Perception of Biological Motion: Difference Between the Visual Fields and Comparison with Non-Biological Motion

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The present study investigated perception of biological motion (BM) focusing on two issues. Although it has been reported that the right posterior region of the superior temporal sulcus (pSTS) is more strongly activated than the left pSTS when viewing BM, the reason is not well understood. Second, most previous studies have focused on the accuracy of BM perception while reaction time (RT) to BM compared with other motion signals remains relatively unknown. BM and non-BM stimuli were briefly presented in each (left and right) visual field in Task 1. In Task 2, the same stimuli were displayed at the center. RT and accuracy were measured in both tasks. To explore a possible perceptual correlate of the neural anisotropy in the pSTS, RT and accuracy between the two visual fields were compared (Task 1). To examine the efficiency of BM processing, RT and accuracy differences between BM and non-BM were examined (Task 1 and Task 2). The result from Task 1 demonstrated that RT was faster and accuracy was higher when BM was presented in the left visual field. This suggests a perceptual correlate of greater right pSTS activation associated with BM perception. The results from Task 1 and Task 2 revealed that BM was detected more quickly and accurately than non-BM, suggesting that BM processing is more efficient than other global motion processing when information is limited by brief exposure. Analysis of error trials from the two tasks also suggests a perceptual bias of judging ambiguous motion signals as BM.

Key words : Biological motion, Visual field, Perception, Superior temporal sulcus (STS), Reaction time

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Perception of biological motion (BM), motion signals generated by other humans or animals, has a role in survival and is also instrumental for developing social skills in our society. A classic study by Johansson (1973) demonstrated that people are readily able to recognize human movement in which explicit form information is minimized by point-light animations that depict activities with only a couple of markers on the head and major joints of the body (see Figure 1). Several subsequent studies using point-light animations reported that BM perception is specific to orientation (Bertenthal & Pinto, 1994; Sumi, 1984), easily recognized even in masking elements (Bertenthal & Pinto, 1994; Cutting, Moore, & Morrison, 1988; Kim, Park, & Blake, 2011; Neri, Morrone, & Burr, 1998), extends to perception of gender (Cutting & Kozlowski, 1977; Mather & Mordoch, 1994), and social signals such as mood and intention (Dittrich, Troscianko, Lea, & Morgan, 1996; Loula, Prasad, Harber, & Shiffrar, 2005; MacArthur & Baron, 1983). Therefore, it has been suggested that a specialized mechanisms for BM processing exists in the visual system (Fox & McDaniel, 1982).

A number of brain imaging studies have attempted to identify neural circuits involved in BM processing (Blake & Shiffrar, 2007; Kim, 2012 for review). One reliable finding in those studies is that activation within the posterior end of the superior temporal sulcus (pSTS) is associated with viewing point-light BM sequence, but not with viewing sequences of scrambled BM (Beauchamp, Lee, Haxby, & Martin, 2003; Gr èzes, Fonlupt, Bertenthal, Delon-Martin, Segebarth, & Decety, 2001; Grossman & Blake, 2001, 2002; Pelphrey, Mitchell, McKeown, Goldstein, Allison, & McCarthy, 2003; Peuskens, Vanrie, Verfaillie, & Orban, 2005; Puce, Allison, Bentin, Gore, & McCarthy, 1998; Santi, Servos, Vatikiotis-Bateson, Kuratate, & Munhall, 2003; Vaina, Solomon, Chowdhury, Sinha, & Belliveau, 2001). In addition, the fusiform gyrus and the inferior temporal sulcus (ITS) in the ventral visual stream are also known to be activated by biological motion and form (Beauchamp et al., 2003; Bonda, Petrides, Ostry, & Evans, 1996; Grossman & Blake, 2002; Grossman, Jardine, & Pyles, 2010; Pelphrey, Morris, Michelich, Allison, & McCarthy, 2005; Santi et al., 2003).

An additional finding from past imaging studies is that blood-oxygen-level-dependent (BOLD) signals are stronger in the right pSTS than in the left pSTS when viewing BM stimuli (Beauchamp et al., 2003; Bonda et al., 1996; Gr èzes, Costes, & Decety, 1998, Grèzes et al., 2001; Grossman & Blake, 2001; Grossman, Donnelly, Price, Morgan, Pickens, Neighbor et al., 2000;Grossman & Blake, 2002, Grossman, Battelli, & Pascual-Leone, 2005; Kim et al., 2011; Pelphrey et al., 2003; Peuskens et al., 2005; Puce et al., 1998; Santi et al., 2003).

