Strutting Hero, Sneaking Villain: Utilizing Body Motion Cues to Predict the Intentions of Others

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A better understanding of how intentions and traits are perceived from body movements is required for the design of more effective virtual characters that behave in a socially realistic manner. For this purpose, realistic body motion, captured from human movements, is being used more frequently for creating characters with natural animations in games and entertainment. However, it is not always clear for programmers and designers which specific motion parameters best convey specific information such as certain emotions, intentions, or traits. We conducted two experiments to investigate whether the perceived traits of actors could be determined from their body motion, and whether these traits were associated with their perceived intentions. We first recorded body motions from 26 professional actors, who were instructed to move in a "hero"-like or a "villain"-like manner. In the first experiment, 190 participants viewed individual video recordings of these actors and were required to provide ratings to the body motion stimuli along a series of different cognitive dimensions (intentions, attractiveness, dominance, trustworthiness, and distinctiveness). The intersubject ratings across observers were highly consistent, suggesting that social traits are readily determined from body motion. Moreover, correlational analyses between these ratings revealed consistent associations across traits, for example, that perceived "good" intentions were associated with higher ratings of attractiveness and dominance. Experiment 2 was designed to elucidate the qualitative body motion cues that were critical for determining specific intentions and traits from the hero- and villain-like body movements. The results revealed distinct body motions that were readily associated with the perception of either "good" or "bad" intentions. Moreover, regression analyses revealed that these ratings accurately predicted the perception of the portrayed character type. These findings indicate that intentions and social traits are communicated effectively via specific sets of body motion features. Furthermore, these results have important implications for the design of the motion of virtual characters to convey desired social information.

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1. INTRODUCTION

Socially realistic virtual characters provide a novel and promising approach as communication tools to enhance entertainment and aid training and learning. As a consequence, the use of virtual characters is becoming more ubiquitous across a range of applications relevant to the contexts of education, health care, and entertainment. However, for virtual characters to convey the desired social information to users, it is important that they are designed to act and behave in a realistic manner to enable engaging interaction and to increase motivation. The perception of socially realistic movements is therefore crucial when creating life-like characters. Such motion has usually been achieved either by using motion capture data (i.e., natural motions recorded from real actors) or by recruiting highly skilled animators to manually animate characters. However, it is not always clear how specific motions are associated with the perception of social information, such as certain emotions, intentions, or traits. For instance, if a virtual human appears trustworthy and attractive, users may feel more motivated to continue to engage with that medium. Furthermore, the modification of these qualities in a virtual character, by controlling the manner in which the body moves, may be an important tool for a designer in order to increase the appeal of the character in an adaptive way according to the user's needs. In order to design virtual characters with more appealing, engaging, and life-like motions, a better understanding of how intentions and social traits of a person are conveyed and perceived through body motion is required.

The aim of the following studies was to investigate whether traits can be determined from the body motion of real actors, and whether these traits were associated with their perceived intentions. The stimuli used in the experiments consisted of short video recordings of 26 professional actors, each performing their interpretation of two extreme character types; namely, "heroes" and "villains," each designed to convey "good" and "bad" intentions. Hero and villain character types were chosen as the associated body movements were expected to be highly differentiated and would best convey the opposite ends of the trait dimension (i.e., heroes with traits of positive valence and good intentions inviting approach behavior, and vice versa). Therefore, the exaggeration of intentions through these opposite character types allowed us to investigate the otherwise subtle social cognitive dimensions.

We examined the most central dimensions of social cognition that are used to make social attributions based on information about an individual (henceforth referred as "cognitive" dimensions). In the first experiment, we investigated whether these dimensions can be determined from the motion of a body by asking participants to rate each portrayed body motion along separate scales associated with different cognitive dimensions (i.e., intentions, attractiveness, dominance, trustworthiness, and distinctiveness). Participants in the second experiment were presented with the same video recordings and required to rate each stimulus according to a classification previously described as "Effort Shape" (ES) analysis [Gross et al. 2010], which allowed us to systematically examine the qualitative aspects of body movements related to hero and villain body motions. The six dimensions of the ES scale (i.e., torso, limb, energy, space, time, flow) provide information about how movement changes form and how exertion is concentrated during movement. This information can guide the design of more realistic, appealing, and engaging virtual characters.

2. BACKGROUND

People make social judgments based on their perception of others' physical characteristics, including the way they look and the way they move [Allison et al. 2000]. For example, previous research has revealed that social judgments can be determined from static features of a face [e.g., Todorov et al. 2008] and that they are sufficient to influence many important social decisions and outcomes from choosing a mate [Cornwell et al. 2006] to judicial outcomes [Zebrowitz and McDonald 1991]. However, there are many situations in which facial information may not be readily available, such as when perceiving a person from a distance. As a consequence, several studies have shown that a variety of social information can be inferred from dynamic body motion alone, including a person's sex [Pollick et al. 2005], identity [Loula et al. 2005], age [Montepare and Zebrowitz-McArthur 1988], and emotional states [Atkinson et al. 2004]. Moreover, social inferences made from body motion cues are thought to be instant and automatic [Albright et al. 1988]. Interestingly, it is commonly reported that observers are consistent in their perception of social information from short exposures to dynamic body motion of others even when the other person is unfamiliar [Borkenau et al. 2004]. Thus, human beings appear to be able to readily determine another's action and body movements, which allows the observer to adapt and guide his or her behavior for effective social interaction.

Previous studies have proposed that social perception is dependent on only a few crucial cognitive dimensions. For example, two orthogonal dimensions, those of dominance and trustworthiness, were found to be sufficient to describe social evaluations from face images [Oosterhof and Todorov 2008]. A recent study identified an additional third dimension, that of youthful attractiveness [Sutherland et al. 2013], which can also be determined from faces. Similar dimensions may also underpin the perception of social inferences made from observing the body motion of others. For example, Thoresen et al. [2012] identified two dimensions of personality, with the first reflecting adventurousness, extraversion, trustworthiness, and warmth, and the second neuroticism, which could be determined from body motion. On the other hand, Montepare and Zerowitz [1988] suggested a three-dimensional model to describe the multiple social inferences that can be drawn from body motion, with the first dimension reflecting predominantly social and physical power or dominance, the second interpersonal warmth, and the third attractiveness. These social inferences have been hypothesized to arise from the perception of facial cues signaling emotional expression, health, age, and/or familiarity of a face (overgeneralization effects) [Zebrowitz and Montepare 2008], allowing for a rapid judgment of another person's intentions and for one to decide the appropriate action to be taken (i.e., approach or avoid) [McAleer et al. 2014; Mcarthur and Baron 1983; Oosterhof and Todorov 2008].

Despite several studies determining social characteristics, such as personality or attractiveness, other factors such as the perceived distinctiveness or intentions have received relatively little attention in the literature on social inferences made from body motion alone. Previous research, particularly studies conducted with face images, has found that distinctiveness is important both for the perception of unfamiliar faces [e.g., Newell et al. 1999] and for the recognition of familiar faces [e.g., Shapiro and Penrod 1986]. For example, according to Valentine's (1991) "face space" model, a distinctive face is more memorable as it has unique features to distinguish it from other faces. In contrast, a nondistinct or typical face is less memorable as it may share features with many other faces [Valentine et al. 2015]. Generally, distinctiveness is associated with superior memory, which may be due to enhanced encoding or retrieval of distinctive items that have unusual features [Fleishman et al. 1976; Shapiro and Penrod 1986; Valentine, 1991]. Furthermore, distinctiveness has also been shown to be related to other cognitive dimensions. For example, ratings of face distinctiveness are negatively correlated with those of attractiveness [e.g. Rhodes and Tremewan 1996]. Recently, a similar negative association was found between the distinctiveness of body movements and the perceived attractiveness [Hoyet et al.

