Affective processing of biological motion with and without awareness

Edward Nguyen

Ayse Pinar Saygin

Department of Cognitive Science,

University of California, San Diego

9500 Gilman Dr. MC 0515, La Jolla, CA 92093-0515

Tel: (858) 822-1992, Email: edn002@ucsd.edu, saygin@cogsci.ucsd.edu

Abstract:

Emotion is a pervasive and important aspect of human experience. Here we employed the affective priming paradigm to study the effects of body movements on emotional cueing. Affective point light displays were used to prime subject responses to target emotional words. Subjects were presented with point-light arm movements that conveyed anger, happiness or neutral affect as primes. They subsequently were asked to make affective judgments on word stimuli that were either positive or negative in valence. Responses in affectively congruent trials were significantly faster than incongruent and neutral trials. No significant difference was found between reaction times for incongruent and neutral trials. The results show that a positive priming effect occurs for affective priming of emotional words by affective biological motion. In a second experiment, the point-light displays were spatially scrambled to have no coherent form while retaining the same local motion; no significant difference was found between any of the prime-target conditions, indicating that the global form of the biological motion stimuli, rather than local motion are likely to be driving the affective priming effect. In a third experiment, awareness of the prime stimuli was suppressed during the priming task. A main effect of prime emotion was present, in which responses following masked angry primes were significantly slower than following masked happy and neutral primes. Affective information is therefore processed from biological motion outside of awareness.

<u>Introduction</u>

Understanding others' body movements is critical for many tasks of biological importance including daily social functions and interactions. Similarly emotional processing is an important part of human life. In this study, we sought to explore the cognitive and perceptual relationships between the two.

Although emotion and how it is evoked unconsciously and implicitly through different means and stimuli has been studied, little is known about whether and how body movements are linked to emotional processing. One way to assess implicit processing of stimuli is priming. Priming occurs when a stimulus that is presented before a target results in a faster reaction time and greater accuracy in responding to that target, regardless of whether the prime is processed consciously or subconsciously. Priming effects have been shown for spatial cueing, semantic cueing, and, perhaps most relevant to daily social life, emotional cueing (e.g. Posner, 1980; Neely, 1977; Kanske *et al*., 2011).

One topic that has not been explored within affective priming studies is affective body movements, or biological motion. Biological motion, or how animals move, is an evolutionarily and socially important cue for all organisms in everyday life. The human visual system can extract body movement information from very sparse visual input. This is demonstrated in the detection of biological motion from point-light displays, created by placing markers (point-lights) at the majors joint of a body in motion (Johannson, 1973). When in motion, such stimuli evoke a vivid percept of a human body in action. In addition to actions, these simple representations can also convey significant high-level information such as gender (Kozlowski and Cutting, 1977) and identity (Cutting and Kozlowski, 1977). In particular, viewers can interpret the affective state of the person behind the point-lights (Dittrich *et al*., 1996). In the

present study, we shall explore the mechanisms of biological motion and its capacity to cue emotional information.

In affective priming processing of a target word is automatically facilitated by a preceding congruent stimulus (Klauer and Musch, 2003). For example, a prime that conveys a positive emotion such as happiness could facilitate the processing of targets in the same affective category. Several different types of visual stimuli have been studied the affective priming paradigm including pictures, facial expressions, and abstract symbols (Zhang *et al.*, 2006; Carroll and Young, 2005; Kanske *et al.*, 2011). However, to our knowledge, visual stimuli in previous studies have been static and briefly presented. One parameter that has been shown to be critical in past studies for producing affective priming is the stimulus-onset asynchrony (SOA). Affective priming has been most robustly obtained for SOAs under 300 ms (Klauer and Musch, 2003). However, here we employed body movements, a stimulus that requires a longer length of time to unfold and convey emotion. With the use of these stimuli, an SOA on the order of several seconds is necessary and unavoidable: therefore, demonstrating priming with affective body movements would not only be a novel contribution to biological motion research, but the success of longer SOAs would be an addition to the affective priming literature. Therefore, in our initial experiment, our primary goal was to demonstrate whether affective biological motion can prime the processing of subsequent emotional words.

