Acta Psychologica 187 (2018) 19–29

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Discrimination between smiling faces: Human observers vs. automated face analysis

Mario Del Líbano[a], Manuel G. Calvo[b,*], Andrés Fernández-Martín[c], Guillermo Recio[d]

[a] Universidad de Burgos, Burgos, Spain
[b] Universidad de La Laguna, Tenerife, Spain
[c] Universidad Internacional de La Rioja, Logroño, Spain
[d] Universität Hamburg, Hamburg, Germany

ARTICLE INFO

Keywords:
Facial expression
Smile
Emotion
Action units
FACET

ABSTRACT

This study investigated (a) how prototypical happy faces (with happy eyes and a smile) can be discriminated from blended expressions with a smile but non-happy eyes, depending on type and intensity of the eye expression; and (b) how smile discrimination differs for human perceivers versus automated face analysis, depending on affective valence and morphological facial features. Human observers categorized faces as happy or non-happy, or rated their valence. Automated analysis (FACET software) computed seven expressions (including joy/happiness) and 20 facial action units (AUs). Physical properties (low-level image statistics and visual saliency) of the face stimuli were controlled. Results revealed, first, that some blended expressions (especially, with angry eyes) had lower discrimination thresholds (i.e., they were identified as "non-happy" at lower non-happy eye intensities) than others (especially, with neutral eyes). Second, discrimination sensitivity was better for human perceivers than for automated FACET analysis. As an additional finding, affective valence predicted human discrimination performance, whereas morphological AUs predicted FACET discrimination. FACET can be a valid tool for categorizing prototypical expressions, but is currently more limited than human observers for discrimination of blended expressions. Configural processing facilitates detection of in/congruence(s) across regions, and thus detection of non-genuine smiling faces (due to non-happy eyes).

1. Introduction

A smile (basically, lip corners turned up and pulled backwards, frequently accompanied by exposed upper teeth) is often assumed to be a diagnostic facial feature of happiness and to reflect positive feelings and motives. Because people typically smile when they are happy, observers generally infer that the smiler feels happy (and/or is probably friendly). However, being happy does not necessarily lead someone to smile, and a smile can be exhibited for reasons unrelated to happiness. Actually, the smile is multifaceted and multifunctional in social interaction (Ambadar, Cohn, & Reed, 2009; Crivelli, Carrera, & Fernández-Dols, 2015; Ekman, 2001; Niedenthal, Mermillod, Maringer, & Hess, 2010). In addition to reflecting positive feelings (enjoyment, warmth, etc.), smiles can conceal or leak non-positive feelings, motives, or intentions (mockery, contempt, arrogance, malicious joy or schadenfreude, embarrassment, nervousness, etc.), or portray mere social politeness devoid of affect. Further, a person can involuntarily experience mixed emotions simultaneously, even involving opposite feelings of pleasantness and unpleasantness (see Russell, 2017), which can produce a variety of blended facial expressions with a smile. Thus, it is important to identify and differentiate the significance of such a variety of smiles.

For an observer, to distinguish a smile conveying positive feelings, motives, and intentions from a smile lacking them (or concealing non-positive ones), contextual factors and prior knowledge of the expresser can play an important role (Fernández-Dols & Crivelli, 2013; Hassin, Aviezer, & Bentin, 2013). In addition, a morphological facial feature called the Duchenne or D marker in the eye region can make a significant contribution (see Gunnery & Ruben, 2016). This marker engages contraction of the *orbicularis oculi* muscle, which lifts the cheek, narrows the eye opening, and produces wrinkles around the eyes (Frank, Ekman, & Friesen, 1993). Although such a marker can be spontaneous or deliberate (Krumhuber & Manstead, 2009), its absence or replacement with negatively valenced expressive changes (e.g., frown, etc.) would indicate that the smile does not reflect authentic happiness. A recent meta-analysis (Gunnery & Ruben, 2016) has shown