2013]. Thus, it may be suggested that distinctiveness evaluations may offer clues of how body motion is processed and its effect on social perception.

An examination of how intentions are perceived from body motion, and the relationship between these intentions and other characteristics of the person that are perceived, is necessary to provide a better understanding of how social decisions are made, particularly whether to engage with another individual. For example, research on body motion has shown that intentions to deceive may be detected solely from body motion alone [e.g., Runeson and Frykholm 1983; Wiseman 1995]. Moreover, even subtle movements of the body have been shown to affect the perceived intentions of others, suggesting the importance of body movements as a reliable cue for social perception [Manera et al. 2011]. Here in the current study we defined the term "intention" as a measure of the perceived valence of the depicted body motion. In other words, "good intentions" refer to body motion perceived to have a positive valence, whereas "bad intentions" refer to body motion perceived to have negative valence.

Some studies have attempted to identify specific body movements that are reliably associated with particular social characteristics. This information is particularly useful for designing socially realistic virtual characters. For example, Montepare and Zebrowitz-McArthur [1988] reported that more youthful gaits were associated with higher ratings of power and happiness, and ratings of power were highly correlated with more "masculine" gaits involving greater stride length and leaning forward. Other research has suggested that personality traits can be associated with different types of body motion and the activation of certain body parts [Koppensteiner and Grammer 2011; Thoresen et al. 2012]. For example, Thoresen et al. [2012] identified two underlying components linked to walking body movements that influenced personality ratings. The first component reflected the increased use of personal space that was related to higher ratings of adventurousness, extraversion, trustworthiness, and warmth, whereas the second component revealed that leisurely, relaxed walking, with a more diffuse use of space, was associated with lower ratings of neuroticism. Body motion cues have also been successfully utilized to predict the perception of other socially relevant information, such as teachers' effectiveness [Ambady and Rosenthal 1993], pride [Gross et al. 2010], or the vulnerability of walkers that could be used to predict the perceived ease of attack [Gunns et al. 2002].

The aim of the following experiments was to extend this previous research by investigating whether intentions can be directly, and consistently, perceived from the body motions of actors portraying characters with known associations with "good" and "bad" intentions, namely, heroes and villains. We were also interested in determining the associations between the perceived cognitive dimensions from the body movements. Specifically, we investigated how perceived intentions are linked to the perceptual qualities of a person, namely, their attractiveness, dominance, trustworthiness, and distinctiveness. A second aim was to identify the specific movements associated with perceived good and bad intentions and other social characteristics. The perceived qualities of body motion may have a direct influence on our initial impression of a person and are thus informative in the design of socially realistic virtual characters.

3. HERO AND VILLAIN STIMULI

The stimuli used for this experiment consisted of individual reference videos of performances recorded during a motion capture session. We recruited 41 professionally trained actors to ensure that each individual would be at ease while being recorded. The recording procedures were approved by the School of Computer Science & Statistics Research Ethics Committee. Each actor was required to move in a hero- or villain-like manner. They all received the same scripted instructions, as follows: "Everyone can think of different types of characters. We are interested in how our memory constructs information about these characters. In this task we would like you to act as a specific type of character. First, based on your own knowledge, how would you portray a hero? Then, based on your own knowledge, how

Fig. 1. Examples of stimuli (i.e., static images) from the hero (left) and villain (right) video clips presented in the experiments. These stimuli are edited for presentation purposes: a larger area of the room was displayed in the actual experiment; face masks were added postediting to avoid any influence on the response from facial expressions.

would you portray a villain?" For each of the actors, two sessions of each hero and villain condition were recorded. Each recording was triggered by a sound alert. Nine actors were excluded because their portrayal amounted to less than 10 seconds of recording or there was no difference between their hero and villain portrayals (e.g., in one case the actor walked around the room using the same, neutral gait pattern for both portrayals). The hero and villain scenarios were chosen for the following reasons: these are commonly depicted character types in games and entertainment, and the character types offered two distinct traits each with opposing intentions and valences (i.e., heroes are associated with good intentions and positive valence, whereas villains are associated with bad intentions and negative valence), which should be discriminable.

The resulting 128 video clips from 32 actors (16 females, mean age 24.8, *SD* 3.6) were then shortened to 10 seconds each, with the starting point matching the start of the actor's movement (i.e., the first movement following the sound). In order to prevent facial expressions from influencing the observers' ratings, all videos were edited to include a mask over each actor's face using Adobe After Effects software, Version CS5.5 (see Figure 1). The effectiveness of the hero and villain portrayals were confirmed in a pilot study in which six observers (two males, mean age 28.8 years) rated each clip on a scale of 1 to 7 for how hero-like or villain-like each actor was (with 1 = not at all like a hero/villain and 7 = very much like a hero/villain). Based on these ratings, one hero and one villain clip per actor were chosen for the final set of stimuli, and all video clips from six actors were excluded from the final stimulus set as they failed to achieve sufficiently high ratings for either character type (overall average 3.53, *SD* 0.81). The final set of 52 stimuli consisted of two video clips each from 26 actors (13 females) who received the highest ratings for each condition (hero: average 4.91, *SD* 0.78; villain: average 5.25, *SD* 0.96).

3.1 Validating the Hero/Villain Stimuli

The validation involved 17 naïve participants (mean age 23.6 years, eight males) performing a two-alternative forced-choice task, in which they had to decide whether each stimulus represented a hero or villain. Each participant was seated in a quiet, darkened room, approximately 60cm from the screen, and each stimulus subtended a visual angle of 21.3° in the horizontal dimension. The experiment was programmed using Matlab (version R2012a) and Psychophysics Toolbox version 3.0.10 [Brainard 1997; Kleiner et al. 2007; Pelli 1997] and presented on a Macintosh G5 computer running OS X. Participants were presented with 104 trials in a random order. Following each video, participants were prompted to respond, as fast and as accurately as possible, using one of two keys on the keyboard (the allocation of response key to hero or villain response was randomized across participants). The duration of the experiment was approximately 30 minutes. The overall accuracy was 81% ($SD = 16\%$) (i.e., 89% ($SD = 14\%$) for hero and 81% ($SD = 16\%$) for villain), suggesting that performance was not based on guessing.

We were then satisfied that the portrayals of hero and villain could be determined from our stimulus set and that we could proceed with our main experiments.

4. EXPERIMENT 1: ASSESSING THE COGNITIVE DIMENSIONS ASSOCIATED WITH PERCEIVED INTENTIONS FROM BODY MOTION

4.1 Aims and Hypotheses

The main aim of the first experiment was to investigate what social judgments can be inferred from specific body motions conveying either hero- or a villain-type traits. In particular, we first tested whether body motions in the hero or villain portrayals were associated with the character having good or bad intentions, respectively. The perception of good or bad intentions in another individual has been shown to predict whether an observer will subsequently engage with that individual [Manera et al. 2011; Runeson and Frykholm 1983]. We then tested whether the ratings along the cognitive dimensions of dominance, trustworthiness, and attractiveness were differently associated with each of the hero or villain character portrayals. These specific cognitive dimensions have previously been shown to be important as they can explain most of the variance in rating responses to general traits determined from either static face images or body motion [Montepare and Zebrowitz-McArthur 1988; Oosterhof and Todorov 2008; Sutherland et al. 2013; Thoresen et al. 2012]. We also included the dimension of distinctiveness as this property has been reported to play a role in the perceptual (and cognitive) processing of faces [Fleishman et al. 1976; Newell et al. 1999; Shapiro and Penrod 1986; Velentine 1991]. A second goal was to examine the relationships between these cognitive dimensions, especially how the more descriptive qualities of a person may be related to his or her perceived intentions. It is important to note that, in order to ensure that we avoided any semantic bias to the results, the participants in the study were never made aware that the actors were instructed to portray body movements associated with hero or villain characters and were not explicitly asked to respond to those categories.

