The not face: A grammaticalization of facial expressions of emotion

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ABSTRACT

Facial expressions of emotion are thought to have evolved from the development of facial muscles used in sensory regulation and later adapted to express moral judgment.

Negative moral judgment includes the expressions of anger, disgust and contempt. Here, we study the hypothesis that these facial expressions of negative moral judgment have further evolved into a facial expression of negation regularly used as a grammatical marker in human language. Specifically, we show that people from different cultures expressing negation use the same facial muscles as those employed to express negative moral judgment. We then show that this nonverbal signal is used as a co-articulator in speech and that, in American Sign Language, it has been grammaticalized as a non-manual marker. Furthermore, this facial expression of negation exhibits the theta oscillation (3–8 Hz) universally seen in syllable and mouthing production in speech and signing. These results provide evidence for the hypothesis that some components of human language have evolved from facial expressions of emotion, and suggest an evolutionary route for the emergence of grammatical markers.

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1. Introduction

Humans communicate with peers using nonverbal facial expressions and language. Crucially, some of these facial expressions have grammatical function and, thus, are part of the grammar of the language (Baker & Padden, 1978; Klima & Bellugi, 1979; Liddell, 1978; Pfau & Quer, 2010). These facial expressions are thus grammatical markers and are sometimes called grammaticalized facial expressions (Reilly, McIntire, & Bellugi, 1990). A longstanding question in science is: where do these grammatical markers come from? The recent evolution of human language suggests several or most components of language evolved for reasons other than language and where only later adapted for this purpose (Hauser, Chomsky, & Fitch, 2002). Since scientific evidence strongly supports the view that facial expressions of emotion evolved much earlier than language and are used to communicate with others (Darwin, 1872), it is reasonable to hypothesize that some grammaticalized facial expressions evolved through the expression of emotion.

The present paper presents the *first evidence* in favor of this hypothesis. Specifically, we study the hypothesis that the *facial expressions of emotion used by humans to communicate negative moral judgment have been compounded into a unique, universal grammatical marker of negation.*

Humans express negative moral judgment using one of three facial expressions of emotion: anger, disgust or contempt. These facial expressions communicate violations of one's rights, societal norms or beliefs (Greene & Haidt, 2002; Oatley, Keltner, & Jenkins, 2006; Rozin, Lowery, Imada, & Haidt, 1999; Shweder, Much, Mahapatra, & Park, 1997; Ekman, Sorenson, & Friesen, 1969), and are thus used to communicate negation and disagreement to observers, Fig. 1A–C. The production of each of these expressions is unique (Ekman et al., 1969), meaning that the facial articulations (known as Action Units, AUs) used to produce these expressions are distinct from one another. Different facial articulations are identified with a distinct AU number. For example, anger is produced with AUs 4, 7 and 24, disgust with AUs 9, 10, 17, and contempt with AU 14 (Ekman and Friesen,1978), Fig. 1. As seen in the figure, each AU involves a unique activation of facial muscles, *e.g.*, AU 4 uses a set of facial muscles that result in the lowering of the inner corners of the brows, while AU 9 wrinkles the nose.

We hypothesize that these facial expressions of negative moral judgment have been compounded to create a unique facial expression of negation. A compound facial expression is one that evolved from the expression of two or more emotions. As shown by Du, Tao, and Martinez (2014), when facial expressions of emotion are

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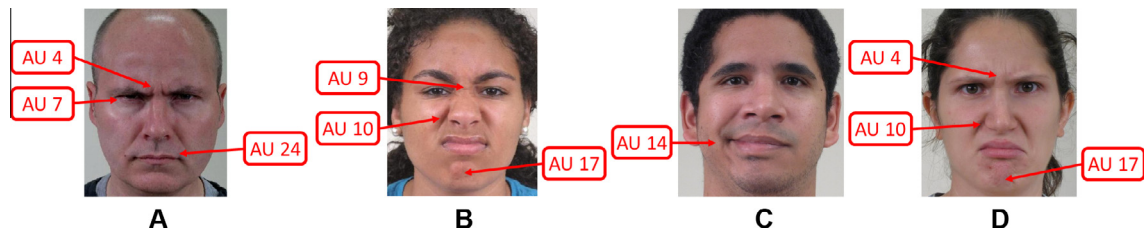 *E-mail address:* martinez.158@osu.edu (A.M. Martinez).

Fig. 1. Example images of facial expressions used to convey negative moral judgment: anger (A), disgust (B) and contempt (C). Compound facial expressions of emotion include a subset of AUs from each of their subordinate categories, *e.g.*, angrily disgusted includes AUs typically seen in the expression of anger and disgust (D).

compounded to create new categories, the resulting expression is defined using a subset of the AUs employed by the original (subordinate) categories. For example, the facial expression of angrily disgusted is produced with AUs 4, 7, 10 and 17 (Fig. 1D), a subset of those used to express its subordinate categories, *i.e.*, anger and disgust, which are AUs 4, 7, 9, 10, 17, 24. This new combination of AUs must be distinct from the ones employed to express any other emotion category; otherwise, the resulting category could not be visually differentiated from the rest. The combination of AUs used to express angrily disgusted, for instance, is distinct from those seen when expressing other emotions (Du et al., 2014).

