Emotion Attribution to Basic Parametric Static and Dynamic Stimuli

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Abstract

The following research investigates the effect of basic visual stimuli on the attribution of basic emotions by the viewer. In an empirical study (N = 33) we used two groups of visually minimal expressive stimuli: dynamic and static. The dynamic stimuli consisted of an animated circle moving according to a structured set of movement parameters, derived from emotion expression literature. The parameters are *direction, expansion, velocity variation, fluency,* and *corner bending*. The static stimuli consisted of the minimal visual form of a *smiley*. The varied parameters were *mouth openness, mouth curvature,* and *eye rotation.* The findings describing the effect of the parameters on attributed emotions are presented. This paper shows how specific viewer affect attribution can be included in men machine interaction using minimal visual material.

1. Introduction

1.1. Affective attribution and recognition

Since the classical research by Heider and Simmel [1] and Michotte [2] on affective attribution processes, it is taken for granted that people do attribute various elaborate characteristics, such as intentionality and character traits, to very abstract stimuli. It seems likely that the attribution of higher-order properties to moving stimuli starts with the lower-order attribution of animacy [3]. Neurological research has shown that animacy attribution leads to a processing in the STS area of the human brain, a part that is also activated in social perception [4]. When animacy is attributed, more elaborate attribution might follow, such as intentions, emotions and even sophisticated characteristics like fiction and non-fiction [5].

Essential in affective attribution research is research on the effective parameters: can we find a set of stimulus parameters that predict which emotion is attributed? Such knowledge will be of major importance to the production of (synthetic) affect production as well as to (automatic) affect recognition. Although some attribution researchers synthesize artificial stimuli in order to find affective parameters (e.g. Michotte [2]; Visch & Tan [5]), most attribution research is performed using abstracted realistic materials. Johansson [6] initiated this line of research by showing that subjects could recognize the gender of a moving human figure that is abstracted to 12 moving dots. A number of recognition experiments followed and showed that captured movement cues, represented by a limited set of dots, let subjects accurately recognize the most elaborate characteristics including deceptive intentions [7]. Even the emotion expressed by an abstracted knocking hand is recognized accurately by subjects [8] - as long as the motion cues derived from reality are maintained.

1.2. Motion and form

The following research aims at investigating the minimal synthetic visual parameters for emotion attribution to static (form) and dynamic (motion) stimuli.

1.3. Dynamic expressions

Since Darwin [9] the description of emotional human expressions has been a topic of research. However, there is ample congruence in the selected parameters to describe the different expressions. Sometimes the parameters overlap strongly such as Scherer and Ellgring's [10] parameter of *amplitude* and Wallbott's [11] parameter of *expansion.* But in most cases each researcher describes the expressions with a different set of parameters. It should be noted that in most cases the parameters were found by analyzing (captured) body expressions - cf. Glowinski et al. for an attempt to automatize emotion recognition of body gestures [12]. Only few researchers did vary the expressive parameters themselves systematically, such as Taguiri [13], who varied movement tracks and asked subjects to attribute emotions. The following research will select a set of dynamic parameters from the literature in order to vary them systematically and show its effectiveness on emotion attribution. The selected set consists of five parameters that are varied on two levels each: *direction, expansion, velocity variation, fluency, corner bending.*

978-1-4244-4799-2/09/$25.00 c2009 IEEE

1.4. Static expressions

Research on static expressions is mainly oriented to facial expressions. Although some research [14] exist on the expression form characteristics, the human face is seen as the most effective static display of emotions. Since we aim at finding the minimal effective parameters for emotion recognition, we abstracted the face to the most minimal set of features hypothetically capable of communicating a basic set of emotions. The most obvious and minimal static expressive facial display is the *smiley*. This face is used in low-tech environment like e-mails and mobile phones to communicate emotions effectively. Scarce research [15] is performed on the social function of using smiley's in electronic conversation but no research has systemically varied the expressive parameters of a smiley. For the present experiment we varied the following facial expressive parameters: *mouth openness, mouth curvature,* and *eye rotation.*

2. Method

2.1. Static stimuli

The static expressive stimuli *smiley*-like pictures were drawn in Adobe Illustrator. The choice of using smiley's instead of the classic schematic facial pictures that includes eyebrows, was based on (1) its minimal perceptual units (2) its proven use in picture communication. The units of the smiley contain only eyes and a mouth. In this experiment we varied the mouth on two parameters: *openness (open, closed), curvature (straight, corners up, corners down).* The eyes were not round but made slightly oval shaped. This shape let us vary the *eye rotation* on three levels: *straight, tops together, bottoms together.* The function of the eyebrow is abstracted to eye rotation as is a common practice in animation. The smiley's were presented individually on a black background. See figure 1 for the used set.