We hypothesized that the body motions associated with the hero portrayals would be perceived as having better intentions relative to the villains. Based on previous research on face perception and traits [Fink et al. 2010; Rhodes and Tremewan 1996], we further hypothesized that (1) attractiveness and distinctiveness would be negatively correlated; (2) attractiveness, dominance, and trustworthiness would be positively correlated; and (3) perceived good intentions would be associated with higher ratings on positive valence cognitive dimensions, namely, attractiveness and trustworthiness.

4.2 Methods

4.2.1 *Participants.* A total of 201 participants (85 females, 34.6 mean age years, 12.0 *SD*) volunteered to take part in the experiment. They were recruited, and they participated in the experiment online through Amazon's "Mechanical Turk" environment (details in Section 4.2.2). Participants were partially compensated for their time at the rate of $0.80 per experiment.

4.2.2 *Design.* The experiment was based on a mixed design with character portrayal (hero or villain) and sex of the actor (female or male) as within-subject factors and cognitive dimension (five levels) as a between-subject factor. The rating score was the main dependent variable.

Each observer was presented with 52 trials consisting of individual video clips of 26 actors portraying the two character types in a randomized order. Each observer rated only one cognitive dimension, to remove any "halo" effects (i.e., a previous positive rating may bias subsequent ratings along other dimensions [Dion et al. 1972]). The cognitive dimension ratings on the hero and villain body motions were collected based on an online experiment that was designed using custom-designed software named Xperiment (http://www.xperiment.mobi/) within Amazon's Mechanical Turk environment. Recent research suggests that data collected online is comparable to data collected from lab-based experiments

Table I. Cognitive Dimensions and the Questions and Scale Used in Experiment 1

Cognitive Dimension	Rating Question	0	100
Intention (INT)	What intentions are conveyed by the body motion?	Bad intentions	Good intentions
Distinctiveness (DIST)	How distinctive is the body motion?	Not distinctive	Very distinctive
Attractiveness (ATT)	How attractive is the body motion?	Not attractive	Very attractive
Dominance (DOM)	How dominant is the body motion?	Not dominant	Very dominant
Trustworthiness (TRUST)	How trustworthy is the body motion?	Not trustworthy	Very trustworthy

[e.g., Germine et al. 2012]. The effects found from the online experiment mirrored those found in a pilot study conducted in a laboratory environment. Each participant was randomly allocated to one of the five rating conditions. This was done automatically in the Xperiment software by randomly assigning each participant to the least populated condition to balance the group sizes. Xperiment was also set to exclude the data provided by participants who started the experiment but who failed to complete the full experiment.

4.2.3 *Procedure.* At the beginning of the experiment, each participant was required to complete a pretest consisting of a set of questions that were designed to ensure that the participant understood the instructions (as recommended by Crump et al. [2013]). The observers could start the experiment only after successfully completing this short pretest.

The experiment was composed of 52 trials, and each 10-second video stimulus was presented once to each participant across trials. After viewing each video clip, participants were presented with a question relevant to the cognitive dimension to which they were allocated (e.g., “How attractive is the body motion?”). Their task was to rate the body motion of the actor on a scale from 0 to 100 on the cognitive dimension in question by dragging a triangle-shaped indicator along a linear visual scale, with the endpoints clearly indicated (see Table I). They were instructed to base their response on the viewed body motion and ignore any other visual information (such as the masks in front of characters’ faces) and were encouraged to consider the whole scale when making their response. Once a response had been made, the next trial was presented. There was no time constraint for making a response. During the experiment, participants were provided with information indicating the number of trials completed relative to the total number of trials. After the experiment, each participant was asked to complete a short survey and was then debriefed on the purpose of the study. A total of 190 observers were included in the analyses and they completed the experiment within, on average, 17.7 minutes. Eleven observers took over 30.7 minutes (2 *SD* over the mean duration) to complete the experiment and their data was therefore excluded from the subsequent analyses.

The experimental procedures of this experiment (and Experiment 2) were approved by the School of Psychology Research Ethics Committee, Trinity College Dublin.

4.3 Results

4.3.1 *Interrater Reliability of the Ratings for Each of the Cognitive Dimensions.* We first calculated the extent to which participants’ ratings were consistent for each cognitive dimension. An interrater reliability score (i.e., Cronbach’s α) was calculated for each cognitive dimension and scores are displayed in Table II. The interrater reliability was high for most of the cognitive dimensions ($\alpha > .70$), although the ratings were less consistent across participants for dominance and trustworthiness made to the hero body motions ($\alpha = .70$ and $\alpha = .75$, respectively). Separate analyses of ratings for the female and male body motions revealed lowest interrater reliability for the dominance and trustworthiness ratings for the female hero body motion ($\alpha < .70$) than other motions, which were due to the low interitem

Table II. Interrater Reliability (i.e., Cronbach's α) Across Participants' Ratings on the Individual Cognitive Dimensions When Viewing the Hero or Villain Body Motions

Cognitive Dimension	N	ALL	Hero	Villain	FEMALE	Hero	Villain	MALE	Hero	Villain
INT	38	0.96	0.91	0.88	0.97	0.90	0.93	0.92	0.86	0.79
DIST	42	0.93	0.93	0.92	0.91	0.90	0.92	0.93	0.94	0.93
ATT	40	0.90	0.9	0.90	0.88	0.80	0.89	0.81	0.80	0.75
DOM	38	0.94	0.70	0.93	0.94	0.43	0.72	0.94	0.81	0.95
TRUST	32	0.93	0.75	0.82	0.95	0.66	0.88	0.91	0.74	0.75

Note: INT = Intentions, DIST = Distinctiveness, ATT = Attractiveness, DOM = Dominance, TRUST = Trustworthiness.

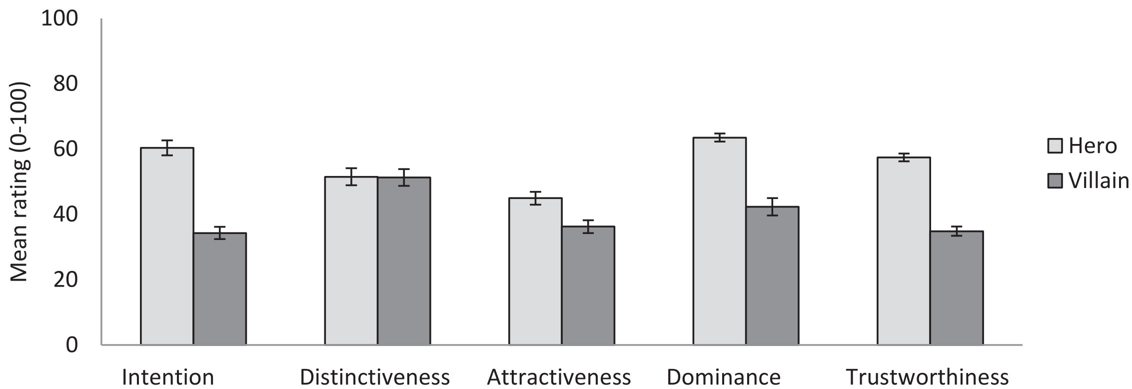

Fig. 2. The mean ratings provided on each of the cognitive dimensions to the hero and villain body motion portrayals. Error bars represent the standard error of the mean ratings.

correlations. Otherwise, the interrater reliability to the other dimensions was reasonably good for both the female and male hero and villain body motions ($\alpha > .70$).