Such asymmetrical activation is not observed in other areas activated by BM. For instance, to the same parafoveal presentation of BM, the ITS and fusiform area are bilaterally activated while the pSTS is more strongly activated in the right hemisphere (Grossman & Blake, 2002; Grossman et al., 2010; Thompton, Clarke, Stewart, & Puce, 2005). With respect to the motion sensitive area MT (V5), bilateral activation is observed even when visual input is limited by hemianopia, probably via direct extrastriatel pathways or interhemispheric connection from the unaffected hemisphere (Brandt, Bucher, Seelos, & Dieterich, 1998). Therefore, greater activation to BM in the right pSTS appears unusual compared with other visual areas. A possible explanation for this would be some kind of functional lateralization; this however, has yet to be clarified.

One way to approach this issue is to explore any perceptual correlate of the asymmetrical activation. Some previous psychophysical works examined whether BM perception is invariant regardless of presentation in the peripheral visual field (Ikeda, Blake, & Watanabe, 2005; Gurnsey, Roddy, Ouhnan, & Troje, 2008; Gurnsey & Troje, 2010). However, there are only a few studies that compared performance on BM task between the two visual fields (e.g. Bradshaw, Nettleton, Wilson, & Nathan,1984; de Lussanet, Fadiga, Michels, Seitz, Kleiser, & Lappe, 2008);

those studies did not report an overall bias favoring one visual field over the other. The absence of perceptual sensitivity differences between the two visual fields might arise because the tasks were not conducive to revealing hemispheric differences in the activation strengths in the pSTS. Another consideration is that locating stimuli in one visual field may not only activate a single hemisphere, for receptive fields of neurons in the pSTS span the vertical meridian such that both ipsilateral and contralateral stimulation activates a given hemisphere (Bruce, Desimone, & Gross, 1981; Giese & Poggio, 2003). Reasoning that large receptive fields of this sort depend on callosal connections between hemispheres (Iwamura, 2000), and that the transfer of such information via corpus callosum requires extra time, a reaction time (RT) task should be a more appropriate means for uncovering a perceptual correlate of the generally stronger right pSTS activation in BM perception. The first purpose of the pr esent study, therefore, was to investigate whether RT to BM presented in the left visual field would be faster than in the right visual field, with the assumption that inputs to the left pSTS may be transferred to the right pSTS via callosal connection.

Furthermore, RT should be another important performance measure of BM processing in addition to accuracy. The importance of rapid

response to BM is evident if we imagine, for instance, emergency situations of finding predators in animals or finding pedestrians on our drive into the city. Regardless, most studies mentioned above have focused on the accuracy of detecting or discriminating between BM and non-BM (e.g. Cutting & Kozlowski, 1977; Mather & Murdoch, 1994; Neri, Luu, & Levi, 2006). In addition to potential RT differences between the two visual fields, it is relatively unknown whether BM perception is more rapid compared with non-biological complex motion. It has been suggested that "life detection" is automatically triggered by low-level local motion cues (Troje & Westoff, 2006). If so, it is possible to hypothesize that RT to BM would be faster than RT to other types of motion. Otherwise, accurate BM perception may require more time, which would be consistent with the typical speed-accuracy trade-off paradigm (Schouten & Bekker, 1967; Wickelgren, 1977). Thus, the second goal of the present study was to compare RT in BM perception with RT in non-BM perception.

Attempting to find answers to these two goals, I designed two tasks for use in the present study. In Task 1, BM or spatially perturbed motion was peripherally presented, and RT and accuracy were compared between the two visual fields, as well as between BM and spatially perturbed motion. Task 2 aimed to further compare BM perception with non-BM perception when stimuli were presented at the center, without the variable of visual field.

Methods

Participants   Twenty-four observers with normal or corrected-to-normal vision participated in the experiment. Mean(SD) age was 28.9 (9.7) years, ranging from 20-65 years.

Stimuli

Biological motion.   Biological motions portrayed by point-light display were presented on a CRT monitor (120Hz, M21L-0332, Image systems corporation, USA) controlled by Mac Pro computer running MATLAB (Mathworks Inc. USA) and the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997). Each point-light animation consisted of 12 black dots against a light-gray background, depicting one of 22 distinct actions (e.g. walking, running, jumping, kicking, throwing). Since each action had two versions (original and mirror-reversed), the total number of actions was 44. The size of each dot was 6-arc min, and the average speed within a sequence was 4°/sec. The cluster of 12 dots defining biological or scrambled motion fell within a rectangular region subtending approximately 4° (width) × 6° (height) on a side. The viewing distance was 57cm.