Experiment 1

Methods

Participants

Participants were 21 undergraduate students (aged 18-22 years) from the University of California, San Diego. All subjects were native English speakers and were right-handed. All reported normal or corrected-to-normal vision and gave informed consent. The study was approved by USCD Human Research Protections Program.

Stimuli

The priming stimuli were point-light displays, obtained from a previous emotional recognition study (Pollick *et al.*, 2001). The displays represented upper body movements performing a knocking motion from a sagittal view, presented with happy, angry, or neutral affect. Each emotional movement had three exemplars, for a total of 9 biological motion stimuli. In addition, we used a scrambled biological motion animation, which was constructed by shifting the starting positions of the point-lights whilst keeping the motion trajectories intact. This is a commonly-used control stimulus in biological motion studies (see Experiment 2) but in Experiment 1, it served only to help draw attention to the task-irrelevant primes (see below). The duration of each motion ranged from 1900-2600 ms.

The target word list was constructed to contain 22 angry and 22 happy words adapted from two past studies in which they were consistently rated by subjects as belonging to either the angry or happy emotional category (Stevenson *et al.,* 2007; Strauss and Allen, 2007). All target words were matched according to word length, frequency, and imageability (Medical Research Council psycholinguistic database; Coltheart, 1981).

Design and procedure

All subjects were tested individually in a dimly lit room. Subjects were told they would be presented with an arm motion followed by a target word which they were to respond to in an evaluative categorization task: classify the target word as a word of either positive or negative valence by pressing the respective key on the computer keyboard. We chose this evaluative categorization task because it is commonly used and has been found to be more reliable in affective priming studies than lexical decision (Klauer and Musch, 2003).

Subjects were not explicitly told about the affective nature of the arm movements. Since the biological motion stimuli are task-irrelevant, a simple monitoring task was added to the prime stage. Subjects were asked not to respond to the target word if the presented movement was scrambled, pressing the spacebar button instead. Scrambled motion was presented in 10% of the trials.

A typical trial proceeded as follows: a central fixation cross was presented for 500 ms, followed by a blank screen for 250 ms. The prime stimulus then appeared for 1900-2600 ms, followed by an interstimulus interval of 100 ms. Matching the prime durations across all stimuli would only be possible if the motion speeds were altered; we opted not to do this so as not to run the risk of modifying the natural dynamics of biological motion. The target word was then presented on the screen, to which subjects had to respond within 3000 ms. Subjects were then asked to press the spacebar to continue to the next trial after an intertrial interval of 500 ms. A trial sequence is shown in Fig. 1 below.

Participants were given 25 practice trials and were required to complete practice with a minimum of 90% overall response accuracy before proceeding to the main experiment. There were a total of 440 trials, including 44 trials with scrambled motion. The trials were split into

multiple blocks, with short breaks in between every 50 trials. The reaction times and accuracy

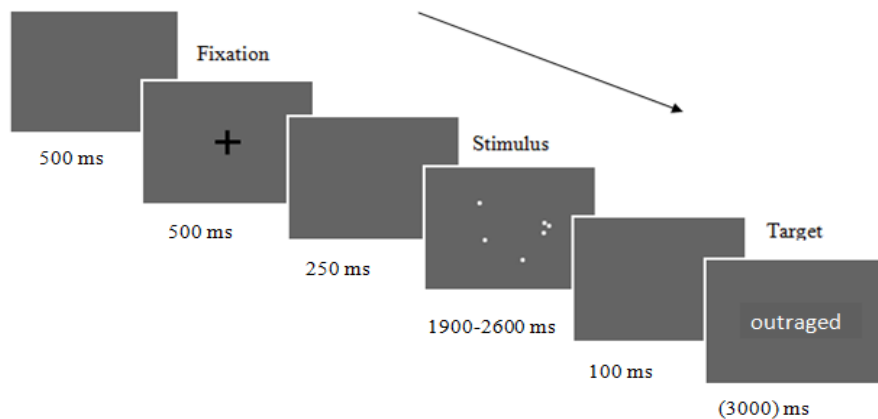for each trial were recorded for each subject.

