Gender differences in the Perception of Affective Movements

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Abstract. Identifying human capabilities in perceiving affective expressions is essential for developing interactive machines that can engage with their human users. In order to ensure that the behaviour of the interactive machine is perceived as intended, any gender–specific differences in the perception of affective expressions are an important design consideration. This paper presents a preliminary study investigating the role of gender in the perception of affective hand movements displayed on both anthropomorphic and non-anthropomorphic structures. The results show that gender significantly influences the participants' perception and that the impact of the display structure and intended-emotion on the perception of the affective movements differs between male and female observers.

Keywords: Affective movements, Gender differences, Display structure, Perception, User study.

1 Introduction

Humans associate different body movements and postures with distinct affective expressions (e.g., anger is associated with frequent tempo changes) [6], [33], [12], [20], [1], and are able to identify the feeling encoded in a displayed movement even when demonstrators try to conceal their expression (e.g., negative body language) [4], [22], [10], [8]. Moreover, the psychology literature reports on the human tendency to ascribe human–like social and affective attributes to non–anthropomorphic structures such as abstract moving geometrical shapes, and even consider them to be engaging in social interactions [15]. Affective movement recognition and generation capabilities are particularly important in the field of human–machine interaction, in applications such as robotic social agents, kinetic sculptures, and animated characters. In order to develop reliable computational models for automatic affective movement recognition and generation for autonomous systems, it is important to understand how humans perceive affect from movement and whether there are gender-specific differences in the perception of affective movement.

The present work is a collaboration with Philip Beesley Architect Inc., a design practice developing a series of architectural responsive environments, called the *Hylozoic* series [3], [2]. These environments use massively repeating components, microprocessors, sensors and actuators to create decentralized responsive

systems capable of subtle motions giving the impression that the environments are 'sensitive' and may even have affective states (Figure 1). The long term goal of our research is to develop sufficient understanding of affective movement generation and perception to enable these structures to engage in affective communication with their occupants through movement.

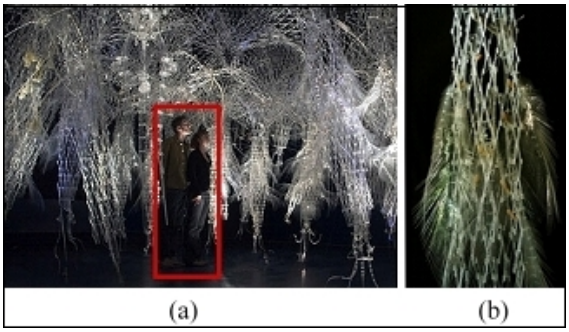

Fig. 1. a) Two visitors highlighted with a red outlined rectangle immersed in Hylozoic Soil, a responsive architectural geotextile environment [2]. b) Hylozoic Soil consists of layers of mechanical fronds and whiskers that move in response to the human occupants [2]. Reprinted with permission.

The effect of gender on the perception of body language and in particular, bodily expression of emotion is largely unexplored. Differences in affective movement perception could arise due to the gender of the demonstrator and/or observer. Furthermore, the structure on which the affective movement is displayed may have a different effect on how the emotion is perceived by male or female participants. In an early study by Carmichael et al. [7], behavioural hand and arm gestures performed by an actor (e.g., hand and arm gestures for prayer, fear, anxiety) were correctly recognized above the chance level and no significant gender-differences in the perception of the gestures was observed. In general, reports on gender differences in the perception of affective expressions mainly focus on facial expressions. Male and female high school, college and university students showed significant differences in their rating of facial expressions corresponding to the six Ekman emotions [17]. Women perceive conveyed emotions through facial expressions more accurately than men [17, 13]. In another study, participants were shown videos of neutral faces gradually changing to express different emotions and women were more accurate and sensitive in perceiving the facial expressions [24]. Furthermore, neurological studies report on the involvement of different underlying circuitry in perception of emotion in men and women [31].