Spatially perturbed motion. For each BM sequence, a spatially perturbed version was produced. Specifically, the starting frame of a given sequence was used to create a corresponding 100% scrambled animation by randomizing the initial positions of each dot. Next, intermediate positions that divided the distance between the dot positions of the original biological motion and their new positions in a scrambled motion in the ratio of 35:65 were derived. In this way, 35% spatially perturbed motion sequences were created from 44 biological point-light animations (see Figure 1). The reasons why 35% perturbation was selected are as follows: first, contrasting normal BM with completely scrambled version makes the task extremely easy. Second, in a recent study (Kim et al., 2011), observers were asked to indicate which of the two simultaneously presented motion sequences looked more like human movements. In this task, observers could discriminate 30% from 45% perturbed motion sequences at slightly above-chance accuracy (approximately 65%). Therefore, 35% was chosen for presenting a single stimulus to insure that the task was difficult but not overly difficult.

Procedure

Task 1: Detection of BM in peripheral location. On each trial, biological or spatially perturbed motion was briefly presented (300ms, 6 frames) either 10° left or 10° right of the central fixation point. Although eye movements were not recorded, all participants were told to fixate their gaze at the central fixation point throughout a block of trials, and this was emphasized as a critical requirement for performing the task. Upon presentation of a stimulus, each observer judged whether the given animation was biological or not by pressing one of two pre-assigned buttons as quickly as possible, guessing if necessary.

Since there were a limited number of actions and each stimulus repeated more than twice throughout the experiment, it was possible to make a decision based on the spatial array of dots in the first frame of the animation. To prevent this possibility, the first frame of the animation in each trial was randomly chosen between the first and fourteenth out of 20 frames. Through this method, the dot array of the first frame appeared differently even if the same animation was repeated. There were 352 trials and observers were allowed to take breaks every 44 trials. The experiment was conducted in a dark room illuminated by the screen only.

Performance was measured in three ways. First, RT in each trial was recorded. Second, accuracy for each type of stimulus in each visual field was measured. Lastly, stimulus-response combinations were classified according to the signal detection categories: hits ('biological'
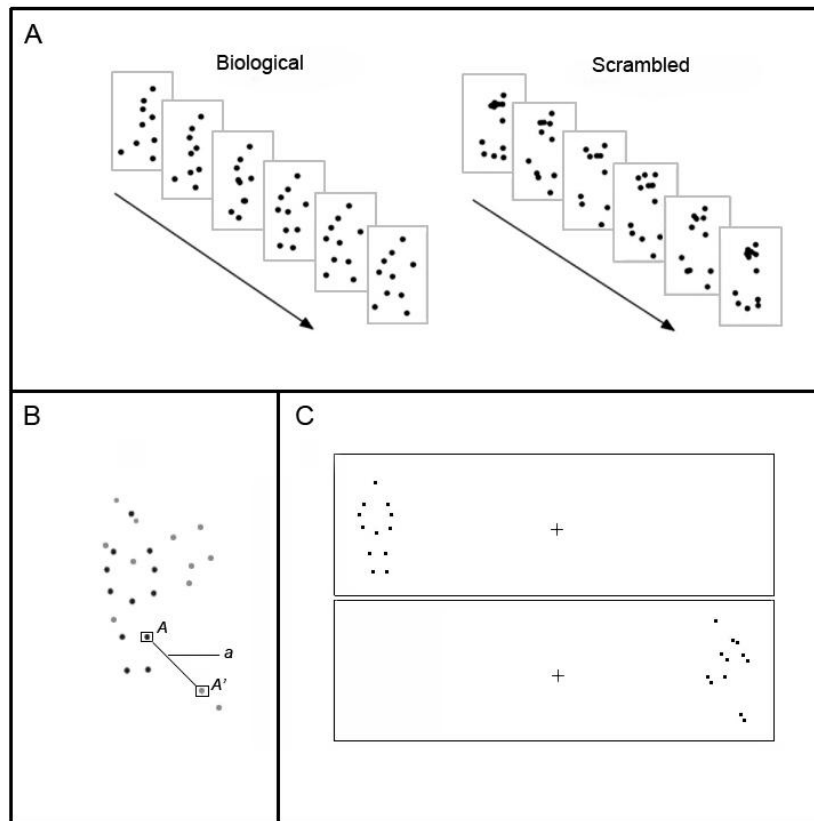
Figure 1. A: An example of point-light biological motion (left) and spatially scrambled motion (right). B: Generation of spatially perturbed motion from biological motion. Dot A′ indicates a new position of the dot A when spatially scrambled. 'a' is an intermediate location dividing the distance between A and A′ with ratio of 35:65. C: Example of trials in Task 1. Either BM or spatially perturbed motion appears left or right to the central fixation in each trial.

response to BM), misses ('perturbed' response to BM), correct rejections ('perturbed' response to perturbed motion), and false alarms ('biological' response to perturbed motion), and then discrimination sensitivity d' was calculated in the follow-up analysis, based on hit-rate and false alarm-rate. All participants performed this task.

