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Eye-tracktive: Measuring Attention to Body Parts When Judging Human Emotions

Cathy Ennis
Technological University Dublin, cathy.ennis@tudublin.ie

Ludovic Hoyet
Trinity College Dublin

Carol O'Sullivan
Disney Research, Los Angeles

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Eye-tracktive: Measuring attention to body parts when judging human motions

Cathy Ennis[†1] Ludovic Hoyet [‡1] Carol O'Sullivan[§1,2]

[1]Graphics, Vision and Visualisation Group, Trinity College Dublin
[2]Disney Research, Los Angeles

Abstract

Virtual humans are often endowed with human-like characteristics to make them more appealing and engaging. Motion capture is a reliable way to represent natural motion on such characters, thereby allowing a wide range of animations to be automatically created and replicated. However, interpersonal differences in actors' performances can be subtle and complex, yet have a strong effect on the human observer. Such effects can be very difficult to express quantitatively or indeed even qualitatively. We investigate two subjective human motion characteristics: attractiveness and distinctiveness. We conduct a perceptual experiment, where participants' eye movements are tracked while they rate the motions of a range of actors. We found that participants fixate mostly on the torso, regardless of gait and actor sex, and very little on the limbs. However, they self-reported that they used hands, elbows and feet in their judgments, indicating a holistic approach to the problem.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Animation

1. Introduction

Bringing virtual characters to life through motion-captured animation presents a range of challenges. Human motions such as walking and jogging are very familiar and any quirks or oddities are easily spotted. In general, retargeting motion from a human actor results in very natural motion, but the inherent inter-actor variety can be difficult to characterize, which makes it difficult to ensure consistency and predictability when it comes to subjective properties.

Knowing what makes a motion attractive can help developers create more appealing characters, while knowing what makes a motion distinctive can be useful when animating a crowd (e.g., where very distinctive motions should not be cloned) or when animating hero characters (e.g., whose motions may need to be more idiosyncratic). We conduct an eye-tracking experiment to determine which body parts are attended to when judging the attractiveness and distinctiveness of retargetted male and female jogging and walking motions.

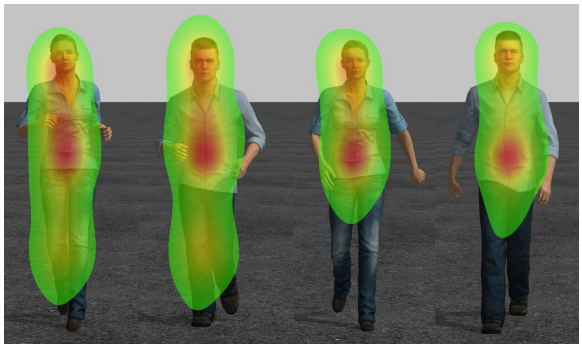

Figure 1: *Heatmaps showing fixation durations from all participants over all actors' motions for ratings of jogging attractiveness (l) and walking distinctiveness (r).*

2. Related Work

Distinctiveness of human motion in a crowd has been investigated by measuring the ease of detecting 'clones' in a crowd [MLH*09]. Eye-tracking data of participants per-

† Cathy.Ennis@scss.tcd.ie
‡ hoyetl@scss.tcd.ie
§ Carol.A.OSullivan@disney.com

forming a clone detection task was used to guide selective variation of different body parts for crowds. For varied realistic rendered models, they found that participants fixated mostly on the head and upper torso and almost never on the legs or lower torso. However, when presented with a mannequin character and asked to identify motion clones on identical characters, participants then fixated mostly on the pelvis area.

The saliency of different body part motions was also investigated by Hodgins et al. [HJO*10]. Participants were asked to audition pairs of virtual actors and to choose which was most convincing. While watching short clips of two virtual characters animated with different or no modifications, participants always reacted negatively to facial anomalies, whereas significant modifications to other body part motions went largely unnoticed.