4.3.2 *Differences Between Hero and Villain Character Types on Each Cognitive Dimension.* The mean rating scores provided to each of the character types (hero or villain body motions) for each of the cognitive dimensions were subjected to a mixed ANOVA with character type (hero or villain) and the sex of an actor (male or female) as within-subject factors and cognitive dimension (five levels) as a between-subjects factor.

There was a main effect of character type ($F_{1,55} = 262.10$, $p < .001$) with higher ratings overall to the hero than villain portrayals. There was a main effect of cognitive dimension ($F_{4,55} = 8.59$, $p < .001$), which was influenced by two-way interaction between cognitive dimension and character type ($F_{4,55} = 23.36$, $p < .001$). The post hoc tests using Bonferroni correction revealed that hero portrayals were rated to have better intentions than the villain counterparts (see Figure 2) (respective mean ratings = 60.3 and 34.3, $p < .001$) and to be more attractive (means = 44.9 and 36.2, $p < .05$), dominant (means = 63.4 and 42.3, $p < .001$), and trustworthy (means = 57.4 and 34.8, $p < .001$).

The sex of the actor influenced the ratings: the female actors received higher ratings than male actors ($F_{1,55} = 13.09$, $p = .001$; means = 49.6 and 44.7, respectively). There was an interaction between cognitive dimension and sex of the actor ($F_{4,55} = 5.17$, $p = .001$), as shown in Figure 3. The effect was mainly driven by the attractiveness dimension (female mean = 47.1 and male mean = 33.6, $p < .005$). There was an interaction between sex of the actor and character type ($F_{1,55} = 13.56$, $p = .001$), with female hero body motions receiving higher ratings compared to female villain body motions (means = 59.7 and 39.6, respectively, $p < .001$). There were no three-way interactions ($p > .05$).

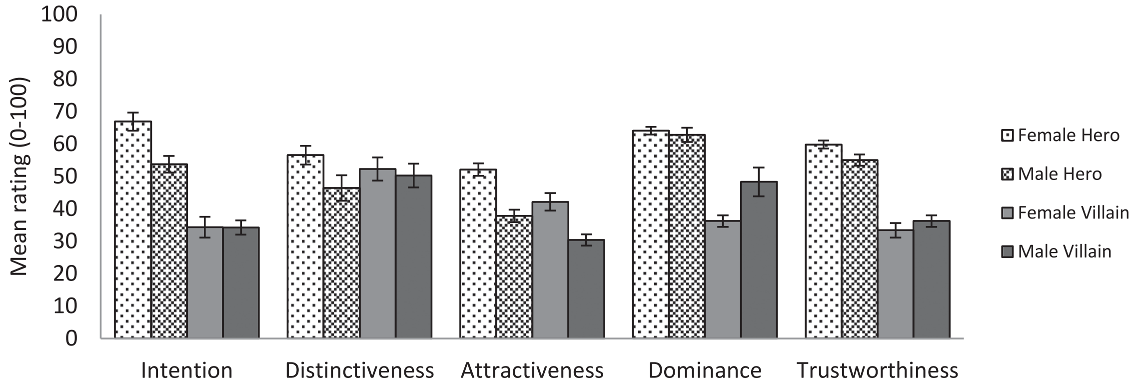

Fig. 3. The mean ratings provided on each of the cognitive dimensions to the hero and villain body motions, according to whether the actor was male or female. Error bars represent the standard error of the mean ratings.

Table III. The Correlations Between the Ratings Provided to Each of the Cognitive Dimensions and the Ratings Provided to the Cognitive Dimensions by the Character Type

		INT	DIST	ATT	DOM	TRUST
ALL	INT	1.00	−.02	.56***	.56***	.91*
	DIST		1.00	.06	.11	−.13
	ATT			1.00	.28*	.45***
	DOM				1.00	.72***
	TRUST					1.00
HERO	INT	1.00	.42*	.44*	.07	.72***
	DIST		1.00	.24	.26	.03
	ATT			1.00	.19	.34
	DOM				1.00	.26
	TRUST					1.00
VILLAIN	INT	1.00	−.61***	.40*	−.03	.79***
	DIST		1.00	−.13	.10	−.54**
	ATT			1.00	−.11	.11
	DOM				1.00	.29
	TRUST					1.00

Note: *** signifies $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

The correlations between the ratings to the different cognitive dimensions are reported in Table III. Next, the correlations between the ratings across the cognitive dimensions were examined separately for female and male actors. The ratings of intentions were highly positively correlated with trustworthiness ratings for female and male hero and villain body motions. Interestingly, the ratings of female villain body motions involved the only other statistically significant correlations: ratings suggesting bad intentions were correlated with reduced attractiveness and increased distinctiveness ratings ($r = .75$, $p < .01$ and $r = -.68$, $p < .01$, respectively). Similarly, more distinctive female villain body motions were perceived to be less trustworthy ($r = -.71$, $p < .01$). In addition, higher attractiveness ratings were associated with increased dominance and trustworthiness ratings ($r = .62$, $p < .05$ and $r = .58$, $p < .05$, respectively).

4.4 Discussion

In general, the ratings provided by the participants were consistent for each of the cognitive dimensions, suggesting that intentions and other social characteristics are readily perceivable from the hero and villain body motions. The findings also provide further support to previous studies suggesting that there is high agreement across observers' ratings on the perceived characteristics of a person they have never met before [e.g., Borkenau et al. 2004]. However, the ratings provided for the dominance and trustworthiness dimensions based on the female hero body motion were relatively less consistent across observers than the ratings to other dimensions. This may be due to greater variation across the body movements of the female actors. As expected, the body motions of the hero characters were rated as having significantly better intentions compared to the body motions of the villain. In addition, the hero body motions were rated to be more attractive and trustworthy, consistent with the hypothesis that cognitive dimensions with positive valence would be more likely to be associated with hero-like qualities. Interestingly, hero body motions were also perceived as more dominant compared to villain body motions.

With regard to the relationships across the dimensions, in general, the body motions of the characters perceived to have good intentions were rated high in attractiveness and trustworthiness. Furthermore, body motions rated as dominant were also associated with good intentions and being trustworthy, which implies that when judging body motions, dominance is perceived as a characteristic with a positive valence. Consistent with the hypotheses, attractiveness, trustworthiness, and dominance were positively associated, in that more attractive body motions were also perceived as more trustworthy and more dominant. These findings are consistent with previous research suggesting that the perceived dominance of a male is associated with an increase in his perceived attractiveness [Sadalla et al. 1987]. These findings highlight the role of body movement in perceived attractiveness and may provide a cues to the individual's mate quality in terms of his or her health and strength [Hugill et al. 2010].

Contrary to a previous finding reported by Hoyet et al. [2013], the distinctiveness of the body motion was not (positively or negatively) correlated with its perceived attractiveness (except for the female villain body motions). The complexity of the body motions involved in hero and villain portrayals may have masked this effect, and further research is required to investigate whether correlations between the perceived attractiveness and other cognitive dimensions are specific to the type of body motion portrayed. However, an intriguing pattern emerged for distinctiveness in relation to the hero and villain character types: distinctive body motion in the hero portrayals was associated with good intentions, whereas distinctive body motion in the villain portrayals was associated with bad intentions and being less trustworthy. Thus, it can be suggested that in accordance with the previous research using face images [e.g., Fleishman et al. 1976; Shapiro and Penrod 1986], distinctive movements may have enhanced the encoding of socially relevant information from the character-type body motions, this process possibly being mediated by acting skill. This finding may imply that utilizing more distinctive body motions in virtual characters will improve the effectiveness of conveying the desired intentions.