Task 2: Detection of BM presented at the center. This task was identical to Task 1, except all stimuli were presented at the center of the screen. The total number of trials was 100, consisting of 50 BM trials and the other 50 trials of perturbed motion. The order of presentation of the two types of motion was randomly determined for each observer.

Observers responded whether the given motion in each trial depicted human motion or not by pressing one of the two pre-assigned buttons as quickly as possible. RT and accuracy were recorded in each trial, and sensitivity d' was also calculated. Fourteen participants performed this task.

Results

Task 1: Detection of BM in peripheral location

Reaction time. Mean (SD) RT from Task 1 is summarized in Table 1. From repeated measure ANOVA, mean RT between the two visual fields were not significantly different
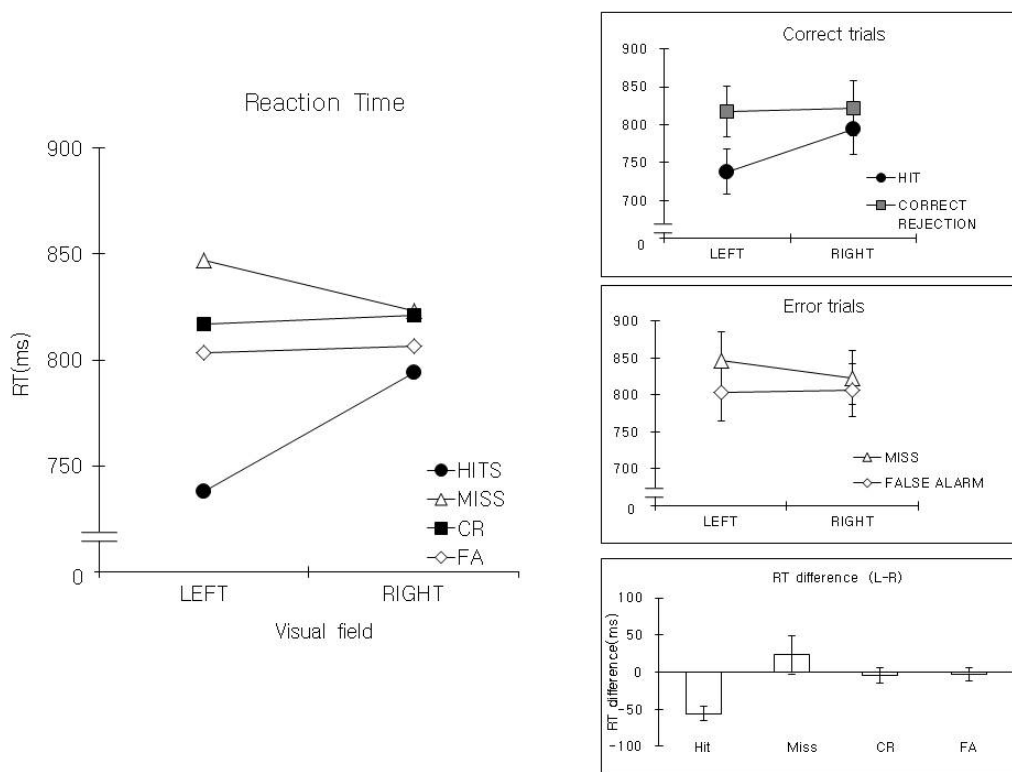

Figure 2. Mean reaction time (RT) to BM or perturbed motion in each visual field. Each symbol represents the signal detection category extracted from stimulus and observer's responses. Hits: 'biological' responses to BM. Misses: 'perturbed' responses to BM. CR: correct rejections, 'perturbed' responses to perturbed motion. FA: false alarms, 'biological' responses to perturbed motion. The two upper plots in the box are from the left plot, divided according to correct and error trials. The lower right plot represents relative RT difference between the visual fields in each signal detection category. Error bars indicate standard error of the mean.

Table 1. Mean (SD) reaction time from Task 1.

