Perceived Emotionality of Linear and Non-Linear AUs Synthesised using a 3D Dynamic Morphable Facial Model

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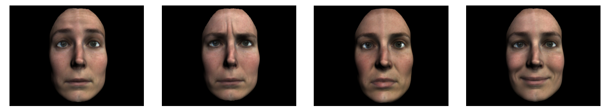
Keywords: Facial animation, Facial perception

1 Introduction

Research using dynamic facial expressions in computer science and psychology is largely focused on facial models with control parameters based on the Facial Action Coding System (FACS) [Ekman et al. 2002]. Facial models used in research and production are typically *linear* in nature, whereas real expressions are *non-linear*. Using a 3D Dynamic Morphable Model [Cosker et al. 2010], in this work we explore the effect of linear and non-linear facial movement on expression recognition. We believe that this has implications in the validity of using linear or non-linear models in facial experiments, and also impacts on the design of facial models in general.

Study Overview: Emotion Recognition and Choice of Animation: In this study, a subset of facial actions that are emotionally relevant, i.e. AU1, AU4, AU5, AU10, and AU12 (see [Ekman et al. 2002]), was selected. 40 participants performed a recognition task in which they were asked to indicate for each AU which emotion is expressed in the face (see Figure 1). To ensure sufficient stimulus variability, the five emotion specific AUs were embedded into a set of distractor AUs consisting of various lip movements: AU14, AU18, AU20, AU24, AU25. Linear and non-linear animations of the 5 target and 5 distractor AUs were always shown side-by-side, with the order of the AUs being randomized. For the 10 pairs of animations at onset phase, expressed emotion was measured within a fixed-choice format that required participants to select an emotion category that best matched the shown facial expressions. Response categories included 5 basic emotions (anger, disgust, fear, happiness, surprise) as well as the option no emotion/other emotion if none of the suggested categories was considered applicable. After completion of the emotion recognition task, participants were presented with the same pairs of facial animations again. They were instructed to make a distinction for each of the 10 AUs in terms of which of the two facial animations looked more natural with respect to the expressed emotion. The order of the AUs was randomized, with the side upon which linear and nonlinear animations appeared being counterbalanced across participants.

Results and Discussion: The mean recognition of target AU animations in terms of the predicted emotions was 76.5%, comparable to those reported in previous research with real videos (e.g.[van der Schalk et al. 2011]). Table 1 shows the confusion matrix of emotion category responses to target AU animations. One sample t-tests revealed that for all target AUs the predicted emotion recognition scores were significantly higher than chance, set conservatively at 33% ($ps < .05$). It can therefore be concluded that the AU animations conveyed affective meaning that was reliably and accurately (in terms of the predicted emotions) recognized by lay participants.



(a) AU 1 (b) AU 4 (c) AU 10 (d) AU 12

Figure 1: *Animation frames extracted from the 3D Dynamic Morphable Model. From left to Right: AUs 1, 4, 5 10 and 12.*

Anim.	Response					
	Surprise	Anger	Fear	Disgust	Happ.	None
AU 1	**86.4**	-	4.5	-	-	9.1
AU 4	9.1	**59.1**	9.1	18.2	-	4.5
AU 5	27.3	-	**63.6**	-	-	9.1
AU 10	-	9.1	-	**81.8**	-	9.1
AU 12	-	9.1	-	-	**90.9**	-

Table 1: *Confusion matrix of emotion category responses to target AU animations (percent recognition). Values of the predicted emotion category for each AU are printed in bold.*

To test for the effects of geometric motion quality (linear, nonlinear) across all AUs, a multivariate analysis of variance (MANOVA) was performed on participants' choice of animation. Results revealed a significant difference in preference frequency between the two types of animation, $F(10, 28) = 2.31, p < .05$. For the majority of AUs participants selected the nonlinear animations to be the more natural: AU1 (M = .63, SE = .08), AU4 (M = .61, SE = .08), AU5 (M = .58, SE = .08), AU10 (M = .61, SE = .08), AU12 (M = .55, SE = .08), AU14 (M = .71, SE = .07), AU24 (M = .55, SE = .08). For AU14 the nonlinear animation was strongly favoured over the linear one, and this preference also emerged as significant on an individual AU level, $F(1, 37) = 7.97, p < .01$. The pattern was reversed for three AU animations in which a linear motion pattern was chosen as the more natural: AU18 (M = .63, SE = .08), AU20 (M = .55, SE = .08), AU25 (M = .61, SE = .08). Our findings suggest that while non-linear movements are generally preferred over linear ones (supporting claims in [Cosker et al. 2010], AUs based on linear morphing may not necessarily compromise naturalness. When designing an animation system linear movement may therefore not be entirely undesirable. Rather, there exists a tendency towards an overall preference for nonlinear over linear movements.

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FAA '15, September 11-11, 2015, Vienna, Austria
ISBN: 978-1-4503-3530-0/15/09
DOI: http://dx.doi.org/10.1145/2813852.2813859