Our findings also suggest that the sex of the actor portraying the body motion influenced the ratings. Female body movements were rated higher overall relative to males; this effect was driven by females' body motion being perceived as more attractive. Furthermore, the correlations between the ratings of the cognitive dimensions were strongest for the female villain body motions. It is possible that the female actors were more expressive in their body motions and thus they were better at conveying the chosen character types [see, e.g., Crane and Gross 2013]. Moreover, gender stereotypes may bias the perception of social information [Koppensteiner and Grammer 2011].

The results of Experiment 1 suggest important links between body movements and the perception of different cognitive traits. However, the results do not elucidate the specific motions underpinning

Table IV. A List of the Effort-Shape (ES) Rating Scales Used in Experiment 2, and a Description of Each Extreme End of the Rating Scale (Adapted from Gross et al. [2010])

ES Factor		Descriptions of Movements (scale 1–5) 1	5
Shape	Torso	Contracted, bowed, shrinking	Expanded, stretched, growing
	Limb	Moves close to body, contracted	Moves away from body, expanded
Effort	Energy	Light, delicate, buoyant	Strong, forceful, powerful
	Space	Indirect, wandering, diffuse	Direct, focused, channeled
	Time	Sustained, leisurely, slow	Sudden, hurried, fast
	Flow	Free, relaxed, uncontrolled	Bound, tense, controlled

each of these percepts. To that end, the aim of Experiment 2 was to help identify the specific motion features of the body that are best associated with the perception of specific traits and intentions.

5. EXPERIMENT 2: DETERMINING THE SPECIFIC BODY MOTIONS ASSOCIATED WITH PERCEIVED TRAITS

5.1 Aims and Hypotheses

The results from Experiment 1 suggest that observers agree on their social inferences determined from body movements, indicating that there are distinguishable visual characteristics in body motion to efficiently communicate social information. Therefore, it should be possible to identify which features of the body motion are crucial for signaling certain types of social information. Although recent research has shown that certain body motion cues are important for signaling specific emotional expressions [e.g., Crane and Gross 2013], the critical motion cues necessary for the perception of the cognitive dimensions examined in the Experiment 1 are still unclear.

In the following study, we applied an "Effort Shape" (ES) analysis of the movements displayed in the video images described in Experiment 1. The study utilized the ES analysis to systematically relate the qualitative aspects of the body movements to hero and villain body motions. The main aim of Experiment 2 was to examine which body motion cues, measured with ES analysis, related to the perceived hero and villain character types and to their other associated cognitive dimensions. As previous research found that specific body motion cues can be used as predictors of emotions [Gross et al. 2010], a further aim was to investigate whether specific dynamic body motion features could be used as predictors of the hero and villain character types and the cognitive dimension ratings. As in Experiment 1, hero characters were thought to portray good intentions and traits of positive valence, whereas villains were thought to portray bad intentions and traits of negative valence.

ES analysis is a systematic qualitative description of body configuration and movement quality (Table IV). Its validity and reliability with nonexpert raters has previously been established [Gross et al. 2010]. The "shape" factors describe how movement changes form: "torso" measures the form of the body itself (1 = toward body center, 5 = away from the body center), and "limb" measures how the body shapes itself with respect to the environment (1 = gathering, 5 = scattering). The "effort" factors describe how exertion is concentrated during movement in four ways: energy (1 = light, 5 = forceful), space (1 = indirect, 5 = direct), time (1 = sustained, 5 = quick), and flow (1 = free, 5 = bound). Based on the previous studies [e.g., Thoresen et al. 2012], it was hypothesized that hero body motions would show increased use of space (i.e., higher torso ratings), more arm and head movements (i.e., higher limb ratings), and higher overall activity with less erratic movements (i.e., higher energy and time ratings) in comparison to the villain motions.

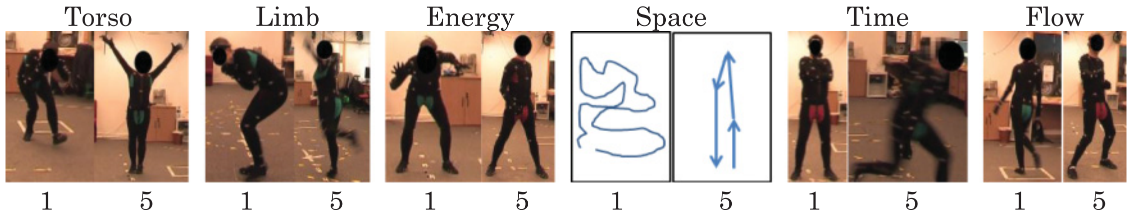

Fig. 4. An illustration of the body motions corresponding to each end of each of the Effort Shape (ES) rating scales used in Experiment 2.

5.2 Methods

5.2.1 *Participants.* Twenty participants (three males, mean age 23.4 years) took part in this experiment. They were all undergraduate students from the School of Psychology, Trinity College Dublin (Ireland), and they received either a small monetary reward (€5) or course credit to partake in the study. All participants reported normal or corrected-to-normal vision. Informed consent was obtained from all participants before the onset of the experiment.

5.2.2 *Design.* The experiment was based on a fully factorial design with character type (hero, villain), sex of the actor (female, male), and ES scale (torso, limb, space, energy, time, flow) as within-subject factors. The total number of 312 trials (i.e., 2 character types (hero, villain) × 2 sex of actor (13 female, 13 male) × 6 ES scales) was divided into 24 blocks of 13 trials each. Participants were tested in four separate rating sessions and were randomly allocated to each session. The order of the blocks was randomized and the trial order in each block was pseudo-randomized across sessions (i.e., a trial presenting an individual actor was shown once only in any one block).

5.2.3 *Procedure.* The rating study was conducted in a teaching room within the Institute of Neuroscience. All participants viewed the same 52 individual videos across the trials for the six different ES scales, and each video was displayed for 10 seconds (as in Experiment 1). These stimuli were projected onto a large screen. The participant's task was to rate the body motion of the person in each video according to a given ES analysis scale using ratings ranging from 1 to 5 [Gross, Crane and Fredrickson 2010] (see Table IV and (still) images corresponding to the extreme ends (i.e., 1 or 5) of each scale in Figure 4). Prior to the rating session, participants were provided with a short description of the ES scales and presented with still images representing the extreme ends of each scale.

Each rating block started with a prompt screen displaying the ES rating condition in question, with a written definition provided of the ends of the rating scale (Table IV). Each video clip was shown for 10 seconds. A 3-second break followed each trial to allow the participants to provide their response by circling their response (1–5) on an answer sheet. All participants were given a 2-minute break halfway through the experiment. The duration of the experiment was approximately 1 hour 20 minutes. The observers were not informed about the hero and villain character types portrayed in the videos.

5.3 Results

5.3.1 *Interrater Agreement of the Effort-Shape Ratings.* The interrater reliability scores are presented in Table V. There was strong consistency across the participants' ratings for most of the ES scales ($\alpha > .75$). However, the interrater reliability was relatively lower for energy ratings for the villain body motions of female actors ($\alpha = .60$) and for flow ratings associated with the hero body motions of male actors ($\alpha = .54$).