		Left visual field	Right visual field	Signal Detection Category
		Overall		
		784.64 (149.52)		
		801.39 (161.93)	811.33 (156.94)	
Biological	Correct	737.75 (142.3)	794.15 (161.49)	Hit
	Incorrect	847.29 (189.47)	823.31 (180.49)	Miss
Perturbed	Correct	817.02 (165.69)	821.14 (177.41)	Correct rejection
	Incorrect	803.49 (186.07)	806.72 (169.47)	False alarm

(F(1,23)=1.61, p=0.22). Main effect of the signal detection category (i.e. hits, misses, correct rejections, and false alarms) was significant (F(3,69)=7.21, p<0.001). Post-hoc analysis revealed that RT from correct response to BM (hit) was significantly shorter than the other three (hits vs. misses: p=0.001, hits vs. correct rejections: p=0.008, hits vs. false alarms: p=0.005) while no significant difference was observed among the others. RT exhibited different patterns depending on each signal detection category between the left and right visual fields as indicated by significant interaction effect (F(3,69)=4.49, p=0.006): In the left visual field, hit trials showed the shortest RT while the longest RT was observed when error occurred in BM trials (i.e. misses). RT to perturbed motion (correct rejections and false alarm trials) were in the middle of hits and misses. On the other hand, such RT difference was not found in the right visual field (Figure 2).

Within the left visual field only, the main effect of the signal detection category was significant (F(3,69)=10.92, p<0.001), and RT from hit trials was shoter than the others(hits vs. misses: p<0.001, hits vs. correct rejections: p<0.001, hits vs. false alarms: p=0.001), whereas no significant main effect was observed within the right visual field (F(3,69)=1.07, p=0.37).

Accuracy. Summarized accuracy data is shown in Table 2, with discrimination sensitivity (d') in each visual field. Repeated measure ANOVA revealed that the mean accuracy between the two visual fields was not significantly different (F(1,23)=0.99, p=0.33). The main effect of motion types was significant (F(1,23)=4.86, p=0.04), indicating that observers perceived BM more precisely compared with spatially perturbed motion. The interaction effect
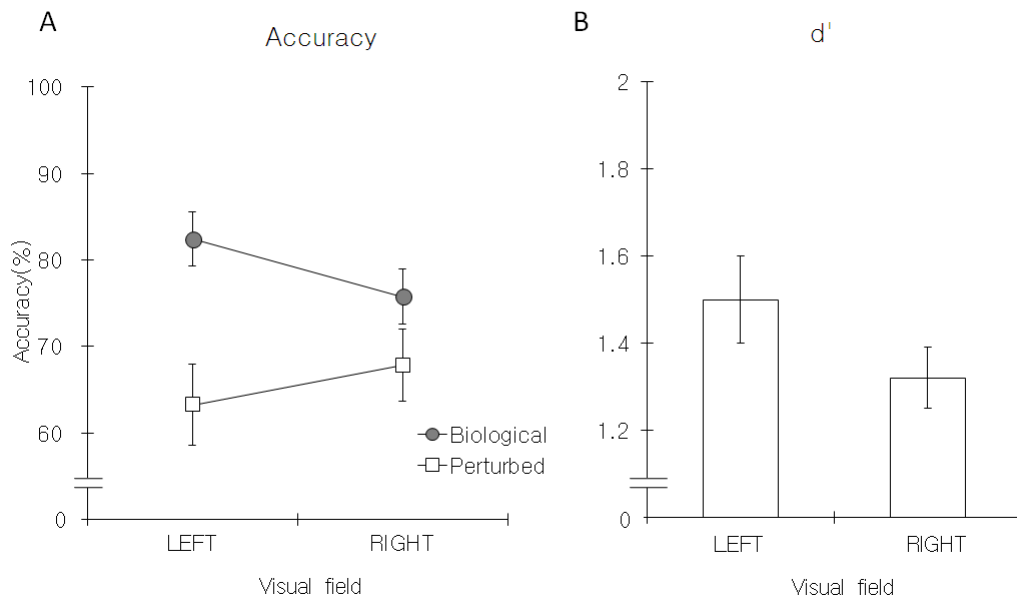
Figure 3. A: Mean accuracy of detecting biological or perturbed motion in each visual field. B: Mean discrimination sensitivity(d′) between the two types of motions in each visual field. Error bars represent standard error of the mean.

between visual fields and motion types was also significant ($F_{(1,23)}$=6.99, p=0.014), showing that accuracy difference between the two types of motion was greater in the left visual field ($t(23)$=2.87, p=0.009 in the left; $t(23)$=1.25, p=0.22 in the right).

Paired t-test revealed that BM presented in the left visual field was more accurately perceived than in the right visual field ($t(23)$=2.87, p=0.009) while accuracy difference between the visual fields in perturbed motion trials did not reach significant level ($t(23)$=-1.93, p=0.07). In addition to simple accuracy for each motion type, discrimination sensitivity d'

Table 2. Mean (SD) accuracy and sensitivity from Task 1.