2.2. Dynamic stimuli

For the dynamic stimuli we created animations in Autodesk Maya of a moving circle on a black background – see figure 2. The duration of the animations was kept constant at six seconds, whereas the dynamics of the movement were varied structurally. On the basis of existing literature we selected the following set of five parameters that were varied on two levels each: *direction (up, down), expansion (expansion, contraction), velocity variation (acceleration, deceleration), fluency (fluent, staggered),* and *corner bending (sharp, round).* – see figure 2 for an illustration. The trajectory of the circle counts 10 corners. *Direction* has two levels, *up* and *down*, and entails the vertical movement direction of the circle: in the *up* condition the circle starts at the bottom of the screen and moves to the top, in the *down* condition the reverse happens. *Expansion* is varied by reversing the trajectory structure. As can be seen in illustration 2, the trajectory of the circle consists of a tree structure, in which the vertical distance is maintained but the horizontal distance is increased/ decreased by one horizontal unit at each corner ranging from 10 to 1. The variable *velocity variation* affects the velocity variation, either the circle *accelerates* or *decelerates* (the two levels are inversely related). The two levels of the *fluency* variable differ in that the fluent level entails one continuous acceleration/ deceleration whereas in the staggered (non-fluent) level, the circle stops for 160 ms (4 frames) at each of the ten corners. Finally, *corner bending* is varied by making sharp corners, as Figure 2, or round U shaped corners.

Figure 1: Complete set of static expressive stimuli.

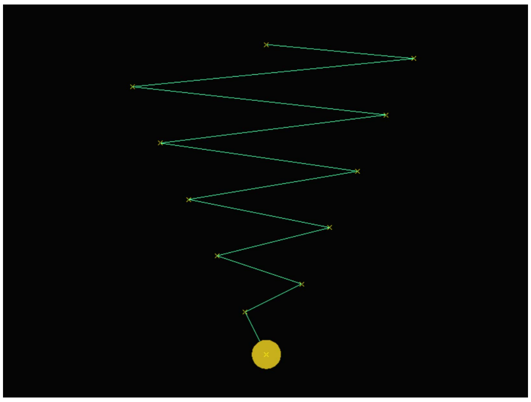

Figure 2: Still of dynamic expressive stimulus showing the trajectory of the circle. Only the circle is shown during the experiment.

2.3. Dependent measures and experimental design

Five dependent variables for emotion attribution were used: *joy, fear, sadness, anger,* and *surprise.* All dependent variables were measured using a 10 point Likert scale.

The experiment was within-subject designed as all participants rated all stimuli. The dynamic stimuli consisted of 25 items and the static stimuli of 18 items. The dynamic and static stimuli were presented as blocks, varying between groups of participants. After each stimulus the participant was asked to attribute each of the five emotions by adjusting an interactive slider continuously ranging from 'no' [specific emotion expression] to 'very good' [specific emotion expression]. After the attributing the emotions to one type of stimulus block, static or dynamic, the complementary block followed.

The participants consisted of 33 students of the University of Tilburg, who were naïve to the purpose of the experiment and were rewarded with course credits.

3. Results

3.1. Expressive static parameters

Using repeated measures showed that all three parameters had a significant main effect on the five emotion variables: mouth open/closed: $F = 31.13$, $p < .001$; mouth curvature: $F = 12.14$, $p < .001$; eye rotation: $F = 13.05$, $p < .001$). However, not all emotions were attributed equally to the stimuli: contrast analyses showed that *sadness* was attributed significantly above average ($F = 24, 90$, $p< .001$) and *anger* below average ($F = 14.68$, $p < .01$). Within the attribution of each emotion the effect of each parameter differed. All three parameter influenced *sadness* and *surprise* significantly ($F > 11.59$; $p < .001$). *Joy* was affected by *mouth curvature* and *eye rotation* (resp. $F = 6.58$, $p < .02$; $F = 5.20$, $P < .02$). *Anger* was influenced by *mouth openness* ($F = 6.81$, $p < .02$) and *eyes* ($F = 11.77$, $p < .001$); *fear* likewise by *mouth openness* ($F = 7.71$, $p < .01$) and *eyes* ($F = 4.09$, $p < .03$). Table 1 lists the settings for each parameter that was optimal within a given emotion attribution. Significance is measured by contrast analysis of the optimal level versus the next to optimal level. For instance, fear attribution is enhanced by an *open mouth* in contrast to a *closed mouth.*

In Table 2, the effect of each parameter on the total set of 5 emotions can be found. Significance is measured by contrast analyses between the effect of a parameter on the attribution of a specific emotion versus the mean effect on the attribution of all 5 emotions. For example, an *open mouth* elicits a significant attribution of *surprise,* but it also reduces attribution of *joy* and *anger.* It should be noted that the measured significance method is dependent on the used set of emotions. However, the used set is based on the standard set of six emotions as used in psychological research since Ekman [16]. From this set of 6 emotions, we removed *disgust* since we expected that this emotion would be too specific bound to realistic facial expression and restrain abstraction.

3.2. Expressive dynamic parameters

Repeated measures showed that only *velocity variation* (acceleration, deceleration) proved to have a main effect on emotion attribution. Contrast analysis showed that *fluency* was effective in the attribution of *surprise* - see Table 1. All in all, the dynamic parameters influenced the attribution of emotions to a much lesser extent than the static parameters did. Table 2 lists the effect of each expressive movement variable on the group of 5 emotions.