It is widely known that facial attractiveness is negatively correlated with distinctiveness and averageness [RT96]. However, attractiveness cues can depend on how stimuli are presented, and the attractive properties of gait or other body movements are still not fully understood [HFN10]. Hoyet et al. [HRZ*13] investigated the distinctiveness and attractiveness of 15 male and 15 female motions retargetted to a single male and female character model. They replicated results from psychology studies on facial beauty, i.e., that an average motion is considered more attractive and less distinctive than original motions. They also found that distinctiveness does not translate across gaits, and that locomotions are more difficult to distinguish from each other than more unconstrained motions, such as dancing.

While Hoyet et al. investigated attractiveness and distinctiveness of motions, the contribution of different body parts and/or motions characteristics to participants' judgments was not investigated. Using the same stimuli as in their study, we perform an eye-tracking study to determine whether attention to any individual body parts contribute more or less to the judgment of motion attractiveness and distinctiveness, or whether a more holistic process is at play.

3. Experiment Design

As stimuli for our experiment, we used walking and jogging motions recorded on 15 male and 15 female Caucasian European actors, as well as average male and female motions. All motions were retargetted to the same female or male character model. More details are available in [HRZ*13].

Nineteen volunteers took part in this experiment: 12 (6F, 6M) rated attractiveness of the motion and 7 (2F, 5M) rated distinctiveness. All participants viewed two motion blocks (walking or jogging) for both actor sexes, presented in counterbalanced order, and stimuli were presented randomly within each block. In total, participants viewed 192 clips: 2 Sex (M/F) $\times$ 16 Actors (15 + average) $\times$ 2 Motions

Figure 2: *Participant taking part in our eye-tracking experiment, in the female jog block.*

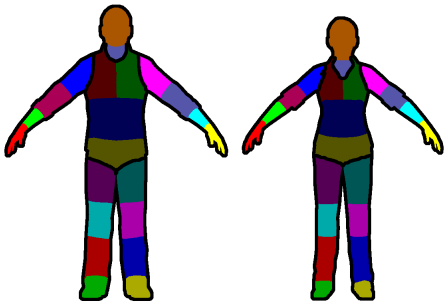

Figure 3: *Character body parts used in this experiment. For analysis, these individual body parts were further grouped into Torso, Head, Arms, and Legs.*

(Walk/Jog) $\times$ 3 repetitions. Participants viewed each stimulus for 5s, and were instructed to rate the attractiveness (resp. distinctiveness) of the motion on a Likert scale from 1 (very unattractive/indistinctive) to 7 (very attractive/distinctive). As in previous work, in order to avoid biasing the participants, we did not explicitly define what attractiveness or distinctiveness was, instead relying on their own understanding of these terms. Clips were displayed on a 24 inch screen at a resolution of 1920$\times$1200 pixels.

Participants' fixations (both count and duration) were measured using an SMI EyelinkII (Figure 2). Both eyes were tracked at 250hz and we recorded the *xy* screen coordinates of fixations. The animated scene was rendered in real time using a two-pass approach. The first pass rendered body parts of the virtual character in false colour and was not presented to participants; the second pass rendered the scene normally using textures. The *xy* screen coordinates were then used to determine the fixated body part for each frame. To account for slight inaccuracies in the fixation point, we did a nearest-neighbour search on the 20$\times$20 pixels surrounding the fixation point, to determine the closest body part. To ensure consistent calibration quality, the eye-tracker was recalibrated every 10 trials, and drift correction was measured and applied at the beginning of each trial.

For this experiment, each character was divided into 22 in-

dividual body parts. To perform a high level analysis, we first grouped the individual body parts into: Torso, Head, Arms, and Legs (as outlined in Figure 3).

We wished to determine which body parts were attended to when evaluating attractiveness/distinctiveness. Based on the results of previous studies, we predicted that the face would receive many fixations. However, to avoid confounding factors based on the character's body shape and appearance (i.e., texture), we used a single male and female character, as in [HRZ*13], which we hypothesized would encourage participants to focus more on the body motions, as these were the only varying factors. We also hypothesized that the lower half of the body would be fixated on the least, as found by McDonnell et al. Finally, it is also known that waist-to-hip ratio in women and shoulder sway in men are significant cues for attractiveness, so it may be the case that different body parts are more important for males and females, or across gaits.

