses. They reached 94.6% correct, on average. The mean error rate was 8% for same- and 2.75% for different-facing directions. Like in [Experiment 1](#), this difference in error rates is opposite to the prediction of a speed–accuracy

trade-off. Thus, the significant difference in reaction speeds cannot be explained by a speed–accuracy trade-off.

Next, we compared trials in which local and global walkers walked both forward or backward with trials in which local and global walkers walked differently (local forward/global backward, or vice versa). There was no significant difference in reaction speed between those cases [[Fig. 4b](#), $t(9) = -.4, p = .701$]. The mean reaction speed for global and local walkers walking in the same direction was 1.68 s^{-1} (RT = 0.60 s), and for different walking directions, it was 1.69 s^{-1} (RT = 0.59 s).

Third, we compared trials in which both local and global walkers walked to the left (or right) to trials in which local and global walkers walked in different directions. In this comparison, walking to the left meant either that the walker faced to the left and walked forward, or that the walker faced to the right and walked backward. Both conditions would correspond to a net walking direction to the left and were considered together in this analysis. There was no significant difference between the conditions [[Fig. 4c](#), $t(9) = 1.5, p = .178$]. The mean reaction speed for trials in which global and local walkers walked in the same direction was 1.7 s^{-1} (RT = 0.59 s), and for different walking directions it was 1.67 s^{-1} (RT = 0.60 s).

The results of [Experiment 3](#), therefore, show that only in the left- as compared with the right-facing direction task was performance impaired when global and local stick figures faced in the same directions. This results fits well with the results of [Experiment 1](#), in which the stimulus consisted of static local stick figures. We therefore conclude that the interference caused by the facing direction of the task-irrelevant local figures is independent of their motion. It made no difference whether the local walkers walked forward or backward, or whether they walked left or right. Thus, we conclude that only the facing direction and not the walking direction of the local stick figures interferes with the perception of the global walker in a facing direction task.

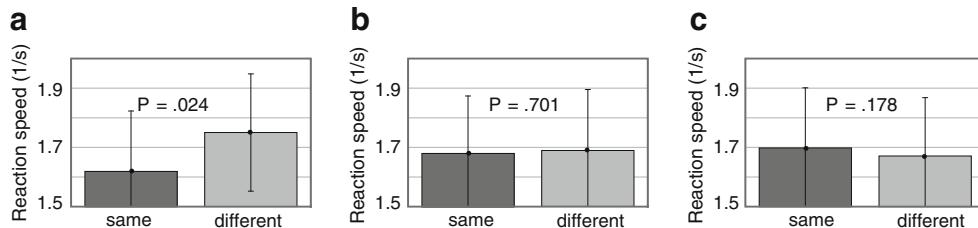


Fig. 4 Results of [Experiment 3](#). The bar charts show the data of the left/right task. In this experiment, the global walker was made up by local stick figures that were walking as if on a treadmill. On the left side (**a**), the data are split a by same- or different-facing direction (left/right) of global and local walkers. In the middle (**b**), the data are split by the same or different walking direction (forward/backward). The bar chart on the right side (**c**) shows the data split by same or different walking direction (left/right). The walking direction (left/right) of a

walker will be defined by the combination of facing and walking direction, as has been explained in the Method section. Reaction speed was lower—that is, participants were slower in deciding whether the global walker faced to the left or to the right—when local and global walkers faced in the same direction (**a**). There were no significant differences in reaction speeds for same or different walking directions (**b** and **c**)

Experiment 4

Influence of walking stick-figures in a forward-versus backward-walking task

From the results of [Experiments 1](#) and [2](#), we have learned that the specific interference of the facing direction of the local walkers is task dependent. The facing direction of the stick-figures had a significant influence only in the facing direction task but not in the walking direction task. It remains possible, however, that walking local stick figures have an influence in the walking direction task because in this case, the local stick figures as well as the task involve walking. In the fourth experiment, we measured the influence of walking stick figures in a forward- versus a backward-walking discrimination task.

Method

The experimental settings and the data analysis were the same as in [Experiment 3](#). Participants were asked to report whether the global walker walked forward or backward. Ten subjects (two male) between 19 and 28 years old (average age of 22.1 years) participated in the experiment. All had normal or corrected-to-normal vision and were naive to the purpose of the experiment.

Results and discussion

As in the preceding experiments, participants were very accurate in their responses (92.3% correct on average). In the analysis of the reaction speeds, we did not find a significant effect for facing direction [Fig. [5a](#), $t(9) = -1.1$, $p = .304$], walking direction [Fig. [5b](#), $t(9) = -0.7$, $p = .994$], or for the comparison between trials in which both local and global walkers walked to the left (or right) and trials in which local and global walker walked in different directions [Fig. [5c](#), $t(9) = 1.0$, $p = .351$].

The mean reaction speed for global walkers facing in the same direction was 1.38 s^{-1} ($\text{RT} = 0.72 \text{ s}$) and 1.41 s^{-1} ($\text{RT} = 0.71 \text{ s}$) for global walkers facing in different directions.