Fig. 1. Schematic of an experimental trial. A central fixation cross was presented, followed by an emotional point light display (angry, happy, or neutral). A target word was then presented, after which the subjects responded.

Results

      As with most priming studies, our analyses focused on reaction times (RTs) and we used RTs for correct trials as our dependent measure. Task accuracy was high (97.5%) and did not differ between conditions.

      A two-way ANOVA with three levels of prime emotion (happy, angry, neutral) and two levels for target emotion (positive, negative) was applied to correct RTs. There was no main effect of prime emotion ($F(2,20) < 1$, n.s.) and no main effect of target emotion ($F(1,20) < 1$, n.s.). There was a significant interaction between prime and target ($F(2,20) = 7.067$, $p = 0.002$).

      RT data for congruency effects were further analyzed using one-tailed paired sample t-tests (since our hypothesis was one tailed, that affective biological motion would facilitate responses to congruent words).
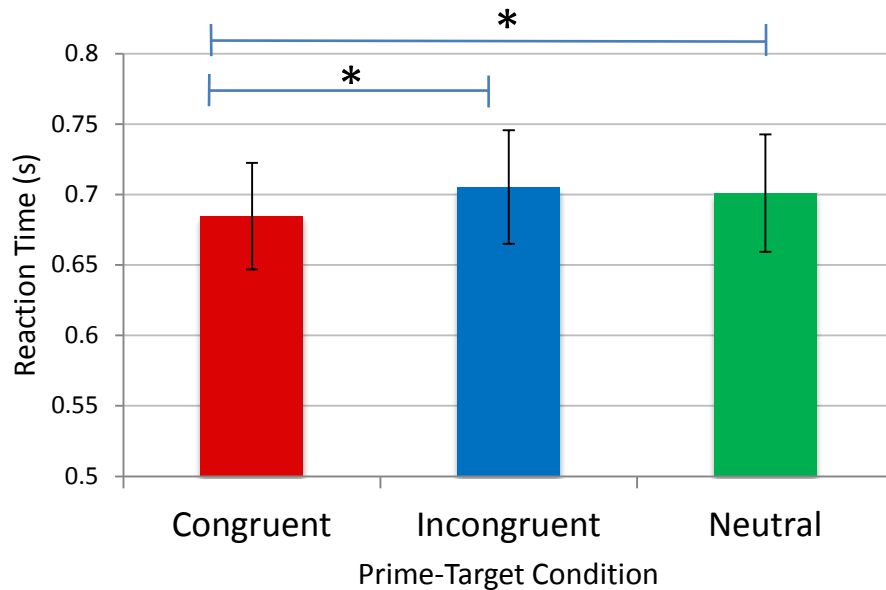
Fig. 2. Mean correct response times to target words for each prime-target condition (standard error bars shown, *$p < 0.05$).

RT data for the priming effects are shown in Figure 2. There was a significant difference between congruent and incongruent trials ($t(20) = 4.0630$, $p < 0.005$). The difference between congruent and neutral trials was marginally significant ($t(20) = 1.6863$, $p = 0.053$). There was no significant difference was found between incongruent and neutral trials ($t(20) = 0.5657$, $p > 0.05$).

Discussion

Affective biological motion was found to facilitate responses to emotional words (RTs for congruent trials significantly lower than incongruent and neutral trials) but was not found to inhibit responses (RTs for incongruent trials not significantly different from neutral trials). This is indicative of a positive priming effect. This finding adds onto both biological motion and affective priming literature, as affective priming with a dynamic stimulus, body movements conveying emotion, had not previously been demonstrated.