Table V. Interrater Reliability (α) of the Cognitive Dimension Ratings from the Body Motions

ES Rating	ALL	Hero	Villain	FEMALE	Hero	Villain	MALE	Hero	Villain
Torso	.98	.93	.97	.99	.90	.95	.97	.92	.97
Limb	.96	.91	.94	.97	.90	.87	.94	.88	.95
Space	.90	.81	.93	.89	.75	.93	.91	.87	.93
Energy	.87	.80	.86	.83	.79	.60	.87	.81	.88
Time	.97	.97	.96	.97	.95	.97	.97	.97	.96
Flow	.84	.80	.88	.87	.86	.88	.80	.54	.89

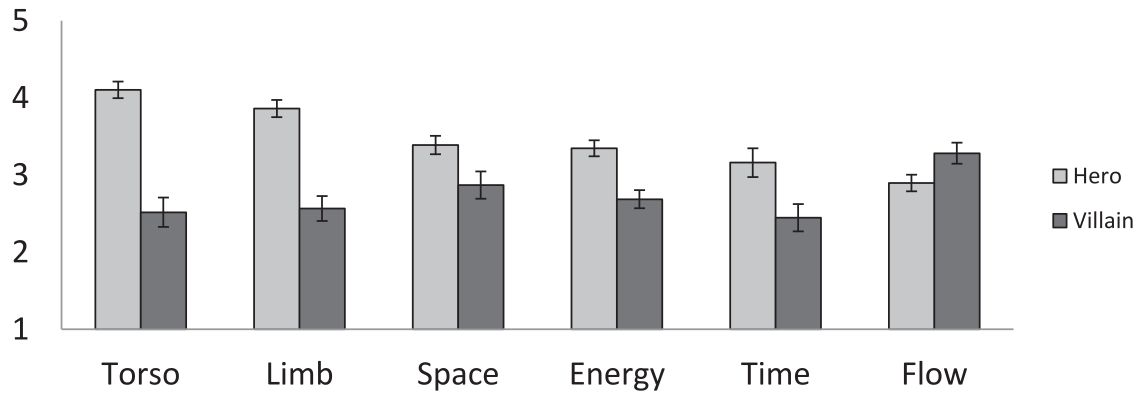

Fig. 5. The mean ratings provided to each of the hero and villain character types, across the different Effort-Shape (ES) scales. Error bars represent the standard error of the mean ratings.

5.3.2 *Differences in the Effort-Shape Ratings Between the Hero and Villain Character Types.* Consistent differences were found across the ES ratings provided for the type of body motion associated with the portrayal of hero characters relative to those of the villain characters. The ratings were subjected to a repeated-measures ANOVA with character type (hero or villain), sex of the actor (male or female), and ES scale (six levels) as within-subject factors. There was a main effect of character type ($F_{1,11} = 82.65$, $p < .001$) with hero body motions receiving higher ES ratings overall relative to villains (means = 3.44 and 2.71, respectively). There were two interaction effects: character type × ES scale ($F_{2.6,28.9} = 18.27$, $p < .001$, Greenhouse-Geisser corrected), and character type × sex of actor × ES scale ($F_{2.3,25.3} = 3.43$, $p < .05$, Greenhouse-Geisser corrected). Post hoc analyses (Bonferroni corrected) were conducted on these interactions. First, the body motion of hero characters received significantly higher ratings on the torso, limb, energy, and time ES rating dimensions ($p < .005$), as shown in Figure 5. Second, female actors portraying a hero had more expanded body motions (torso and limb dimensions) compared to both male and female villains ($p < .005$), but male hero body motion did not differ from male villain body motion. The body motion of male heroes was rated to be stronger and more forceful (energy dimension) than that of the female villains ($p < .05$), as shown in Figure 6.

The sex of the actor affected the ratings as there was an interaction between character type × sex of actor ($F_{1,11} = 12.35$, $p < .005$). Post hoc analyses revealed that the female villain body motion (mean = 2.49) received low ratings compared to the body motions of female hero (mean = 3.48, $p < .001$) and male heroes and villains (means 3.41 and 2.92, respectively, $p < .01$). Also, male villain body motion received lower ratings compared to that of female hero ($p = .001$).

5.3.3 *Predicting Character Type Based on the Effort-Shape Ratings of Body Motions.* The correlations between the different ES scales are reported in Table VI. A logistic regression analysis was performed

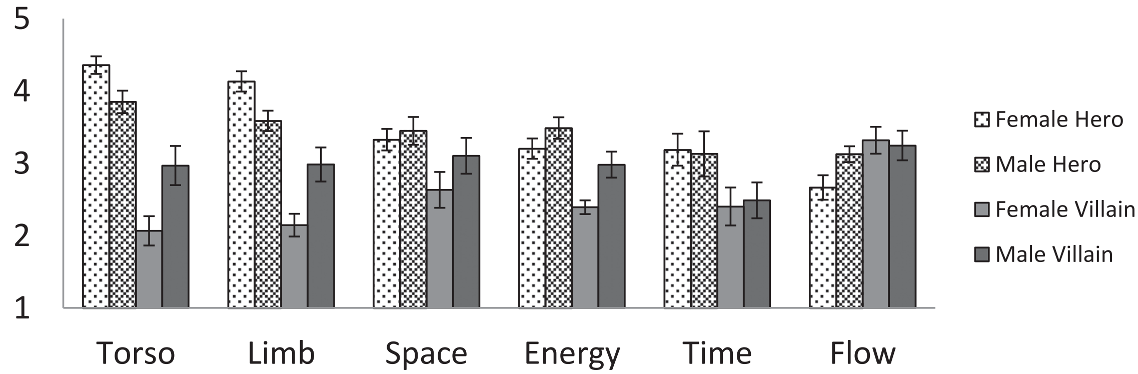

Fig. 6. The mean ratings provided to the male and female body motions associated with the hero and villain character types, across the different Effort-Shape (ES) scales. Error bars represent the standard error of the mean ratings.

Table VI. The Correlations Between the Ratings Provided to Each of the Effort-Shape (ES) Factors and Ratings Provided to the Effort-Shape (ES) Factors by the Character Type

		Torso	Limb	Space	Energy	Time	Flow
ALL	Torso	1.00	.86***	.39**	.64***	.28*	−.50***
	Limb		1.00	.34**	.60***	.40**	−.49***
	Space			1.00	.52***	−.06	.22
	Energy				1.00	.27	−.06
	Time					1.00	−.45***
	Flow						1.00
HERO	Torso	1.00	.56***	.23	−.06	.06	−.37
	Limb		1.00	−.22	−.23	.42*	−.56**
	Space			1.00	.43*	−.13	.41*
	Energy				1.00	.27	.57**
	Time					1.00	−.07
	Flow						1.00
VILLAIN	Torso	1.00	.81***	.24	.72***	.00	−.47*
	Limb		1.00	.34	.80***	.08	−.33
	Space			1.00	.44*	−.27	.33
	Energy				1.00	−.05	−.21
	Time					1.00	−.66***
	Flow						1.00

Note: *** signifies $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

to predict the character type perceived from the body motion based on the ES factor ratings. ES factor ratings predicted the portrayed character type correctly for 84.6% of the body motion videos ($R^2 = .70$, $X^2(6) = 38.58$, $p < .001$). Torso ratings were the only statistically significant predictor (Wald $R^2(1) = 5.02$, $p = .03$). The prediction equation of the probability p for perceiving a villain was (i.e., probability for perceiving a hero is $1 - p$)

$$Log_{(p/1-p)} = 13.301 - 2.435^{*}ES_{Torso} - .518^{*}ES_{Limb} + .281^{*}ES_{Space} + .303^{*}ES_{Energy} - .860^{*}ES_{Time} - .858^{*}ES_{Flow}.$$

Table VII. The Correlations Between All of the Effort-Shape (ES) Factors and Cognitive Dimensions (Taken From Experiment 1)