* Corresponding author at: Department of Cognitive Psychology, University of La Laguna, 38205 Tenerife, Spain.
E-mail addresses: mdlibano@ubu.es (M. Del Líbano), mgcalvo@ull.edu.es (M.G. Calvo), andres.fernandez@unir.net (A. Fernández-Martín), guillermo.recio@uni-hamburg.de (G. Recio).

https://doi.org/10.1016/j.actpsy.2018.04.019
Received 27 November 2017; Received in revised form 9 April 2018; Accepted 30 April 2018
0001-6918/

that Duchenne smiles and people producing them are rated more positively (i.e., authentic, real, attractive, trustworthy) than non-Duchenne smiles. Thus, observers can to some extent discriminate smiles assumed to convey positive affect from other smiles by relying on the eye region expression (see Ambadar et al., 2009; Gunnery & Hall, 2014; Krumhuber, Likowski, & Weyers, 2014; McLellan, Johnston, Dalrymple-Alford, & Porter, 2010; McLellan, Wilcke, Johnston, Watts, & Miles, 2012; Miles & Johnston, 2007; Quadflieg, Vermeulen, & Rossion, 2013; Slessor et al., 2014).

However, discrimination is limited and sometimes smiling faces with non-D eyes are seen as if they showed genuine happiness (see Krumhuber et al., 2014; Okubo, Kobayashi, & Ishikawa, 2012; Quadflieg et al., 2013). A central question is the influence of upper-face action and intensity in modifying the perceived meaning of smiles. In this context, to examine the role of the eye expression in discriminating among different types of smiling faces, a series of studies have been conducted in which the *type* of non-happy eye expression was varied. In addition to explicit expression recognition, measures of affective priming (Calvo, Fernández-Martín, & Nummenmaa, 2012), eye movements (Calvo, Gutiérrez-García, Avero, & Lundqvist, 2013), event-related potentials (ERPs) of brain activity (Calvo, Marrero, & Beltrán, 2013), and perceptual thresholds (Gutiérrez-García & Calvo, 2015) were collected, using blended expressions (i.e., a smiling mouth but non-happy eyes—neutral, angry, fearful, etc.) as stimuli. For comparison, prototypical happy faces (smiling mouth and Duchenne, happy eyes) and prototypical non-happy faces (e.g., angry mouth and angry eyes, etc.) were also presented. Across the various paradigms, difficulties in identifying (as "non-happy") blended expressions with a smile increased in the presence of angry vs. disgusted vs. sad vs. fearful vs. surprised or neutral eyes. That is, discrimination was better for smiling faces with angry eyes (i.e., the least likely to be confused as happy) than for those with disgusted eyes, which were discriminated better than those with sad or fearful eyes, and discrimination was poorest for smiling faces with surprised or neutral eyes.

The current study extended prior research with two major aims. First, we investigated smile discrimination *thresholds* and gradients, depending on type and intensity of the eye expression. We determined threshold as the *minimum* expressive intensity of happiness in the eye region that is required to recognize a smile as conveying positive feelings, as well as the minimum intensity of non-happy eye expressions (i.e., angry, etc.) that allows observers to identify a smiling face as *not* truly happy. To this end, using Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998) as stimuli, (a) we varied the degree of intensity (11 levels, from 0 to 100%, in 10% steps) of different eye expressions (happy, angry, fearful, disgusted, sad, surprised, or neutral) by means of a graphics morphing software (FantaMorph; Abrosoft; see 2.2. Stimuli); and (b) we combined a smiling mouth with different eye regions by means of the composite face technique (e.g., Quadflieg et al., 2013; Tanaka, Kaiser, Butler, & Le Grand, 2012). Thus, we generated photographs of (a) *prototypical* happy expressions with a smiling mouth and a happy eye expression, and (b) *blended* expressions with the same smiling mouth, but an eye expression that varied in intensity (from happy to non-happy).