Though biological motion was found to produce affective priming, little can be extrapolated about the mechanisms and parameters underlying the ability of biological motion to do so. For example, it is unclear whether emotional information contained within the stimuli is dependent on the perception of the coherent form of the action or on the dynamics of the motion itself. Indeed, a currently active area of discussion within biological motion research involves the relative contribution of form and motion elements to our perception of biological motion (Lange and Lappe, 2007; Saygin *et al*., 2004; Troje and Westhoff, 2006). The use of point-light stimuli here allows us the advantage to separate these elements by spatially scrambling the starting location of each motion dot, disrupting the global form of an arm while retaining the local motions of each dot. To explore the individual contributions of form and motion in the percept of emotional biological motion, a second experiment was run in which the prime stimuli were scrambled.

Experiment 2

Methods

Participants

21 new undergraduate students (aged 18-22 years) from the University of California, San Diego participated. All subjects were native English speakers and were right-handed. All reported normal or corrected-to-normal vision and gave prior informed consent. The study was approved by UCSD Human Research Protections Program.

Stimuli

The priming stimuli were scrambled versions of the point-light displays used in Experiment 1. The displays were spatially scrambled such that the starting positions for each

point light were randomized while retaining approximately the same overall visual angle as the unscrambled displays. Three different repetitions for each emotion were displayed along with one inverted display to ensure visual attendance, for a total of 10 different displays. The duration of each motion ranged from 1900-2600 ms, as in Experiment 1. The target word list was identical to that used in Experiment 1.

Design and procedure

Subjects were tested individually in a dimly lit room using the same computer and monitor as Experiment 1. Subjects were told they would be presented with a display of moving dots followed by a target word, to which they were to respond to in an evaluative categorization task, as in Experiment 1. Subjects were asked not to respond to the target word if the presented display was inverted, but to press the spacebar button instead. Trial structure and experimental procedures were identical to those used in Experiment 1.

Results

Analysis of reaction times (RTs) was done only for correct responses to target words. Task accuracy was high (97.5%) and did not differ between conditions.

As in experiment 1, a two-way ANOVA with three levels of prime emotion (happy, angry, neutral) and two levels for target emotion (positive, negative) was applied to correct RTs. There was no main effect of prime emotion ($F(2,20) < 1$, n.s.) and no main effect of target emotion ($F(1,20) < 1$, n.s.). There was no significant interaction between prime and target ($F(2,20) < 1$, n.s.).

Discussion

When the affective body movements were spatially scrambled to have no coherent form, no priming effect was found across each of the prime-target conditions. This indicates that local motion information in affective biological motion displays was not sufficient for an affective priming effect and that instead global form information is necessary to produce cueing. Therefore some degree of specialized processing of biological motion occurs and is crucial for extracting affective information from the stimuli. This result is unsurprising in context of the tendency of the brain to assign salience to biological motion due to its evolutionary and ecological importance. Despite this, it is currently unknown at which levels of processing does biological motion becomes "special" and selected for by perceptual and attentional mechanisms (Cavanagh *et al.*, 2001; de-Wit *et al.*, 2011).

One particularly strong piece of evidence for prioritized processing would come from studying effects of stimuli perception when it is presented outside of conscious awareness. Prior research performed by Saygin and colleagues (Bahrami *et al.*, under revision) has provided evidence for biological motion perception outside of awareness, in which unconsciously presented point-light walkers were shown to influence direction discrimination of subsequent consciously presented walkers. This study demonstrated that at the very least, low-level properties of biological motion are processed and are adapted to. Whether high-level properties of biological motion, such as emotion, are accessed even outside of consciousness is currently unknown. Therefore, in our third experiment, we looked at modulating subjects' awareness of the prime biological motion stimuli to study whether emotional biological motion would still affect responses to other emotional stimuli without conscious perception of the primes.