		Torso	Limb	Space	Energy	Time	Flow
ALL	INT	.78***	.70***	.24	.36**	.34*	−.44***
	DIST	−.16	.19	−.05	−.01	.42**	−.05
	ATT	.35**	.30*	.01	.01	.26	−.46***
	DOM	.82***	.81***	.49***	.80***	.39**	−.36**
	TRUST	.85***	.74***	.31*	.54***	.30*	−.44***
HERO	INT	.72***	.69***	.20	−.14	.23	−.32
	DIST	.13	.73***	−.38	−.05	.61***	−.42*
	ATT	.35	.37	.05	−.22	.06	−.38
	DOM	.18	.09	.19	.67***	.28	.17
	TRUST	.66***	.29	.41*	.04	−.05	−.13
VILLAIN	INT	.41*	.10	−.21	.00	−.06	−.40*
	DIST	−.47*	−.08	.15	.01	.29	.26
	ATT	−.03	−.18	−.28	−.29	.21	−.40*
	DOM	.75***	.82***	.47*	.80***	.18	−.37
	TRUST	.66***	.46*	−.13	.34	−.02	−.52**

Note: INT = Intentions, DIST = Distinctiveness, ATT = Attractiveness, DOM = Dominance, TRUST = Trustworthiness. *** signifies $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

Based on these findings, only torso ES ratings were included in the subsequent logistic regression analysis. In this model, the character type was predicted correctly in 86.5% of the body motion videos ($R^2 = .64$, $X^2(6) = 34.28$, $p < .001$). Torso ratings were a statistically significant predictor (Wald $X^2(1) = 13.36$, $p < .001$). The prediction equation of the probability p for being a villain was

$$Log_{(p/1-p)} = 8.244 - 2.382^{*}\text{ES}_{\text{Torso}}.$$

Furthermore, multicollinearity was not present for the first full model (variance inflation factor (*VIF*) values < 6, tolerance values $> .10$).

5.3.4 *Using Effort-Shape Ratings to Predict Perceived Traits.* The various correlations between the ratings to the cognitive dimensions (taken from Experiment 1) and Effort-Shape ratings are displayed in Table VII. Based on the several statistically significant correlations between ES ratings and intentions, dominance, and trustworthiness ratings, these cognitive dimensions were chosen for further analysis to investigate whether the ES ratings could be used to predict perceived intentions, dominance, and trustworthiness. For this purpose, and to achieve compatibility across the rating scales, the ES ratings were transformed to a scale of 0 to 100.

ES factor ratings predicted the perceived intentions, dominance, and trustworthiness from the body motion videos. The prediction equation models (the full models including all the ES ratings and the models including only the statistically significant predictors in the first full model) for intentions, dominance, and trustworthiness are displayed in Table VIII.

For predicting intentions, all the ES ratings were informative, as the model including all the ES ratings explained slightly more variance than the torso and energy rating scales alone. Interestingly, the energy and limb ratings were sufficient in successfully explaining the variance for dominance. The torso scale was the most crucial body motion cue related to the trustworthiness ratings.

A residual analysis was performed for each of the models and it did not reveal any outliers or data abnormalities that may have influenced the results. The normality of residuals was improved with

Table VIII. The Prediction Equation Models for Cognitive Dimensions Intentions, Dominance, and Trustworthiness

	PREDICTION EQUATION	MODEL FIT	STATISTICALLY SIGNIFICANT PREDICTORS
INT: -Model 1	$INT_{pred} = 1.44 + .71{*}ES_{Torso} + .05{*}ES_{Limb} + .00{*}ES_{Space} - .41{*}ES_{Energy} + .18{*}ES_{Time} + .17{*}ES_{Flow}$	$R^2 = .67$, $F_{6,45} = 15.26$, $p < .001$	-Torso ($t(45) = 4.69$, $p < .001$) -Energy ($t(45) = -2.41$, $p < .05$) -Time ($t(45) = 1.97$, $p = .05$)
-Model 2	$INT_{pred} = 14.22 + .67{*}ES_{Torso} - .32{*}ES_{Energy} + .14{*}ES_{Time}$	$R^2 = .66$, $F_{3,48} = 31.26$, $p < .001$	-Torso ($t(48) = 8.11$, $p < .001$) -Energy ($t(48) = -2.25$, $p < .05$)
DOM: -Model 1	$DOM_{pred} = -2.90 + .14{*}ES_{Torso} + .19{*}ES_{Limb} + .13{*}ES_{Space} + .48{*}ES_{Energy} + .06{*}ES_{Time} - .11{*}ES_{Flow}$	$R^2 = .85$, $F_{6,45} = 41.93$, $p < .001$	-Energy ($t(45) = 4.68$, $p < .001$) -Limb ($t(45) = 2.02$, $p = .05$)
-Model 2	$DOM_{pred} = -7.13 + .40{*}ES_{Limb} + .57{*}ES_{Energy}$	$R^2 = .81$, $F_{2,49} = 107.41$, $p < .001$	-Energy ($t(49) = 6.37$, $p < .001$) -Limb ($t(49) = 6.66$, $p < .001$)
TRUST: -Model 1	$TRUST_{pred} = 8.62 + .53{*}ES_{Torso} - .02{*}ES_{Limb} - .02{*}ES_{Space} - .03{*}ES_{Energy} + .06{*}ES_{Time} + .05{*}ES_{Flow}$	$R^2 = .73$, $F_{6,45} = 19.94$, $p < .001$	-Torso ($t(45) = 4.90$, $p < .001$)
-Model 2	$TRUST_{pred} = 12.91 + .50{*}ES_{Torso}$	$R^2 = .72$, $F_{1,50} = 128.87$, $p < .001$	-Torso ($t(50) = 11.35$, $p < .001$)

Note: Model 1 = Full model including all the ES ratings, Model 2 = Model including only the statistically significant predictors in the first full model. INT = Intentions, DOM = Dominance, TRUST = Trustworthiness.

the models including only the statistically significant predictors. Moreover, multicollinearity was not present in any of the models (variance inflation factor (*VIF*) values < 6, tolerance values $> .10$).

5.4 Discussion

The findings of Experiment 2 suggest that specific body movements are important for the perception of socially relevant information such as perceiving intentions and determining social traits. The interrater agreement across participants was high for the ES ratings, which further confirmed the good reliability of the ES method [Gross et al. 2010]. As hypothesized, the ES ratings of the body motions of the hero and villain characters differed as the body motion of the hero characters was rated to be more expanded, powerful, and hurried and included more movements away from the center of the body. Furthermore, the sex of the actor portraying the character types influenced the ratings. Regression analyses also indicated that specific body motion cues were informative in signaling certain traits. For example, the torso ES ratings accurately predicted the portrayed character type 85% of the time, with expanded body movements away from the body center indicating a hero character type. This finding is consistent with that of Ambady and Rosenthal [1993], who reported that body motion cues could be used to predict character traits (in their case the effectiveness of teachers).

In addition, the correlational analysis suggested strong relationships between body motion cues, as measured with ES analysis, and the cognitive dimensions of intentions, dominance, and trustworthiness. Subsequent regression analyses revealed that the expanded form of the body, forceful and fast movements, best predicted good intentions. The stretched form of the body was also the most crucial cue for perceiving trustworthy traits from body motions, which was in accordance with the finding of Thoresen et al. [2012] that higher ratings of trustworthiness are related to the increased use of personal space. It may be suggested that the different body motion cues that effectively signal intentions and trustworthiness imply that these two dimensions, though closely related, do not depict the same personality characteristics but rather different aspects of approach/avoid behavior: trustworthiness cues signal the approach/avoid qualities of the person, and perceived intentions prompt the perceiver to the most appropriate course of action to be taken. Dominance in body motion was associated with powerful movements away from the center of the body.