Other studies investigate the role of the demonstrator's gender in the perception of affective movements. In a user study, participants tended to apply social stereotypes to infer the gender of a point-light display throwing a ball with different emotions: happiness, sadness, anger, and neutral. Angry movements were perceived to be demonstrated by men and sad movements were more likely to

be attributed to women [16]. Due to kinematic similarities between fearful gait and female gait, the fearful gait is better perceived if the walker is female [14]. Significant gender differences in the perception of emotion from static postures of *Venus* and *Apollo* with different arm positions are reported in [29].

According to these studies, gender might play an important role in the perception of affective movement; hence, further investigation is needed to identify the role of gender in affective movement perception. To the best of the our knowledge, there has been no research reported on gender differences in the role of display structure on the perception of affective movements.

We have conducted a user-study in which participants watched videos of a set of affective hand movements displayed on human-like and frond-like structures (Figure 2) and evaluated the perceived affective expressions. The frond-like structure appearance was designed to be similar to the Hylozoic soil structural elements. In a previous study, the effect of the intended–emotion and display structure on the participants' perception of the movements was investigated and it was found that the intended–emotion has a main affect on the participants' perception of the affective movements and that the participants' perception of the affective movements was significantly affected by the display structure, specifically in the case of sad movements [28]. In the present study, we investigate the following questions:

1. Did the gender of the observers have an influence on the perception of affective hand movements?
2. Did the intended–emotion and display structure have a different impact on male or female observers?

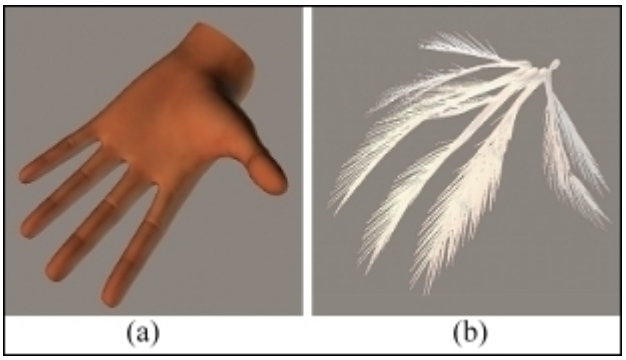

Fig. 2. Structures used to display expressive movements. a) anthropomorphic (human–like) hand model, b) non–anthropomorphic frond–like structure. These animated structures are produced using Poser (version 8, Smith Micro Inc.).

2 Affective human hand movements

The labeled dataset from [**?**] is used in this study, and includes one movement type, closing and opening of the hand, which mainly involves phalangeal and carpo–metacarpal joint movements. Three different affective expressions were considered: sadness, happiness and anger. Five repetitions of each expression were collected. A demonstrator, who has been exposed to Laban notation [18], and is familiar with other human movement perception works (e.g. Camurri et al [6]), performed the hand movements while wearing a data glove (ShapeHand from Measurand [21], [23]). Videos of these movements are available in [27].

The movements were animated on each of the two structures shown in Figure 2. These structures have the same kinematics but their physical appearance differs. The rationale for choosing hand movements in this study is that the hand is an important medium for communicative gestures [33], and it closely resembles the motion style and structure of the moving components of the Hylozoic environments.

3 Questionnaire study

In order to assess how affective movements are perceived and any impact of display structure, human observers were asked to rate the level of observed affective expression in each movement.

Observers were asked to rate the level of affect using both a discrete and dimensional emotion models. For the discrete model, the well known Ekman model was used, which proposes anger, happiness, sadness, surprise, disgust and fear as the six basic and universally recognized emotions [11]. For the dimensional model, the Circumplex model of emotion [26] was used, which represents emotions in a continuous two dimensional space defined by arousal and valence. The arousal dimension represents the intensity of an emotion and the valence dimension ranges from negative (unpleasant) to positive (pleasant).