Experiment 3

Methods

Participants

23 new undergraduate students (aged 18-22 years) from the University of California, San Diego participated. All subjects were native English speakers and were right-handed. All reported normal or corrected-to-normal vision and gave prior informed consent. The study was approved by UCSD Human Research Protections Program.

Stimuli and display

To present biological motion outside of consciousness, a dichoptic stimulus was created and presented with use of a stereoscope. Binocular suppression, a variant of binocular rivalry developed by Saygin and colleagues (Bahrami *et al.,* under revision) was utilized: Point-light primes from Experiment 1 were presented to one eye while a noise mask was presented to the other eye. The noise mask consisted of 100 spatially scrambled dots drawn equally from the angry, happy, and neutral point-light stimuli. The noise dots were identical to the prime stimuli in size, color, luminance, and contrast. To promote binocular fusion of the two different images, such as subjects would perceive only the presence of noise dots, with the prime stimulus masked within the noise, the same square tile frame was presented around the stimulus in each eye (Figure 3). Following masked presentation of the prime, the target word was presented unmasked in both eyes, to which the subjects made their response. Durations, task, and target word list were identical to that of Experiment 1.

During the study, subjects viewed the screen through the stereoscope at a distance of 70 cm, with support from a chin rest. At the start of the experiment, subjects were presented with

large fixation crosses in both eyes, and were asked to overlay the crosses in their percept by adjusting their position and stereoscope.
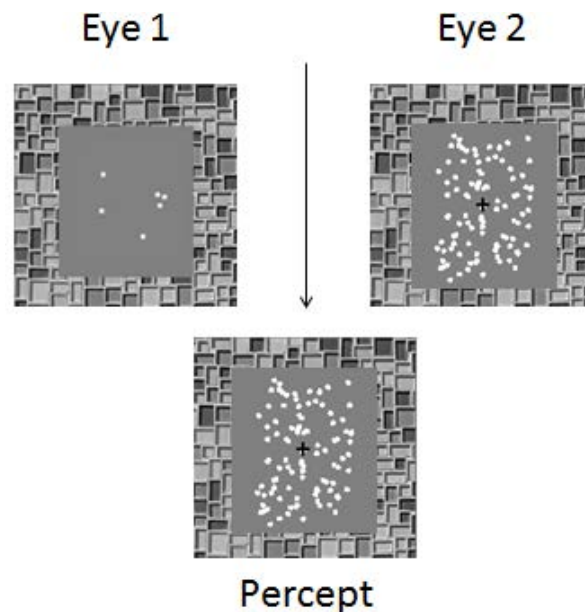

Fig. 3. Biological motion was presented outside of awareness using point light displays, binocular suppression with noise dots, and a stereoscope.