	Overall accuracy			
	72.32 (8.04)			
	Left visual field		Right visual field	
	Accuracy	d′	Accuracy	d′
Biological	82.44 (14.84)	1.496 (0.49)	75.77 (14.71)	1.32 (0.37)
Perturbed	63.22 (22.08)		67.85 (19.47)	

between the visual fields was significantly different (F(1,23)=6.41, *p*=0.02), indicating that observers were more sensitive to differences between BM and perturbed motion when the stimuli appeared in the left visual field.

Task 2: Detection of BM at the center

Reaction time. Like in Task 1, RT from the four signal detection category was significantly different (F(3,39)=3.35, *p*=0.03). The shortest RT was recorded from correctly perceived BM (hit) trials. Post-hoc pair-wise comparison revealed significant RT difference between hit and false alarm trials (*p*=0.01). Overall mean RT was shorter than in Task 1.

Accuracy and sensitivity(d′). With respect to accuracy, BM was more accurately perceived than spatially perturbed motion (t(13)=3.70, *p*=0.003). Mean (SD) discrimination sensitivity

d′ was 1.65 (0.73), which was greater than in the left and in the right visual fields. As mentioned, fourteen participants out of 24 performed both Task 1 and 2. Mean (SD) d′ in the left and right visual field for these fourteen participants were lower than d′ values from twenty four observers, described in Table 2. For fourteen people, d′s were 1.25 (0.55) and 1.16 (0.48), in the left and in the right visual field, respectively. Comparing d′ values in the three locations (left, center, and right) from the fourteen observers yielded significant difference (F(2,26)=6.87, *p*=0.004). Specifically, the d′ difference was significant between the center and the right visual field (*p*=0.04) while the difference between the center and the left visual field was not significant (*p*=0.07). Summarized accuracy and RT results are shown in Figure 4 and Table 3.
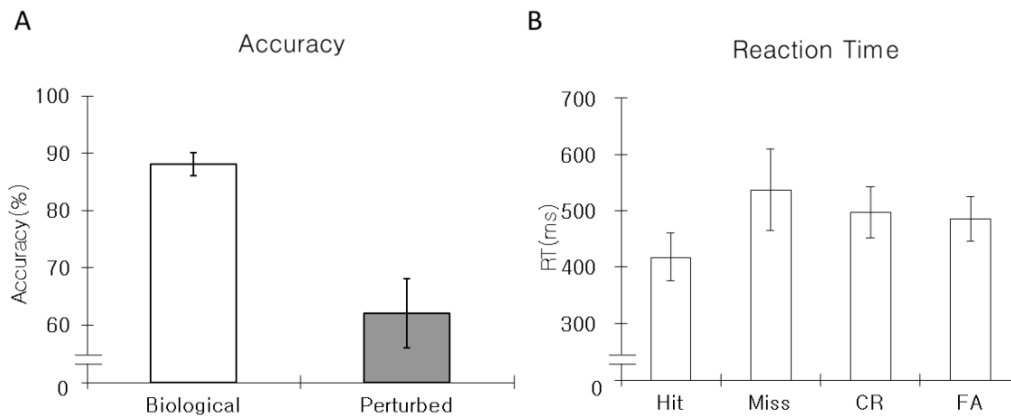

Figure 4. A: Mean accuracy in Task 2. B: Mean RT in each signal detection category. Error bars indicate standard error of the mean.

Table 3. Results from Task 2.

Stimulus		RT	Response rate	d´	Note
Biological	Correct	418.29 (154.16)	0.88 (0.09)		Hit
	Incorrect	537.38 (296.32)	0.12 (0.09)	1.65	Miss
Perturbed	Correct	497.66 (165.91)	0.62 (0.23)	(0.73)	Correct rejection
	Incorrect	485.91 (147.20)	0.38 (0.23)		False alarm

Discussion

The present study explored a perceptual correlate of asymmetrical hemispheric activation within the pSTS in BM perception. It was hypothesized that RT would be faster when BM is presented in the left visual field. I also investigated how BM perception would be different from perception of other complex motion (with respect to RT and accuracy).

Visual field difference in detection of biological motion Several imaging studies found a specialized role of the pSTS in BM perception, reporting generally stronger activation associated with viewing BM in the right hemisphere. The first major finding in the present study was that RT to BM presented in the left visual field was faster than to BM presented in the right visual field, consistent with the hypothesis. It should be noted that significant RT differences between the two visual fields was found only in correctly detected BM trials ('miss' trials will be discussed later), not in perturbed motion trials. Considering the stimulus-selective activation of the pSTS, the BM-limited RT difference could be attributed to the function of this area. These RT results thus suggest a possible perceptual concomitant of the anisotropy in activation strength wherein point-light BM evokes larger BOLD signals in the right pSTS, supporting the hypothesis of longer RT to BM presented in the right visual field. This may also have to do with delayed input from the right visual field to the right pSTS via left pSTS and corpus callosum.