4. Results

We first checked for correlation between participant responses for each experiment block (Male and Female actors for Walk and Jog gaits) and those found by Hoyet et al. We found significant correlations for both attractiveness and distinctiveness ratings (ranging from $r = 0.81$ to $r = 0.98$). We averaged over participant responses for each condition. We first conducted a repeated measures ANalysis Of VAriance (ANOVA) for fixation duration across the body part groups, with between-group condition *Task* (rating either Distinctiveness or Attractiveness) and within-group conditions *ActorSex*, *Gait* and *BodyGroup* (Head, Torso, Arms and Legs).

We found a main effect of BodyGroup ($F_{1,17} = 4.74$, $p < 0.05$) indicating that participants fixated more on the Torso, followed by Head, and fixated least on the limbs (Arms and Legs). While previous work had indicated that the lower body received less attention in clone/anomaly detection tasks, this means that it is also the case for evaluations of attractiveness and distinctiveness. There was also an interaction between ActorSex and BodyGroup ($F_{3,51} = 7.76$, $p < 0.0005$). A Newman-Keuls comparison of means showed that participants fixated for longer on the Head of the Female characters compared to the Male characters, and less on the Torso ($p < 0.05$ in all cases), as seen in Figure 4. Interestingly, we found no interaction between Task and BodyGroup, which implies that participants focus similarly on the same body parts when making decisions on both Attractiveness and Distinctiveness. We also found a main effect of Gait ($F_{1,17} = 5.33$, $p < 0.05$), where participants tended to have longer fixations for Walking motions over Jogging motions.

It is possible that participants fixated on the arms or legs to determine whether the motion was attractive/distinctive, but decisions were quickly made, resulting in short fixations. In order to investigate this, we also analysed the number of fixations (as opposed to fixation duration) across body groups

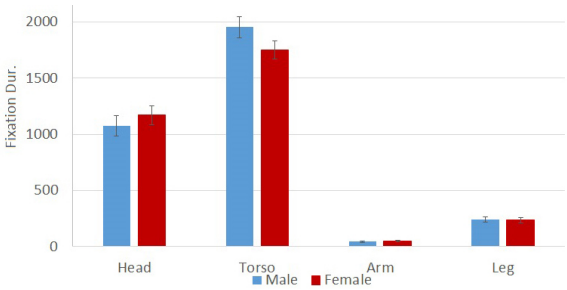

Figure 4: *Average fixation duration per trial for both our Male and Female Motions for each BodyGroup.*

for the same conditions as listed above. Here, we found a main effect of ActorSex ($F_{1,17} = 5.96$, $p < 0.05$), where participants had more fixations for the female motions compared to their male counterparts, implying that participants' eyes moved more between female body parts than for males.

We also found a main effect of Gait ($F_{1,17} = 44.01$, $p < 0.00005$), where participants had more fixations on the jogging motions than the walking motions. This corresponds to the effect we found for fixation duration, and suggests that participants fixated longer on walking motions but scanned the scene more for jogging motions. We had a main effect of BodyGroup ($F_{3,51} = 155.65$, $p < 0.0005$), which replicated our analysis of fixation duration i.e., participants fixated most on the Torso, followed by the Head, with limbs being fixated on least. We also found a similar interaction as for fixation duration for ActorSex and BodyGroup ($F_{3,51} = 3.89$, $p < 0.05$). Again, there were more fixations on the head of the female motions when compared to the male motions.

Torso Body Parts: As participants focussed mostly on the Torso for each task and both gaits, we wished to investigate whether there were any areas of the Torso that were more fixated on than others. We used the more detailed separation of body parts for this analysis, breaking the Torso into the following: Neck, Chest, Waist, Pelvis. We found a main effect of BodyPart for both fixation count ($F_{3,51} = 79.905$, $p < 0.00005$) and fixation duration ($3,51 = 70.312$, $p < 0.00005$), where post-hoc analysis showed that participants fixated more often and for longer on the Waist over any other part of the Torso. This was followed by the Chest, and finally the Neck and Pelvis. As the Waist is at a central location of the body (see Figure 3), the fact that participants fixate quite heavily on this area of the body could imply that peripheral vision plays an important role when making judgements on body motion. As can be seen in Figure 5, there seems to be a trend for participants spending less time looking at the Chest for female motions than their male counterparts. This corresponds to a near-significant interaction between ActorSex and BodyPart ($F_{3,51} = 2.694$, $p = 0.056$) that might become significant with more participants.