Design and procedure

Subjects were tested individually in a dimly lit room using the same computer and monitor as Experiment 1. Subjects were told they would be presented with a cloud of moving dots followed by a target emotional word, to which they were to respond to in an evaluative categorization task, as in Experiment 1. Trial structure was identical to that used in Experiment 1 (Figure 4). Prior to testing, a practice session was held to ensure successful masking of the prime stimuli by the subject.
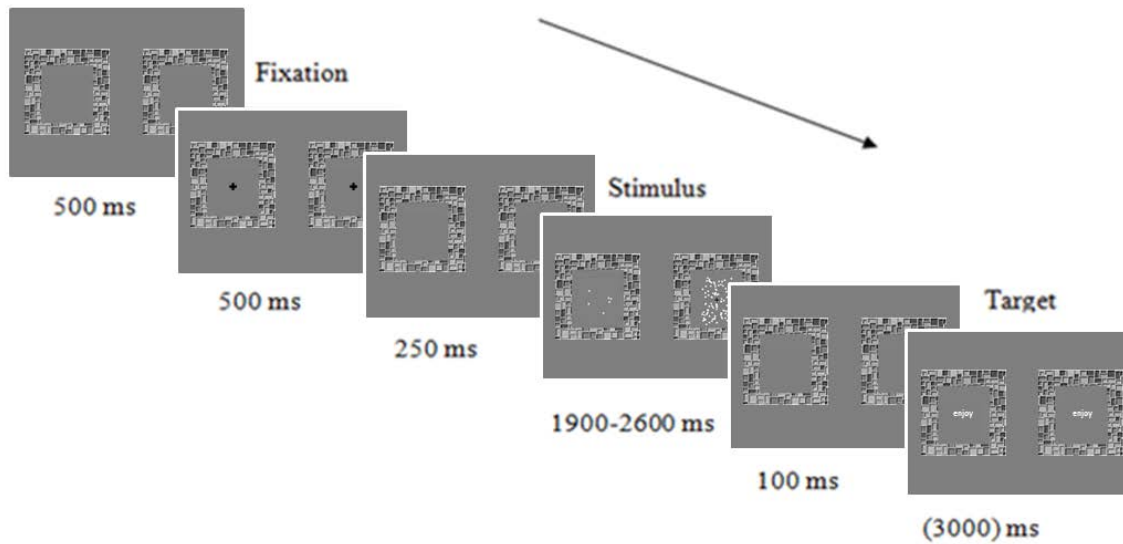
Fig. 4. Schematic of a trial in Experiment 3. A central fixation cross was presented, followed by a dichoptic presentation of prime and noise mask, then the target word to which subjects responded.

Results

Analysis of reaction times (RTs) was done only for correct responses to target words. Task accuracy was high and did not differ between conditions.

Again, a two-way ANOVA with three levels of prime emotion (happy, angry, neutral) and two levels for target emotion (positive, negative) was applied to correct RTs. There was a significant main effect of prime emotion ($F(2,22) = 22.31$, $p < 0.001$). There was no main effect of target emotion ($F(1,22) < 1$, n.s.). There was no significant interaction between prime and target ($F(2,22) < 1$, n.s.).
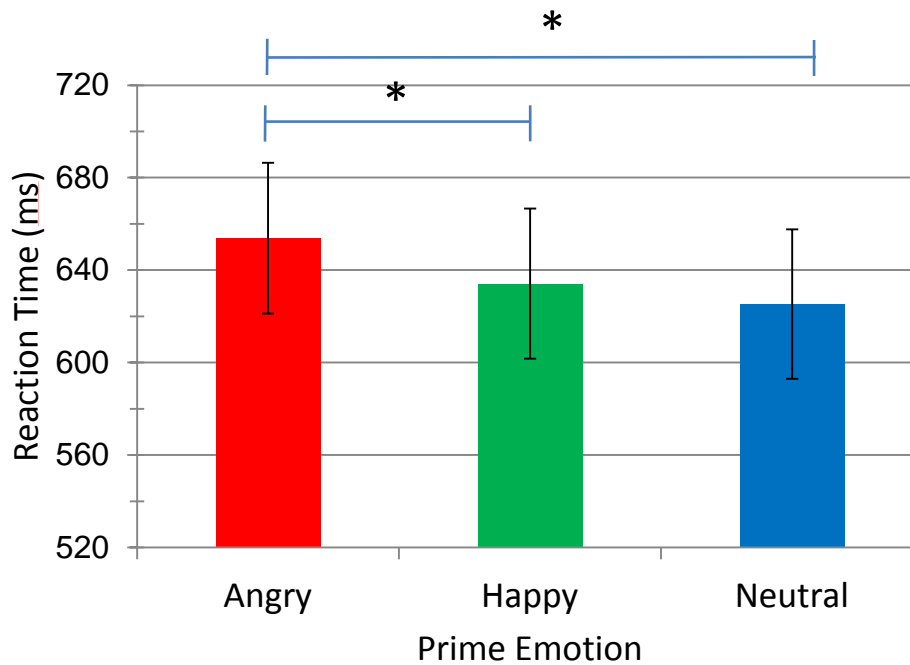
14

Fig. 5. Mean correct response times to target words for each prime condition (standard error bars shown).