During the user study, videos of the movements performed on the two different structures (Figure 2) were shown to the participants. They were then asked to evaluate the demonstrated movements in terms of expressivity. A total of 22 participants (26.1 years $\pm$ 5.8 years, 12 male, 10 female) completed the questionnaire. Participants were healthy adults with a basic working knowledge of computers and were students at the University of Waterloo. They were provided with detailed information on the study and the procedure to complete the computer–based questionnaire. All the questionnaire sessions took place at the same location and were administered by the author to ensure a uniform experience for all the participants. The study received ethics approval from the Office of Research Ethics, University of Waterloo, and a consent form was signed electronically by each participant prior to the start of the questionnaire.

In a questionnaire session, a participant watches and rates the same affective movements displayed on the human–like hand structure (Figure 2.a) and the frond–like structure (Figure 2.b). The following naming format is used to refer

to the animations in the rest of the paper: "(structure: hand, frond)_(intended–emotion: angry, happy, sad)" (e.g., "Hand_Happy" represents the happy movement displayed on the human–like hand structure).

The animations of affective hand movements were shown to the participants in randomized order. Each video was accompanied by two questions. The first question was a multiple–selection question asking participants to select among a list of keywords those that most closely described the animated structure in the video. Detailed data analysis for the first question can be found in [28].

The second question asked the participants to rate on a Likert scale the extent to which each of the six Ekman basic emotions was conveyed in the displayed animation, with 1 being "not conveyed at all" and 6 being "strongly conveyed". We used all six Ekman emotions in the questionnaire to determine emotion recognition capabilities accurately. Offering participants the choice of six emotions gives a more accurate picture of recognition rate, since it does not artificially constrain the responses and shows whether emotions are unambiguously recognized. In the third question, participants were asked to rate the arousal and valence components of the emotion perceived for each displayed movement, using a 7-point scale. A brief description of the arousal and valence dimensions of emotion was provided, along with a schematic representation of Circumplex model of emotion adapted from [9] and shown in Figure 3. Low intensity–high intensity and unpleasant–pleasant are the adjective pairs displayed at the extremes of arousal and valence scales, respectively, to further guide the participants in evaluating the arousal and valence components.

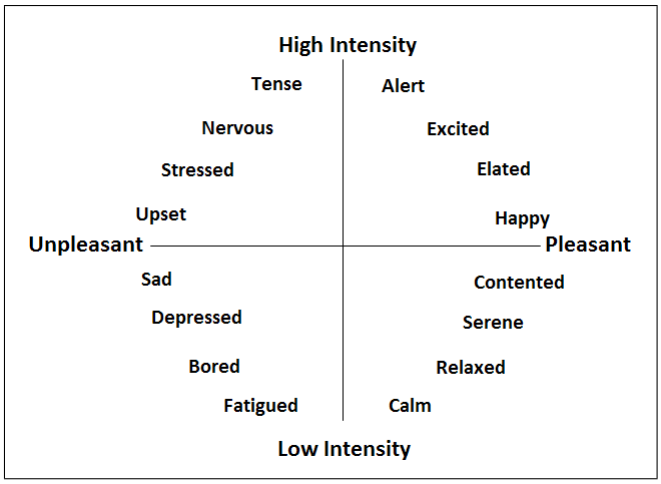

Fig. 3. A schematic representation of affective Cicumplex used in the questionnaire. This figure is adapted from [9].

4 Questionnaire data analysis

To investigate the effect of gender and its interaction with the display structure and intended–emotion on the participants' ratings of the affective movements, a three-way repeated measure ANOVA can be used with gender as a between-group variable, and display structure and intended–emotion as within-group variables. However, the interpretation of the significant effects from a three-way repeated measure ANOVA is difficult due to the large number of variables and their main and interaction effects (7 main and interaction effects). Furthermore, a larger sample size would be needed to detect significant effects of all the variables presented in the study. To reduce the number of effects and simplify the analysis, we instead performed two sets of two-way repeated measure ANOVAs (each set contains five ANOVA tests) to assess the main and interaction effects of the intended–emotion and structure on the ratings of anger, happiness, sadness, arousal, and valence by the male participants (set 1) and female participants (set 2). This way, we have reduced the number of variables to two within-group variables: intended–emotion and display structure. Therefore, the number of main and interaction effects is reduced to three, which facilitates the interpretation of different effects on the male and female participants' perception. Table 1 shows the null hypotheses tested in each repeated measure ANOVA.