Thus, since the AUs used to express negative moral judgment are 4, 7, 9, 10, 14, 17 and 24, a facial expression of negation that has evolved through the expression of negative moral judgment should be defined by a unique subset of these AUs. The most accepted way to study this, is to determine if the AUs used by subjects of different cultures and languages are the same (Ekman & Friesen, 1978; Bartlett, Littlewort, Frank, & Lee, 2014; Du et al., 2014). An identical use of AUs across cultures and languages is considered strong evidence of a biological origin of this expression. We analyze a large number of facial expression of negation produced in isolation (*i.e.*, in nonverbal communication) as well as facial expressions used in speech and signing of negative sentences. Our studies include native speakers of English, Spanish and Mandarin Chinese and native signers of American Sign Language (ASL). The same facial expression of negation was identified in participants of all languages and cultural backgrounds. Crucially, this expression was identified as a compound of the expression of negative moral judgment as hypothesized, Fig. 2.

Our results demonstrate that the identified facial expression of negation is used as a nonverbal signal by people of distinct cultural upbringings, as a co-articulator in negative sentences in spoken languages and as a grammatical marker in signing. That is, in ASL, this facial expression of negation is used as a grammatical marker of negation in lieu of the manual sign for "no" and the headshake, which, until now, were the only other two substantiated ways to mark negation in signing (Pfau & Quer, 2010).[1] This means that, in some cases, the only way to know if a signed sentence has positive or negative polarity is to visually identify this facial expression of negation because it is the *only* grammatical marker of negation. We called this facial expression, the "not face." To prove that this "not face" is indeed easily identified by observers, we demonstrate that the newly identified facial expression of negation is distinct from all known facial expressions of emotion and is, hence, readily visually identifiable by people.

Additionally, syllable production in speech and signing falls within the theta band, between 3 and 8 Hz (theta oscillation) (Chandrasekaran, Trubanova, Stillittano, Caplier, & Ghazanfar, 2009; MacNeilage, 1998), *i.e.*, the function defining speech or sign

movement of a syllable has a frequency of 3–8 Hz. This is true even in facial expressions used by primates, *e.g.*, lip-smacking (Ghazanfar, Morrill, & Kayser, 2013). Increasing or decreasing these frequencies beyond these margins reduces intelligibility of speech and facial articulations in primates. This is thought to be due to oscillations in auditory cortex, which allow us to segment theta-band signals from non-coding distractors (Gross et al., 2013). Thus, the herein identified grammatical marker of negation should also be produced within this intelligible theta rhythm. We test this prediction and find that the production of the identified facial expression of negation exhibits this rhythm in all languages (spoken and signed). We also measure the production of the "not face" in spontaneous expressions of negation without speech or signing and found it to be within the same theta range. The fact that this facial expression of negation is produced within the theta band not only in signing and speech, but also in isolation as a nonverbal signal, demonstrates that this rhythm of production is not an adaptation to language but an intrinsic property of this compound facial expression.

In sum, to the authors knowledge, these results provide the first evidence of the evolution of grammatical markers through the expression of emotion. Our results suggest a possible route from expression of emotion to the recent evolution of human language.

2. Materials and methods

2.1. Participants

The experiment design and protocol was approved by the Office of Responsible Research Practices at The Ohio State University (OSU). A total of 184 human subjects (94 females; mean age 23; SD 5.8) were recruited from the local community and received a small compensation in exchange for participation. This sample size is consistent with recent results on the study of emotion (Du et al., 2014). In addition, we analyzed the ASL dataset of Benitez-Quiroz, Gokgoz, Wilbur, and Martinez (2014), which includes 15 native or near-native signers of ASL. This is the largest annotated set available for the study of non-manual markers in ASL.

2.2. Data acquisition

Subjects participating in Experiments 1–2 were seated 1.2 m from a Canon IXUS 110 camera and faced it frontally. Two 500-W photography hot lights were located left and right from the midline, passing through the center of the subject and the camera. The light was diffused with two inverted umbrellas, *i.e.*, the lights pointed away from the subject toward the center of the photography umbrellas, resulting in a diffuse lighting environment.

In Experiment 1, participants were asked to produce a facial expression of negation. Additionally, the experimenter suggested possible situations that may cause a negative answer and expression. Then, participants were photographed making their own facial expression of negation. Crucially, subjects were not asked

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[1] Other authors have studied additional non-manual markers, in particular the eyebrows (Gökgöz, 2011; Veinberg & Wilbur 1990; Weast, 2008) which could be a component of the "not face."