Participant Responses: While this theory is impossible

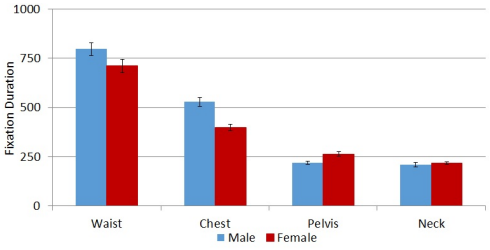

Figure 5: *Breakdown of average fixation duration per trial across each part of the Torso for male and female motions, showing Waist was the part most fixated on.*

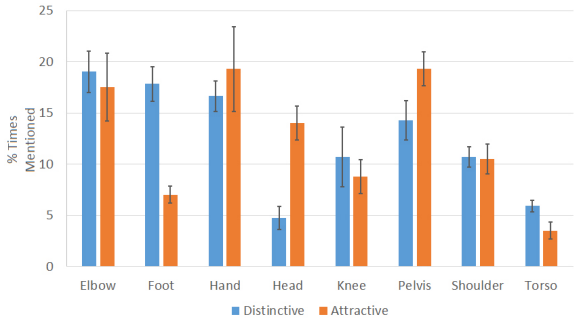

Figure 6: *Participants own ratings indicating the most important body parts for making judgements of the attractiveness and distinctiveness of our motions.*

to quantify with the data we collected from our participants' eye movements, we did obtain qualitative information from participants regarding which body parts were most important when they were making their decisions. After each motion block, we asked them to order which areas of the body were most important for their judgements. It was not mandatory that participants order each body part, so we only received data for the first three most important body parts for each participant across each condition. Averaging over responses for both tasks, we found that the body part selected most often was the Elbows (18.3%), followed by the Hands (18.0%). This was followed by the Pelvis (16.8%) and the Feet (12.4%). The Torso was actually the Body Part that appeared least often in the top 3 most important body parts as rated by participants themselves, with 4.7% (Figure 6). Given that participants' fixations were mostly centered about this area, yet was not rated as the most important cue when rating Attractiveness or Distinctiveness, it is likely that peripheral vision is key to these kinds of tasks.

5. Discussion

Results from the experiments described here add to the literature on rating attractiveness. We now know that when judging attractiveness, the limbs are fixated on far less than the centrally located body parts (Figure 1). It is possible that the fixation on a central focal point allows peripheral vision to contribute to fixated information, creating a holistic impression of the motion under examination due to their familiarity.

We also found that there tends to be more scanning of scenes with Female motions and longer fixations for Male motions, though the same body parts are most frequently viewed. This is a surprising result as male and female motions tend to be very different (e.g., more hip sway for female walks compared to males). Similarly, we found more scanning present during ratings of jogging motions than walks, with walking motions having longer fixations. These results imply that distribution of time spent on the important cues can change to determine features of different motions e.g., higher frequency movements may require more monitoring to ensure attractive features such as symmetry are present.

We found that, at a high level at least, there is a discrepancy between the cues that people believe they use in rating attractiveness/distinctiveness and what they are fixating on. This warrants further investigation, to determine whether a high-level decision is made based on the whole movement, or whether specific parts of the body are measured in peripheral vision. It could be the case that the parts of the body with fewest fixations (limbs) are those that move the most and are most likely to portray obvious asymmetry.

Finally, we obtained qualitative data from participants in the form of unstructured comments about qualities of motions they found attractive/distinctive. Future work will use this data to guide investigation of our eye-tracked information with some tangible metrics obtained from analysis of the motions themselves. For example, angular velocity of upper or lower arm segments could be important in making a jog appear distinctive, or symmetry between the motion of the legs could result in an attractive walk. We will guide analysis of these metrics by our findings in these experiments and match these to high level observations from our participants.

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