Tables 2 and 3 show the resulting F–statistics, p–values, and effect sizes (η^2) for male and female participants, respectively. The SPSS statistical software package [30] was used to generate the user study results. The ANOVA results are considered significant at $p<0.05$. According to the ANOVA results in Table 2, there is a significant interaction between structure and intended–emotion in the male participants' ratings of anger, happiness, sadness, and valence; hence rejecting $H_0^{male}(3,i)$ for $i = \{anger, happiness, sadness, valence\}$. However, no significant interaction between the intended–emotion and structure in the female participants' ratings was observed (Table 3); hence, retaining $H_0^{female}(3,i)$'s.

There are also differences in the main effects of the intended–emotion and display structure on the male and female participants' perception. The intended–emotion was found to significantly influence the ratings of both the male and female participants in all the cases in this study except for the male sadness

Table 1. Null hypotheses tested in the repeated measure ANOVAs for the male participants' ratings; $i = \{Anger, Happiness, Sadness, Arousal, Valence\}$, $G = \{male, female\}$.

$H_0^G(1,i)$:	*The means of the G participants' ratings of i for different intended–emotions are equal.*
$H_0^G(2,i)$:	*The means of the G participants' ratings of i for different structures are equal.*
$H_0^G(3,i)$:	*Structure and intended–emotions are independent and no interaction effect between the two is present in the G participants' ratings of i.*

Table 2. F–statistics, p-values and effect size (η^2) results from two-way repeated measure ANOVAs each testing the main and interaction effects of structure and intended–emotion on male participants' ratings of anger, happiness, sadness, arousal, and valence. There are 12 male participants. Greenhouse-Geisser correction is used when sphericity assumption is violated. "*" sign indicates a significant effect. Bonferroni adjustment was made for multiple comparisons.

	i : Anger	Happiness	Sadness	Arousal	Valence
Intended–Emotion	$F(2,22) = 15.006$	20.749	2.127	18.947	9.981
$\left(H_0^{male}(1,i)\right)$	$p = 0.000$*	0.000*	0.143	0.000*	0.001*
	$\eta^2 = 0.315$	0.244	0.089	0.503	0.162
Structure	$F(1,11) = 0.014$	4.068	3.000	1.232	2.129
$\left(H_0^{male}(2,i)\right)$	$p = 0.908$	0.069	0.111	0.291	0.172
	$\eta^2 = 0.000$	0.027	0.014	0.004	0.012
Structure x Intended–emotion	$F(2,22) = 5.421$	7.871	8.406	1.329	17.488
$\left(H_0^{male}(3,i)\right)$	$p = 0.012$*	0.003*	0.002*	0.285	0.000*
	$\eta^2 = 0.071$	0.166	0.103	0.008	0.228

Table 3. F–statistics, p-values and effect size (η^2) results from two-way repeated measure ANOVAs each testing the main and interaction effects of structure and intended–emotion on the female participants' ratings of anger, happiness, sadness, arousal, and valence. There are 10 female participants. Greenhouse-Geisser correction is used when sphericity assumption is violated. "*" sign indicates a significant effect. Bonferroni adjustment was made for multiple comparisons.