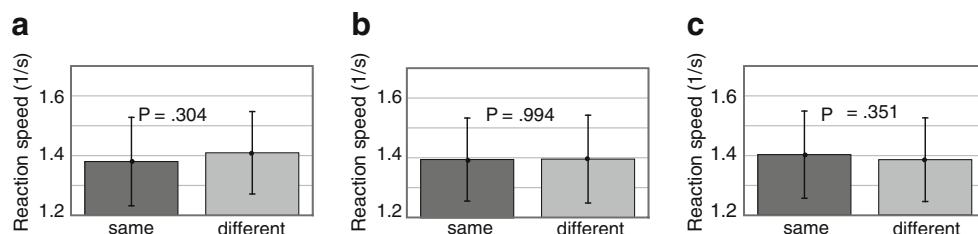


Fig. 5 Results of [Experiment 4](#). Data of the forward/backward task. The global walker consisted small walking stick figures. As in Fig. [4](#), the bar chart on the left (a) shows the effect of facing direction, the bar chart in the middle (b) shows the effect of walking direction (forward/

backward), and the bar chart on the left (c) shows the effect of walking direction (left/right). There were no significant differences in any of the comparisons

The mean reaction speed for trials in which global and local walkers walked in the same direction were 1.39 s^{-1} (walking forward/backward; $\text{RT} = 0.72 \text{ s}$) and 1.4 s^{-1} (walking left/right; $\text{RT} = 0.71 \text{ s}$), and for trials in which global and local walkers walked in different directions they were 1.4 s^{-1} (walking forward/backward; $\text{RT} = 0.71 \text{ s}$) and 1.39 s^{-1} (walking left/right; $\text{RT} = 0.72 \text{ s}$).

Thus, in the forward versus backward task, it did not matter whether the facing (left/right) or walking (forward/backward, left/right) direction of the task-irrelevant stick figures was the same or different as compared with the facing and walking directions of the global walker.

General discussion

Previous work showed that different categories of local objects (tools, vehicles, animals, humans) interfere with the recognition of biological motion (Wittinghofer et al., [2010](#)). In particular, human shapes cause the strongest interference, suggesting that the similarity between the local objects and the global walker is an important factor for the strength of interference. In the present investigation, we further explored the similarity between the local and the global figures with respect to their orientations and walking patterns. We did this in order to determine at which levels of biological motion processing in the brain such interference can occur. We found four new results. First, facing discrimination shows selective interference by the facing direction of local stimuli. Second, this interference is independent of the motion (walking vs. static) of the local stimuli. Third, forward versus backward discrimination is independent of the facing direction of local stimuli. Fourth, forward versus backward discrimination is also independent of the walking direction of the local stimuli. Thus, interference occurred at the facing level but not at the walking level, and for the facing tasks but not for the walking tasks.

Our data thus confirmed that the presence of complex objects interferes with the recognition of biological motion. This suggests that object recognition and biological motion share capacities (Wittinghofer et al., [2010](#)) and, therefore,

that biological motion recognition can be seen as a special case of object perception. The interference that we found may seem surprising, because many studies on the interactions in object perception show priming—that is, a facilitation of recognition performance when related objects are present in the surrounding scene (Henderson & Hollingworth, 1999). However, the interference we observed is consistent with previous studies of biological motion stimuli composed of objects (Hunt & Halper, 2008; Wittinghofer et al., 2010), suggesting that interference is prevalent in such conditions. Whether priming or interference occurs in object recognition depends on the specific paradigm and stimulus material (see, e.g. Henderson & Hollingworth, 1999).

We could speculate that both priming and interference occur concurrently in opposite directions when viewing a walker made from local objects. In this case, we would assume that the total influence on RT depends on task and stimulus conditions. For example, it is possible that in walking direction discrimination, a strong priming effect occurs, which compensates the interference effect found in facing direction discrimination, such that the overall RT is the same. Likewise, the relative size of the local walkers, task relevance of local objects, or stimulus type (point-light walker, stick figure, or fully illuminated body animations) may influence the balance between interference and priming. Indeed, the results of preliminary investigations with variants of our stimuli suggested the possibility of priming effects for facing direction—for example, when the walker stimulus was composed of arrows oriented to the left or to the right. Thus, interference as well as priming effects can be found in biological motion processing, depending on the specific methods used. Nonetheless, in the present investigation, we clearly showed interference of local stick figures with the recognition of a global point-light walker in a facing discrimination task.

Although biological motion stimuli lack much visual detail, they still contain different levels of information that are useful for recognition processes. In the following, we refer to local motion as the movement of each single stimulus dot. Global motion is the complex global pattern of human movement, which is conveyed by the sequence of body postures during walking or by the pattern of all dot movements. Each single body posture defines form information about the body.

One static posture of a human walking is sufficient to recognize the facing direction (Beintema et al., 2006; Reid et al., 2009). Thus, facing direction discrimination requires only form, not local or global motion processing. Our finding that facing recognition suffers from interference by static local walkers is consistent with a form-based analysis of biological motion for facing discrimination.