Post-hoc analysis of reaction times to prime emotion were performed using one-tailed t-tests. Responses following angry primed trials were significantly slower than following happy trials ($t(22) = 4.04$, $p < 0.05$), as well neutral trials ($t(22) = 7.71$, $p < 0.05$). No significant difference was found between happy and neutral trials ($t(22) = 1.70$, n.s.).

Discussion

When emotional body movement primes were presented outside of awareness, the affective priming effect seen in Experiment 1 was abolished. Instead, a main effect of prime emotion was observed, in which targets following masked angry primes were responded to slower than those following masked happy or neutral primes. The results of experiment 3 show that even when rendered unconscious, biological motion is still processed for higher-level information such as affect, and that this information can have influence on response times.

General Discussion

This study shows for the first time that emotional words can be primed by affective biological motion. The current literature on affective priming has shown that priming can take place with visual stimuli such as emotional words, emotional pictures, and facial expressions (Zhang *et al.*, 2006; Carroll and Young, 2005; Kanske *et al.*, 2011). This study adds to the body of work on affective priming by demonstrating that a dynamic stimulus such as biological motion can elicit an effect.

After confirming that affective body movements can produce a priming effect, we explored whether the local motion information in biological motion displays would suffice in eliciting an affective priming effect. When the coherent form of the displays was removed, the movements failed to produce a priming effect, indicating that local motion cues are insufficient and the global form of the action is necessary for affective priming.

Motion, by nature, requires time to unfold. Since our primes were much longer than most previous studies of affective priming, we had a longer SOA. In addition, the SOA varied between trials since the duration of the biological motion stimuli were variable. The presence of an affective priming effect at a much longer SOA compared to previous work indicates the priming mechanisms may differ between dynamic and static visual stimuli, for which a much shorter SOA (around 300 ms) is optimal to produce an affective priming effect (Klauer and Musch, 2003). The effect of different SOAs on affective priming with dynamic stimuli may be explored in further studies, with the inclusion of body movements with longer or shorter durations.

Finally, we contribute the novel finding that emotional information is still processed in some capacity even when biological motion stimuli were presented outside of consciousness. Notably, this processing occurs differently than when the stimuli are conscious: affective

16

priming was present under conscious conditions (Experiment 1) but not under unconscious conditions (Experiment 3). While no main effects were present under conscious conditions, a main effect of angry primes was found when presented outside of awareness. The anger-specific effect corroborates with past emotional literature, including that of increased detection for anger emotion in biological motion than for happy emotion (Ikeda and Watanabe, 2009). One explanation offered for this effect has indicated the role of the amygdala in appraising the potential threat of incoming stimuli (Chouchourelou *et al.*, 2006). Therefore, it is possible that our angry stimuli received subconscious processing by the amygdala under unconscious conditions due to containing fear-relevant affective information. One possible reason for the observed slowing of reaction times might then be the capture of attention by the implicitly perceived angry primes, leaving less attentional resources to complete the evaluation task (Elmer and Kiss, 2007). However, the reason for the presence of this attention capture only under unconscious conditions shall have to be explored.

Additionally, future directions for this study may include as measuring the time course and electrophysiological correlates of affective biological motion priming with electroencephalography (EEG).

In conclusion, we found that subjects can be primed to the emotional content of a target word by affective cues conveyed by biological motion. This effect is one of facilitation with prime-target congruency rather than inhibition with prime-target incongruency. The priming effect requires the body action to have coherent form, and is not produced with solely the local motion of the displays. Finally, affective information from biological motion is processed and accessed even when stimuli are presented outside of awareness, producing an anger-specific effect interfering with response times.