		Joy	Fear	Sadness	Anger	Surprise
Static parameters	Mouth openness		Open F=7.71, p<.01	Closed F=43.81, p<.001	Open F=6.81, p<.02	Open F=58.69, p<.001
	Mouth curvature	Corners up F=8.40, p < .01		Corners down F=116.48, p<.001		Straight F=16.30, p<.001
	Eye rotation	Bottoms together F=4.30, p<.05	Straight & Tops together F=7.60, p<.01	Tops together F=52.30, p<.001	Bottoms together F=11.77, p<.001	Straight F=11.59, p<.001
Dynamic parameters	Direction					
	Expansion					
	Velocity Variation	Acceleration F=7.56, p<.02		Deceleration F=13.87, p<.01	Acceleration F=7.71, p<.01	
	Fluency					Fluent F=7.32, p<.02
	Corner bending					

Table 1. Effect of parameters within each attributed emotion. Significance is measured by contrast analysis between most effective and next to effective level of the parameter.

		Joy	Fear	Sadness	Anger	Surprise
Static parameters						
Mouth openness	Open	- F=11.72, p<.001			- F=4.44, p<.05	+ F=21.85, p<.001
	Closed			+ F=74.72, p<.001	- F=15.28, p<.001	- F=18.19, p<.001
Mouth curvature	Corners down	- F=9.59, p<.01		+ F=145.49, p<.001		- F=12.27, p<.02
	Straight	- F=15.37, p<.001	- F=5.94, p<.03			+ F=43.64, p<.001
	Corners up	+ F=5.65, p<.03		- F=50.16, p<.001		
Eye rotation	Tops together	- F=10.20, p<.01		+ F=52.30, p<.001	- F=22.76, p <.001	
	Straight				- F=21.22, p<.001	+ F=33.02, p<.001
	Bottoms together		- F=13.01, p<.001		+ F=5.57, p<.03	- F=4.79, p<.04
Dynamic parameters						
Direction	Up			- F=7.39, p<.02		
	Down					- F=5.54, p<.03
Expansion	Expansion				+ F=4.32, p<.05	
	Contraction					
Velocity Variation	Acceleration			- F=12.46, p<.001	+ F=4.53, p<.05	
	Deceleration					
Fluency	Fluent			- F=12.46, p<.001		
	Staggering		+ F=5.02, p<.04			- F=6.95, p<.02
Corner bending	Round		+ F=4.34, p<.05		+ F=4.29, p<.05	- F=6.03, p<.03
	Sharp					

Table 2. Effect of parameters on the group of attributed 5 emotions (Between effect). Significance is measured by contrast analysis between the effect of a parameter on a specific emotion versus the mean effect of that parameter on the group of emotions. A plus sign (+) denotes a positive effect of the parameter on the emotion, a minus sign (-) a negative effect.

4. Discussion

The present research investigated the effect of basic dynamic and static stimulus features for emotion attribution. It was found that static expressive stimuli had more distinct effects on the attributed emotions than dynamic stimuli did. Also, it was found that static stimuli led to a dominant attribution of *sadness* and *surprise* over the other emotions, *joy, fear,* and *anger,* whereas the attributed emotions to the dynamic stimuli were more equally divided. Table 1 and Table 2 present the found parameter settings for the elicitation of each emotion: Table 1 lists the optimal parameter setting within each emotion, and Table 2 lists the parameter setting that is specific for the attribution of one of the five emotions. All of the parameters did effect the attribution *within* one or *between* all of the emotions significantly. Two settings however, *deceleration* and *sharp corner bending,* did not affect any of the emotions significantly. Summarized the findings show that subjects attribute distinctively five basic emotions to visual minimal static stimuli as well as to minimal dynamic stimuli. The dynamic and static visual parameters are presented in this research.

A possible explanation to the more effective static expressive features in contrast to the dynamic expressive features might be that the visual smiley represents a human facial expression better than a moving circle represents a human movement expression. Animacy attribution might therefore be stronger for the smiley stimuli. In order to correct for this, in future research a neutral face could be displayed on the circle.

The presented research will be of importance for affective computing in that it lists the features that require attention when generating expressive stimuli. For instance, the Tables show that the attribution of *joy* and *anger* share some features such as *acceleration* or *eye rotation bottom together*. Designers who want to elicit *joy* should therefore pay explicit attention to the *mouth curvature corners up*, as this is the distinctive stimulus feature. Also, the research shows that very limited visual material is required in order to let subjects attribute specific emotions. Even low-tech visual displays and man machine interactions might be extended by including predicted user emotion attributions, such as in a mobile phone for affective messages 'eMoto' [17]. Such affective interaction might on its turn facilitate an intended usage of the machine and enhance product appreciation.

Planned future research will extent the presented findings by (1) raising the number of subjects to make the effects still more significant, (2) by inclusion of a dimensional emotion scale on the rating, and (3) by conducting a priming experiment to show the respective strength of expressive static versus dynamic visual stimuli.

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