The performance in the facing direction task was slowed down when global and local stimuli faced in the same

direction. The global point-light walkers as well as the local stick figures are depictions of human bodies and contain static form information of body postures. The influence of the facing direction of the local stick figures can be explained by the relevance of form information for the facing direction task. Our results thus suggest that the automatic processing of the irrelevant local stick figures interferes with the facing direction discrimination for the global walker. Moreover, the interference depends on the facing direction of the local figures so the interference must occur at a level that is specific for the orientation of the body pose.

The interference of local facing direction on global facing discrimination provides information about the relevance of local motion for the recognition of the global walker. If the facing direction of the global walker would rely on motion analysis, the facing of the local stick figures should be irrelevant, since only the trajectory on which they move should matter. Each static local stick figure can be regarded as a shape that is fixed to a joint of the body, and that moves along with this joint. This joint-movement information is independent of whether the local object is facing left or facing right. Therefore, the facing-dependent interference cannot be explained by local motion processing.

Moving stick figures did not seem to interfere more strongly than static stick figures with the facing discrimination task. This suggests that the facing discrimination probably does not rely on motion signals, either local or global. If the facing discrimination would use local motion signals, moving local figures should provide more interference to the local motion system than static local figures and hence result in more total interference. Likewise, if the facing discrimination would use global motion signals, the walking local figures should produce more interference in the global motion system, also predicting more total interference. Thus, since the interference seems to be the same for static and for walking local figures, the task must predominantly rely on form, not on motion information. Thus, the specificity of the interference of the facing of local stick figures agrees well with proposals that form information is used in biological motion recognition (Beintema & Lappe, 2002; Beintema et al., 2006; Lange et al., 2006; Lu, 2010; Reid et al., 2009; Thirkettle et al., 2010; Thompson et al., 2005).

The walking direction discrimination task showed no interference from either the static or the walking local figures. There are at least three different possibilities why this may be the case. First, walking direction discrimination might be independent of facing direction—that is, the facing direction of a walker might be irrelevant for the decision of whether the stimulus walks forward or backward or to the left or right. Second, an unknown additional effect might compensate the interference of facing in the walking direction discrimination. For example, priming effects are opposite to interference and may mask any interference effect.

Third, because walking discrimination is a more demanding task than facing discrimination, it takes longer to decide about the walking direction than about the facing direction of a walker. Thus, if the interference lasts briefly, it may affect only the short RTs of the facing discrimination tasks, but not the longer RTs of the walking discrimination task. Further investigations are needed to substantiate these explanations.

Hunt and Halper (2008) related the impaired recognition of walkers consisting of different complex objects to attentional processes, proposing that complex objects draw attentional resources away from the main task. However, there is no reason to assume that local stick figures that face in the same direction as the global walker are more salient than ones that face in a different direction. Moreover, the circumstance that participants were told to ignore the local stick figures, makes it more likely that they attended only to the global walker.

Given that the participants were explicitly told to ignore the local walkers, it is remarkable that the local stimuli still affected the performance in the global walker recognition task. During the debriefing after the experiment, some participants informally reported that they never noticed that facing and walking directions were sometimes the same and sometimes different. This suggests that features of the irrelevant local walkers were processed in an automatic and subliminal way. We can thus conclude that even complex features such as the shape of the human body are processed automatically in the recognition of biological motion.

Together with the two previous studies of similar design, we observed a very specific and detailed interaction between object recognition and biological motion perception. When Hunt and Halper (2008) replaced the point lights of a walker with various simple geometrical objects, letters, faces, or complex objects, they found that participants who were naïve to the experiment purpose had difficulties in spontaneous recognition of a walker that was composed of objects other than simple point lights, and that complex objects had the most detrimental effect on recognition. These results showed an interaction between object perception and biological motion recognition that was stronger for complex objects than for simple ones. Wittinghofer et al. (2010) used images of human shapes, animals, tools, vegetables, or cars as local objects. All objects showed interference with RTs in a speeded walking discrimination task, but human shapes gave more impairment than any other tested object category. These results demonstrated that the interaction between object perception and biological motion recognition is specific to the object category and becomes even stronger when the objects are more similar to the walker. It suggests that the interference is caused by shared processing capacities between biological motion and human shape recognition.

In the present study, we explored this interference in more detail with respect to body form and body motion analysis. Our results show that form similarities influenced the facing direction discrimination down to the level of facing orientation. Walking direction similarities, on the other hand, had no influence on the reaction speeds, either in the facing direction discrimination or in the walking direction discrimination. The specific interference of the facing direction supports the hypothesis that the processing of body postures plays a major role in biological motion processing (Beintema & Lappe, 2002; Lange et al., 2006).

Following from the relevance of body postures and, more specifically, from the relevance of the facing direction for the recognition of biological motion, we assume that facing direction of human body postures is represented in the brain at one of the stages of biological motion perception. Other evidence for this comes from aftereffect studies (Jackson & Blake, 2010; Theusner, de Lussanet, & Lappe, 2011) and from imaging (Michels, Kleiser, de Lussanet, Seitz, & Lappe, 2009) and electrophysiological (Oram & Perret, 1996; Vangeneugden et al., 2011) investigations.

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