Additional difference between the visual fields are found in accuracy and discrimination sensitivity, d´. Contrary to a conventional speed-accuracy trade-off (Schouten & Bekker, 1967; Wickelgran, 1977), accuracy of BM detection was also higher when the stimulus appeared in the left visual field. Overall, these results show that briefly exposed BM in the left periphery is more efficiently processed.

Cortical processing for BM perception in each visual field As mentioned earlier,

past imaging studies also reported bilateral activation of ventral visual areas including the ITS and fusiform gyrus in BM perception, in addition to the greater right pSTS activation (Grossman & Blake, 2002; Grossman et al., 2010; Thompson et al., 2005). Activation within the ventral visual stream is not that surprising because spatiotemporal kinematics within the point-light BM does draw form information of body shape, regardless of minimized explicit form. A recent imaging/simulation study (Thurman, Giese, & Grossman, 2010) investigated the relationship between motion/form information and the dorsal/ventral visual processing in BM perception. According to their results, motion information has more weight when BM duration is less than 300ms while form information become more important when exceeds that threshold.

In the present study, stimulus duration was 300ms. This suggests that motion information may be a primary component for processing, but also that some form information extracted by spatiotemporal kinematics of the point-light animation is available. The right pSTS may receive motion information from the left visual field directly without delay. At the same time, form information may be also available via form pathway areas. As a result, BM presented in the left visual field could be processed quickly and accurately by integrating motion and form information. On the other hand, when BM appears in the right visual field, motion input to the right pSTS would be made via callosal connection, resulting in slower RT. Furthermore, form information would be more critical for detection before integrating motion information, which, in turn, would lead to lower accuracy because the virtual form information extracted from only 300ms stimulus may not be sufficient. Given this putative cortical processing, such visual field difference would be attenuated when the stimulus duration is longer because of sufficient motion and form information. The present data do not provide evidence for this speculation. However, a previous study (Bradshaw et al., 1984) reported no visual field superiority in detecting gender from peripherally-presented BM with unlimited duration.

On another note, it is argued that the right hemisphere is particularly sensitive to briefly presented, physically degraded materials that require gestalt integration (Sergent, 1982; 1983). This might be also true for the right pSTS.

Comparison BM processing with perturbed motion processing Results from Task 1 revealed different efficiency of BM processing depending upon whether the stimulus was presented in the left or right visual field. Follow-up questions include whether such effect

is also observed with other types of global motion, and whether perception of BM is more efficient than other motions. These were examined by comparing performance between BM and spatially perturbed motion in each visual field (Task 1), and without visual field variation (Task 2). Results from Task 1 indicated that BM presented in the left visual field was faster and more accurate than when presented in the right visual field; furthermore, BM presented in the left visual field was faster and more accurate than perturbed motions presented on the same side (Figure 3). Such pattern was also observed when the stimuli were presented at the center (Figure 4). Note that these results do not suggest that people are always more sensitive to BM than any other motion signals: Spatially perturbed motion in this study was sophisticatedly controlled stimuli that maintained the same local motion signals; only global organization was perturbed.

Overall, for non-biological global motion, the visual field difference did not exist, and its processing was slower and less accurate than BM processing. Implications of these results are as follows. First, although perceptual difference between BM and perturbed motion did not exist when the stimuli were presented in the right visual field (Task 1), this is not surprising given that the left pSTS are less activated than the right pSTS. Regardless, faster and more accurate

response to BM presented in the center may reflect the sum of the bilateral pSTS activation as well as other BM perception involved areas. Second, those areas are regarded as a specialized neural circuit for BM perception (e.g. Grossman et al., 2010), and preference to BM seems to be innate, suggested by young infants' longer fixation of gaze (Fox & McDaniel, 1982). Therefore, faster RT to BM provides additional evidence that people are ready to perceive BM. Not just 'ready', but the present data even suggest that people may be perceptually biased to judge an ambiguous, potentially biological movement as BM. This is because the false alarm rate was higher than the miss rate in both tasks. This tendency seems to be relevant ecologically and socially, especially in emergency situations. Lastly, top-down processing may have been involved to perform the tasks in this study. Indeed, BM perception requires both bottom-up and top-down processing (e.g. Dittrich, 1993). In the RT data, the longest RT was recorded from miss trials in which observers misperceived BM as perturbed. Considering the possibility of perceptual bias toward BM (i.e. higher false alarm), making a reversed decision would require additional processing for overcoming the bias or for matching a stimulus to a 'template' in mind (Lange & Lappe, 2006).