	i : Anger	Happiness	Sadness	Arousal	Valence
Intended–Emotion	$F(2,18) = 8.825$	7.676	14.333	33.081	15.221
$\left(H_0^{female}(1,i)\right)$	$p = 0.002$*	0.004*	0.000*	0.000*	0.000*
	$\eta^2 = 0.254$	0.174	0.230	0.612	0.311
Structure	$F(1,9) = 16.308$	1.385	11.000	11.184	38.383
$\left(H_0^{female}(2,i)\right)$	$p = 0.002$*	0.269	0.009*	0.009*	0.000*
	$\eta^2 = 0.114$	0.009	0.042	0.047	0.122
Structure x Intended–emotion	$F(2,18) = 1.619$	2.739	3.508	0.360	2.521
$\left(H_0^{female}(3,i)\right)$	$p = 0.226$	0.092	0.084	0.703	0.108
	$\eta^2 = 0.019$	0.050	0.064	0.003	0.060

ratings. The structure has a significant main effect on the female participants' ratings in all the cases at $p < 0.05$ except for the happiness ratings (rejecting $H_0^{female}(2, i)$ for $i = \{anger, sadness, arousal, valence\}$), whereas the effect of structure on the male participants' ratings was not found significant at $p < 0.05$.

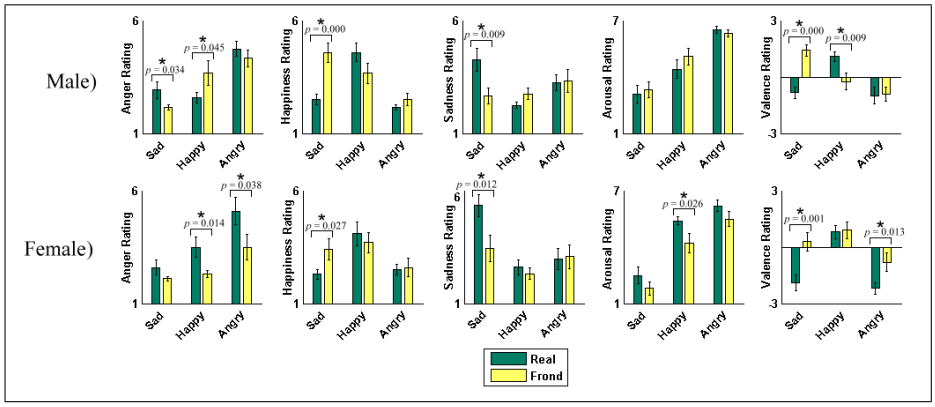

Fig. 4. Average ratings (mean ± SE) for the affective movements displayed on the human–like and frond–like structures by 12 male and 10 female participants. From left to right, ratings for: anger, happiness, sadness, arousal, valence. Significant pair-wise differences between the ratings of an intended–emotion displayed on different structures are indicated using "*" sign and their p-values are reported.

Bar charts of average ratings of anger, happiness, sadness, arousal, and valence by male and female participants are shown in Figure 4. Paired t-tests are performed between the pairs of the male and female participants' ratings of the affective movements displayed on the hand–like and frond–like structures and significant pair-wise differences are shown using "*" in Figure 4.

Table 4 shows a confusion matrix of the perception of the intended–emotions (i.e., anger, happiness, sadness). For the confusion matrix, an emotion is considered recognized if it is rated 3 or above on the Likert scale. Note that this recognition cut–off is applied only for illustrative purposes in Table 3 and all the analysis in Section 4 is done on the full scale of ratings obtained in the questionnaire study.

As can be seen in Table 4, the perception of anger by the female participants was significantly affected by the structure as the angry movement displayed on the frond–like structure was less frequently recognized as conveying anger in comparison with the angry movement displayed on the human-like structure (female anger rating of the angry movements in Figure 4). The male participants equally attributed high-arousal and negative valence to the angry movement and correctly recognized angry movement regardless of the structure (male anger, arousal, and valence ratings of the angry movement in Figure 4). However, female participants associated a lower-level of arousal and less-negative valence to the frond–like structure displaying the angry movement (female arousal and valence ratings of the angry movement in Figure 4). The better performance of

the male participants in recognizing angry movements is congruent with [32, 25] suggesting that men are more accurate in recognizing angry expressions. The happy movement displayed on the human–like structure is correctly recognized as conveying happiness and positive valence by both male and female participants, whereas the frond–like structure displaying happiness is less frequently recognized as happy. The male participants frequently misperceived the happy movement displayed on the frond–like structure as conveying anger, which might be the reason for the slightly negative valence attributed to the Frond_Happy movement by the male participants. Frond_Happy movement is correctly recognized by the female participants. Although there is a significant difference between the average arousal ratings of the Frond_Happy and Real_Happy movements by the female participants, these average ratings are relatively high for both structures with the Real_Happy movement regarded as conveying a higher arousal. The relatively higher accuracy of the female participants in recognizing happy movements in comparison to the male participants is similar to the reports in [34, 5] suggesting that women are more tuned to experiencing positive expressions.