References

Bahrami, B., van Kemenade, B.M., Song, C., Rees, G., Saygin, A.P. (under review). Unconscious perception of human motion.

Carroll, N.C., Young, A.W (2005). Priming of emotion recognition. *The Quarterly Journal of Experimental Psychology*. **58A:**1173-1197.

Cavanagh, P., Labianca, A.T., Thornton, I.M. (2001). Attention-based visual routines: sprites. *Cognition*. **80**:47-60.

Chouchourelou, A., Matsuka, T., Harber, K., Shiffrar, M. (2006). The visual analysis of emotional actions. *Social Neuroscience*. **1:**63-74.

Coltheart, M. (1981). The MRC psycholinguistic database. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*. **33A:** 497-505.

Cutting, J.E., Kozlowski, L.T. (1977). Recognizing friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonomic Society*. **9:** 353-356.

de-Wit, L.H., Lefevre, C.E., Kentridge, R.W., Rees, G., Saygin, A.P. (2011). Investigating the status of biological stimuli as objects of attention in multiple object tracking. *PLoS ONE*. **6**(3).

Dittrich, W. H., Troscianko, T., Lea, S. E., Morgan, D. (1996). Perception of emotion from dynamic point-light displays represented in dance. *Perception*. **25:**727-738.

Elmer, M., Kiss, M. (2007). Attentional capture by task-irrelevant fearful faces is revealed by the N2pc component. *Biol Psychol*. **74**:108-112.

Ikeda, H., Watanabe, K. (2009). Anger and happiness are linked differently to the explicit detection of biological motion. *Perception*. **38**:1002-1011.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis.

Perception & Psychophysics. **14**: 201-211.

Kanske, P., Plitscha, J., Kotz, S. A. (2011). Attentional orienting towards emotion: P2 and

N400 ERP effects. *Neuropsychologia*. **49:**3121-3129.

Klauer, KC., Musch, J. Affective priming: Findings and theories. In: Musch, J.; Klauer, KC.,

editors. The psychology of evaluation: Affective processes in cognition and emotion. Lawrence

Erlbaum; Mahwah, NJ: 2003. p. 8.

Kozlowski, L.T., Cutting, J.E. (1977). Recognizing the gender of a walker from a dynamic point-light

display. *Perception and Psychophysics*. **21:**575-580

Lange, J., Lappe, M. (2007). The role of spatial and temporal information in biological motion perception.

Advances in Cognitive Psychology. **3**:419-428.

Neely, J.H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless

spreading activation and limited-capacity attention. *Journal of Experimental Psychology*. **106**:226-

254.

Pollick, F.E., Paterson, H.M., Bruderlin, A., Sanford, A.J. (2001). Perceiving affect from arm

movement. *Cognition*. **82:**B51-B61.

Posner, M. (1980). Orienting of attention. *The Quarterly Journal of Experimental Psychology*. **32:**3–

25.

Saygin, A.P., Wilson, S.M., Hagler Jr, D.J., Bates, E., Sereno, M.I. (2004). Point-light biological

motion perception activates human premotor cortex. *The Journal of Neuroscience*. **24**:6181-6188.

Stevenson, R.A., Mikels, J.A., James, T.W. (2007). Characterization of the Affective Norms for

English Words by discrete emotional categories. *Behavior Research Methods*. **39:** 1020-1024.

Strauss, G.P., Allen, D.N. (2007). Emotional intensity and categorization ratings for emotional and

nonemotional words. *Cognition & Emotion*. **22**: 114-133.

Troje, N.F., Westhoff, C. (2006). The inversion effect in biological motion perception: evidence for a

"life detector"? *Current Biology*. **16**:821-824.

Zhang, Q., Lawson A., Guo, C.Y., Jiang, Y. (2006). Electrophysiological correlates of visual affective priming. *Brain Res. Bull.,* **71:** 316-323.