Additional notes and limitation   There

are a few previous studies on perception of peripherally presented BM (e.g. Bradshaw et al., 1984; de Lussanet et al., 2008); these studies however did not report overall visual field superiority. On a last note, I wish to consider some discrepancy between those and the present study, specifically on the visual field superiority. Bradshaw et al.'s (1984) task looks similar to the task in the present study in terms of having used various human actions portrayed by point-light animation at the left- and right to the center. In their task, observers were told to detect gender from moving point-light displays. The lack of superiority of either visual field found in their experiment appears to weaken the results from the present study. However, it should be noted that considerable difference exist. In Bradshaw et al.'s (1984) study, the eccentricity between the stimulus and the central fixation was only 5.29° while it was 10° in the present study. Such small amount of eccentricity might have diluted a potential visual field difference. Next, Bradshaw et al.'s (1984) task required observers to detect gender of a point-light walker, which requires high level perceptual and cognitive processing. RT was also not recorded in their study. Lastly, stimulus duration was unlimited in Bradshaw et al.'s (1984) task, and as discussed above, BM perception is affected by amount of available motion and form information (Thurman et al.,

2010). de Lussanet et al. (2008) found that detecting facing direction of a walker depended upon the visual field where the stimulus was presented. It is argued that only spatial information plays an important role in detecting facing direction while both spatial and temporal information are required for recognition (Chang & Troje, 2009; Lange & Lappe, 2007). Taken together, these differences from the current study might have contributed to these seemingly discrepant results.

One limitation of this study was that observers' eye movements were not recorded due to the lack of a device to capture such data. Instead, participants were instructed prior to beginning the task to fixate their gaze on the center of the screen throughout the experiment. Although there is no quantitative data of fixation, the relatively consistent RT and accuracy patterns found across the participants (only three exhibited reversed visual field superiority or no superiority) suggest that they performed the tasks as instructed.

Conclusion   To summarize, this study found different RT and detection accuracy for peripherally presented BM in each visual field for the first time, which is a possible perceptual concomitant of the anisotropy in stimulus-selective activation of the pSTS. Next, this study examined the role of RT differences between BM

and perturbed motion as another index of BM processing, in addition to accuracy in previous studies. The results also suggest that people can process BM more rapidly as well as accurately than other types of global motion. Analysis of error trials suggests the possible potential bias toward BM and/or involvement of top-down processing in BM perception. More studies are needed to examine whether findings in the present study could be generalized to more natural situations. More systematic manipulation of test variables, including manipulations to visual periphery and stimuli duration, would also contribute to increased understanding of the perception of BM.

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생물형 운동지각: 좌우 시야에 따른 지각의 차이와
생물형-비생물형 운동간의 차이 연구

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생물형 운동지각과 관련된 후부상측두구(pSTS)의 활동은 특히 우반구에서 강한 것으로 보고되어 왔으나 그 이유는 알려져 있지 않다. 또한, 기존의 정신물리학적 연구들에서 생물형 운동자극에 대한 반응시간에 관해 알려진 바가 거의 없다. 본 연구에서는 정확도 뿐 아니라 반응시간을 측정하는 과제를 이용하여 두 연구문제에 관한 실험을 수행하였다. 첫 번째 과제에서는 후부상측두구의 비대칭적 활동에 관련된 지각적 상관현상을 밝히기 위해 생물형 및 비생물형 운동자극을 좌우 시야에 짧은 시간 제시하고 탐지의 반응시간 및 정확도를 측정하였다. 두 번째 과제에서는 시야의 중앙에 생물형 및 비생물형 운동자극을 제시하여, 첫 번째 과제의 결과와 함께 생물형 운동지각과 비생물형 운동지각간의 차이점을 분석하였다. 실험 결과, 좌측 시야에 제시된 생물형 운동자극에 대한 반응시간은 우측 시야에 제시된 경우보다 짧고 정확도 역시 높은 것으로 나타났다. 두 종류의 운동자극간의 비교에서는 생물형 운동자극에 대한 반응이 더 빠르고, 정확도도 높았다. 또한 오류 시행의 분석 결과는 비생물형 운동을 생물형 운동으로 지각하는 오류가 그 반대의 경우보다 빈번하였다. 본 연구의 결과는 짧은 시간동안 좌, 우 시야에 노출된 생물형 운동에 대한 반응시간의 차이가 후부상측두구의 우반구 편향 활동의 지각적 상관 현상일 수 있음을 시사하며, 생물형 운동이 비생물형 운동에 비해 더 빠르게 효율적으로 처리된다는 것을 보여준다. 또한 모호한 자극을 생물형 운동으로 지각하려는 편향이 존재할 수 있음을 시사한다.

주요어 : 생물형 운동, 시야, 지각, 상측두구, 반응 시간