In sum, as hypothesized, the body motions associated with heroes were rated to have better intentions and to be more trustworthy and dominant. These body motions involving increased use of space, more limb movements, and higher overall activity were also rated as portraying positive valence. In contrast, the opposite type of body motions was associated with portrayals of the villain characters. These results therefore help to identify the specific body motions that are more readily associated with specific traits, which will facilitate the design of more life-like virtual characters.

As in Experiment 1, female and male actors were perceived as different in their use of body motion to portray the character types. When performing hero characters, the female actors showed a more upright posture and more motions moving away from the body center compared to their portrayals of villains, whereas male actors did not increase their use of personal space when performing a hero compared to a villain character. This tendency may be due to the variability in the perception of dominance from female body motions, as the interrater agreement across participants was relatively low for the dominance ratings of the female hero portrayals. On the other hand, the female actors may have adopted body motions to compensate for their lesser physical strength relative to males, as their body motions during hero portrayals involved a greater occupation of space. As mentioned in Experiment 1, gender stereotypes may also have affected these findings [Crane and Gross 2013; Koppensteiner and Grammer 2011], but further research is required to provide a better understanding of the role of gender stereotyping on perceived intentions from body motions.

6. GENERAL DISCUSSION

The findings from both Experiments 1 and 2 support the view that the perception of social traits can be driven by visual physical cues from body motions [Freeman et al. 2012]. According to more data-driven approaches to social cognition, observers can make instant and reliable social judgments based on short exposures to dynamic body cues through the movements of other unfamiliar persons [Allison et al. 2000]. In Experiment 1, participants were highly consistent in the ratings provided to each cognitive dimension, suggesting that information on intentions and other social characteristics is readily perceivable from the hero and villain body motions portrayed by the actors. This finding is consistent with research showing that observers tend to highly agree with each other when making social judgments [Thoresen et al. 2012].

In terms of hero and villain character types, we found that the ratings to the respective body motions were higher for perceived intentions when the hero body motions were portrayed relative to villain body motions and that higher ratings of attractiveness, trustworthiness, and dominance were also associated with hero characteristics. Furthermore, the finding that distinctiveness in hero body motions is associated with good intentions, whereas it is associated with bad intentions for villain body motion, implies that utilizing more distinctive body motions could improve the effectiveness of conveying the desired intentions of socially realistic virtual characters. Furthermore, given the differences in ratings for each of the cognitive dimensions that correlated with either the hero or villain body motions, this suggests that social intentions may be perceived as categorically distinct (i.e., good or bad intentions) and that positive (or negative) attributes are readily associated with each character type. The high agreement across participants' ratings suggests that body motion cues are readily perceivable and are consistently used to infer specific social information from other people.

Using an Effort-Shape analysis (Experiment 2) suggested that there are distinct body movements that can be identified and associated with each character type (hero or villain). For example, we found that the body motion of the hero characters was rated to be more expanded, powerful, and hurried and included more movements away from the center of the body. In particular, the "torso" (i.e., the posture) ES ratings were highly informative in the perception of character type as these torso ratings accurately predicted the portrayed character type 85% of the time. Similarly, the torso ratings were also an important cue for perceiving trustworthiness from body motions, which was in accordance with the finding of Thoresen et al. [2012]. Furthermore, specific body movements such as an expanded form of the body and forceful and fast movements were best associated with the perception of good intentions from body motion. In fact, even though the ES analysis cannot provide exact temporal and spatial information on the specific movements of body parts (e.g., torso dimension may aggregate several smaller body motion cues), it offers a promising approach to systematically identify characteristic body movements that are associated with social traits. The ES analysis has already been successfully used to generate naturalistic synthetic gestures in character animations [Chi et al. 2000].

Previously, the importance of dynamic body postures for the perception of social information from other people was mainly shown through studies of the perception of emotions from body motion [Crane and Gross, 2013; Gross et al. 2010, 2012]. These findings showing body posture to be a key cue are consistent with previous studies utilizing kinematic analysis and different classification systems to capture the variation in body motion during emotional expressions [see Dael et al. 2012; Roether et al. 2009]. In addition, Shindler et al. [2008] proposed a biologically inspired, hierarchical model that successfully categorized static images of body postures into seven basic emotional states (angry, disgusted, fearful, happy, sad, surprised, and neutral). Therefore, body movements alone can be readily associated with important social information. Previous research also identified characteristic body motion patterns that were most associated with approach and avoidance behaviors. For example, approach behaviors (e.g., engagement) were characterized by erect upper body, backward head posture, and stretched-out arms to the front, whereas avoidance behaviors (e.g., shame) were associated with collapsed upper body, downward head posture, and increased number of hand movements directed to self [Scherer and Ellgring 2007; Wallbott 1998]. Our findings extend this literature in an important way by showing that body motions can also be associated with specific traits, and moreover, that specific movements of the body differentially convey different information about the intentions and traits of another person. For example, the body motion of hero portrayals was associated with approach behaviors such as increased use of space, limb movements, and higher overall activity involving forceful and fast movements, in comparison to the body motions associated with villains, which were more suggestive of avoidance behaviors. Future studies could investigate the perceived intentions and other social characteristics, and the associated body motion cues, with more typical body motions, such as walking or reaching, using kinematic analysis methods.

It is not clear from our results how the perception of good and bad intentions arise from the body movements of hero and villain characters, and further research is required to elucidate the etiology during the course of development. It may be that there is an innate perception of the intentions of others, as suggested by some recent studies from developmental psychology [see, e.g., Hamlin et al. 2007, 2011], or it may be that these social categories are acquired in one's lifetime by exposure to popular fictional characters in books and films during childhood. Our findings support the idea that social categories are shared across individuals. Moreover, these findings suggest that it is possible to apply specific body motion cues to virtual characters in order to trigger the desired perception of social traits in the user interacting with the virtual character.

Finally, our results provide valuable insights to understand how intentions and social traits are perceived through body motion. While these experiments utilized video recordings of real actors as stimuli, such insights would also be highly valuable when designing the movement of virtual characters, when using either motion capture or manual animations. From this study, we would expect that the specific body motion cues previously mentioned could be applied on such virtual characters to trigger the perception of desired social traits when users interact with the character.

7. CONCLUSION

In general, humans appear to be able to readily perceive other people's intentions from their actions and body movements, which allows the observer to adapt and guide their behavior for effective social interaction. These decisions can have important implications for social behavior, including the possibility that the perception of qualities and intentions of virtual characters may influence the extent to which the user engages with that character. Based on the findings from this study, it can be suggested that specific body motions may be deployed to elicit and predict the accurate perception of certain social traits and intentions. Our results imply intriguing potential opportunities that could also be used to enhance the appeal and believability of virtual characters. Controlling and modifying the body movements of virtual characters so that they convey desired traits and intentions would be valuable to target different social situations. For instance, our findings suggest that making a virtual character use a large amount of its personal space, with a high number of limb movements and overall activity, would make the character be perceived as trustworthy and dominant and to have good intentions, which may be especially important when designing hero characters for games.

The ES analysis [Dell 1977; Gross et al. 2010] was an optimal method to identify which body motion cues were related to hero and villain character types as it provided a comprehensive, high-level description of the complex body motions associated with each character type. In combination with kinematic analysis and classification systems, these approaches could disentangle which body motions are related to different character types, personality characteristics, and intentions. Moreover, such a comprehensive analysis of body motions would help improve the design of moving virtual characters so that they convey the desired combination of these social qualities. More realistic virtual characters would be immensely valuable for the design of particular games and entertainment, particularly "serious" games, which are developed to aid training and learning in areas such as education, health care, and fitness. A better understanding of how social information and intentions are conveyed through human body motion is therefore essential for making this vision a reality.

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