Both the male and female participants correctly rate the sad movement displayed on the human–like structure as sad with low arousal and negative valence attributes, while the Frond_Sad movement is less frequently recognized as sad. The Frond_Sad movement is frequently perceived as conveying happiness and positive valence, especially by the male participants. Overall, both male and

Table 4. Confusion matrix showing percentage (%)* of anger, happiness, and sadness ratings for different affective movements by the 12 male and 10 female participants. The recognition rates greater than 50% are highlighted.

	Perceived emotions		
	Anger	Happiness	Sadness
Hand_Angry (male)	**92%**	0%	33%
Frond_Angry (male)	**75%**	8%	33%
Hand_Angry (female)	**70%**	10%	30%
Frond_Angry (female)	30%	20%	40%
Hand_Happy (male)	17%	**83%**	0%
Frond_Happy (male)	50%	50%	25%
Hand_Happy (female)	50%	**70%**	30%
Frond_Happy (female)	0%	**60%**	20%
Hand_Sad (male)	25%	17%	**58%**
Frond_Sad (male)	0%	**67%**	17%
Hand_Sad (female)	20%	10%	**90%**
Frond_Sad (female)	0%	40%	40%

∗ There are cases where an affective movement was rated 3 or above for more than one emotion. On the other hand, there are cases in which anger, happiness and sadness were all rated below 3. This is why none of the emotion ratings add up to 100% in the confusion matrix.

female participants correctly recognized differing levels of arousal from the affective movements, while women rate the perceived valence more accurately, which is consistent with [19].

Another important observation in this user–study is that the male and female participants exhibit a more similar affective movement perception when the demonstrator structure is human-like (Figure 4 and Table 4). Such structure-specific similarities in the perception of affective movements merit further investigation and would potentially motivate the use of more human–like structures for communicating affect during human-robot interaction to ensure consistent perception.

5 CONCLUSIONS

User studies allow for the exploration of the human capabilities in recognizing affective expressions displayed on different structures. Insight gained from such user studies can inform the design of interactive technologies capable of displaying various affective expressions. To the best of our knowledge, this study is the first report on gender differences in the perception of dynamic structures displaying affective movements. In the preliminary study presented in this paper, gender-specific differences in the perception of affective hand movements displayed on two different structures were investigated. It was found that the gender significantly influenced the perception of the affective movements in many cases. Furthermore, cases were observed in which the impact of the intended–emotion and display structure on the participants' perception of the affective movements varied between male and female participants (e.g., anger ratings for Frond_Angry movement). The male participants perceived angry movements more accurately than the female participants regardless of the display structure, whereas the female participants performed better in recognizing happy movements. Both male and female participants frequently misperceived sad movements displayed on the frond-like structure as conveying a positive expression.

The detected main and interaction effects of the intended–emotion and display structure in this study are of medium to large sizes. These findings demonstrate the important role that gender might play in the perception of affective movements and emphasize the importance of considering gender in the design of affective display mechanisms in general . There are a few prominent effects (e.g., intended–emotion effect on the sadness ratings of the male participants) that were not detected in this study. Future studies with a larger sample size will enable investigating the importance of these effects.

In future studies, the role of gender in the perception of affective movements will be further explored with a larger number of participants and a larger variety of affective movements in terms of expressivity and motion path. Furthermore, gender differences in the perception of different display structures will be further investigated to identify if there exist structures that might limit (or modulate) the communication of affective expression with male or female observers.

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