The second aim addressed the comparison of *human* 'subjective' perception vs. *automated* 'objective' assessment of smile discrimination. An important issue here is the relative role of affective valence (as measured by subjective ratings) vs. physical features (as measured by objective automated analysis) of facial expressions. To this end, from human observers, we obtained (a) the probability that they categorized faces as happy or not happy; and (b) the degree of affective valence rating of each face, i.e., how positive or negative the expression configuration looked like. In addition, by means of automated analysis with Emotient FACET software (iMotions; see 2.5. Automated analysis of facial expressions), we computed (a) the probability of each of the six basic emotions (joy, anger, etc.) and neutrality for each face stimulus; and (b) each of 20 morphological action units (AUs) at local regions. Prior assessment of AUs by the Facial Action Coding System (FACS; Ekman & Friesen, 1978; Ekman, Friesen, & Hager, 2002) has shown that specific muscle movements characterize different emotional expressions. Recent developments (e.g., FACET) have standardized the assessment, allowing for a quantification of emotions and AUs as a function of spatial parameter maps of facial features (see Bartlett & Whitehill, 2011; Cohn & De la Torre, 2015).

In a related approach, Calvo, Gutiérrez-García, and Del Líbano (2018) recently found that, for human observers, (a) the probability of perceiving happiness in prototypical happy faces and also in blended expressions with a smile increased mainly as a function of affective valence of the facial configuration; and (b) the probability of (wrongly) perceiving blended expressions as happy increased with delayed saliency and reduced distinctiveness of the non-happy eye region, and with enhanced AU6 (cheek raiser) and reduced AU4 (brow lowerer). The current design makes three significant contributions. First, we have directly compared human processing and automated modelling of prototypical happy faces and blended expressions with a smile. Second, by means of automated analysis, we have assessed 20 AUs, and also six other expressions apart from happiness. Third, the eye expression intensity has now been systematically varied to examine discrimination thresholds, whereas previously only single (apex) happy or non-happy eye expressions were presented.

For the current study, we conducted two experiments, with two samples of 100 participants each and two different tasks, either happiness categorization or affective valence ratings. In addition, we performed computational modelling of facial expressions and AUs, as well as assessment of physical properties of the face stimuli (low-level image statistics and visual saliency). Nevertheless, for economy of exposition, and to provide an integrated view of the different measures, all of them will be presented together (in the Materials and methods, Results, and Discussion sections), as parts of the same study.

2. Materials and methods

2.1. Participants

Two-hundred university undergraduates (124 female; 76 male; aged 18 to 30 years; $M = 21.1$ years) from different courses (Psychology, Medicine, Law, Economics, and Education) participated voluntarily or for course credit, after providing informed consent. One-hundred of them (62 female) were randomly assigned to a facial happiness judgment task, and another 100 (62 female), to a valence rating task (see 2.4. Procedure). The study was approved by the University of La Laguna Ethics Committee, and was conducted in accordance with the WMA Declaration of Helsinki 2008.

2.2. Stimuli

For the different tasks (happiness judgment, valence rating, automated assessment, and computation of physical image properties), we used color photographs from the KDEF set (Lundqvist et al., 1998). The face stimuli portrayed 24 individuals (12 females: KDEF model numbers 01, 02, 07, 11, 14, 19, 20, 22, 26, 29, 31, 33; 12 males: 03, 05, 06, 10, 11, 12, 22, 23, 24, 25, 31, 35, each posing seven facial expressions (neutral, happiness, anger, disgust, sadness, fear, and surprise). All 24 models were presented once in their original form as (a) prototypical *happy* expressions showing Duchenne eyes and a smile, and as (b) prototypical *non-happy* expressions (neutral, anger, etc.).

In addition, (c) based on the KDEF original stimuli, we constructed six *blended* expressions with a smile but non-happy eyes, thus producing 144 new face stimuli, by means of the composite face technique (e.g., Tanaka et al., 2012). The upper half of each non-happy face and the lower half of the happy face were combined, by cutting each face along a horizontal line through the bridge of the nose and smoothing the junction. The following blends were created for each of the 24 models: