NONVERBAL SIGNS OF EMOTION: DO PROTOTYPICAL EXPRESSIONS OF BASIC EMOTIONS OCCUR WHEN EXPECTED?

by

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NONVERBAL SIGNS OF EMOTION: DO PROTOTYPICAL FACIAL EXPRESSIONS OF BASIC EMOTIONS OCCUR WHEN EXPECTED?

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Perceptual studies strongly support the hypothesis that prototypical expressions of emotion are widely recognized in the faces of other people. However, the question remains: Do people actually produce prototypical expressions when they experience the corresponding emotion? This study investigated the hypothesis that people produce prototypical facial expressions of joy, sadness, fear, and disgust when experiencing these emotions. Emotions were elicited in a variety of emotion inductions. Self-report measures of emotion confirmed that the target emotions were elicited. Prototypical expressions were defined in terms of specific action unit combinations as proposed by Ekman and colleagues. Modest evidence was found for the correspondence between prototypical expressions and emotion. Prototypical expressions of joy and disgust occurred with high frequency and lasted longer in the corresponding emotion induction, but occurred with high frequency at other times as well. Prototypical expressions of sadness occurred with high frequency when unexpected (e.g., joy condition). Prototypical expressions of fear failed to occur even when participants reported that emotion. Discussion is focused on considerations in studying emotion expression in laboratory settings and directions for future work in facial expression of emotion.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

I am grateful to Jeffrey M. Girard, M. S. and Celia Brownell, Ph. D. for their valuable feedback on this project. I am also grateful to my mother, Diana Petkova, M. S., for her interest and support of my academic work.

1.0 INTRODUCTION

If a person experiences fear, do they produce a prototypical expression of fear? A critical, yet unresolved question, is whether prototypical facial expressions map onto the experience of emotions (Carroll & Russell, 1997; Ekman & Rosenberg, 2005). Although prototypical facial expressions of emotions have been consistently recognized in the face of others, little is known about the production of these expressions under emotion eliciting circumstances (Elfenbein & Ambady, 2002). The evidence that prototypical facial expressions are reliably elicited by emotion-specific events or stimuli remains modest and disperse (Bonanno & Keltner, 2004).

Over historical time and place, descriptions of facial expressions of emotion have remained remarkably consistent. In 5th century BCE Greek tragedy actors and chorus members wore masks of discrete facial expressions of emotion. In 14th century Japan, exaggerated masks depicting discrete emotions were introduced and are still used in classical Japanese Noh theatre (Johnson, 1992). Darwin (Darwin, 1872/1998) described specific facial expressions of emotion that he believed were universal. Influenced by Darwin's ideas, researchers hypothesized that coordinated patterns of emotion expression might have evolved to facilitate the responses to environmental events and the communication of social information (Ekman, 1992; Shariff & Tracy, 2011). For example, the widening of the eyes when experiencing fear increases the scope of the visual field to allow for identification of peripheral objects. Similarly, the facial expression of disgust, characterized by a scrunched nose and mouth, leads to the constriction of the orifices and reduces air intake to provide protection from noxious stimuli (Shariff & Tracy, 2011). Research has also examined the social significance of prototypical facial expressions. For example, individuals who smile more frequently are perceived as more sincere, sociable, and competent (LaFrance & Hecht, 1995).

Ekman and Friesen (Ekman & Friesen, 1978; Ekman, Friesen, & Hager, 2002a) and Izard (1971) developed anatomically-based coding systems to describe facial expressions and their link to emotions. To date, the Facial Action Coding System (FACS) (Ekman & Friesen, 1978; Ekman, Friesen, & Hager, 2002a) is the most comprehensive anatomically-based system for coding facial expressions. The FACS Investigator's Guide (Ekman, Friesen, & Hager, 2002b) and The Emotional Facial Action System (EMFACS) provide widely referenced descriptions of prototypical facial expressions of joy, sadness, fear, disgust, anger, and surprise. These six emotions are referred to as basic because they are thought to represent discrete emotional states that differ in expression, physiology, behavioral responses, and appraisal (Ekman, 1992).

Images of facial expressions of emotion that are consistent with anatomically based descriptions have been used as stimuli in behavioral research. Studies on how individuals perceive basic emotions suggest a link between prototypical facial expressions and specific emotion states; however, these studies do not address the production of such expressions under emotion-eliciting circumstances. Among the studies that do address the production of prototypical facial expressions, the precision with which FACS allows for the annotation of facial behavior has not been fully utilized (see Table 1 for a summary of studies that documented the occurrence of prototypical expressions). A surprising observation that our review of the literature revealed is that several decades after the development of FACS, little is known about whether individuals produce prototypical facial expressions during emotional experiences.

Following the exact definitions of required facial behaviors that Ekman provided, we examined whether the joy, sadness, fear, and disgust prototypical expressions occurred during procedures aimed to elicit each of these emotions. In other words, we investigate whether prototypical facial expressions, as described by Ekman and used as stimuli in research of perception of facial expressions, occur as fixed signals of basic emotions?

Table 1. Studies examining spontaneous facial expressions of emotion under various eliciting procedures

Citation	**Design & Participants**	**Emotions**	**Eliciting Procedure**	**Validating of Eliciting Procedure**	**Facial Coding System**	**Specification of AUs?**	**Brief Results**
Ekman, Frisesen, & Ancoli (1980)	Within-subjects; n=35 (Caucasian female)	Joy; disgust	Video clips	Self-report	FACS	No	Agreement between expressions of joy and disgust and self-reports
Chesney et al. (1990)	Between-subjects; n=24 (Type A or B males)	N/A	Interview assessing Type A behavior	N/A	FACS	No	Type A males showed more disgust than Type B males
Ruch (1993)	Between-subjects; n=61 (Caucasian female)	Humor in 3 conditions (low, high, or no alcohol)	Slides of jokes and cartoons	Self-report	FACS	AU 12; 6 + 12 AU 12 (with 13 or 14)	Extraversion predicted exhilaration expressions
Rosenberg & Ekman (1994)	Within-subjects; n=20 (Caucasian female)	Disgust; fear; joy (not analyzed)	Video clips	Self-report	FACS	Unspecified emotion and non-emotion AU categories	Agreement between self-reports and disgust expressions
Heller & Haynal (1994)	Between-subjects; 17 suicidal depressed; 9 non-suicidal depressed	N/A	Interview with patients and psychiatrist	N/A	EMFACS	60 unspecified facial expressions	Expressions of sadness, anger, fear, joy, disgust, contempt

Ruch (1995)	Mixed design; n=63 (Caucasian female)	Exhilaration	Slides of jokes and cartoons	Self-report	FACS	AU 6, 7, 12	Agreement between facial expressions and self-report coherence, even with alcohol consumption
Bonanno & Keltner (1997)	n=38 conjugally bereaved individuals (63% female; mostly Caucasian)	N/A	Speak freely about deceased spouse (6 months after death)	Self-report	EMFACS	No	Expressions of anger predicted increased grief and poor perceived health; expressions of positive emotion - decreased grief
Keltner & Bonanno (1997)	n=39 conjugally bereaved individuals (67% female; mostly Caucasian)	N/A	Speak freely about deceased spouse (6 months after death	Self-report	EMFACS	No	Duchenne laughter related to self-reports of reduced anger and increased enjoyment
Bonanno et al. (2002)	n=67 females with childhood sexual abuse; n = 70 control females	N/A	Interview about the most distressing event they ever experienced	Heart rate; measures of PTSD, trauma, externalizing/internalizing	EMFACS	No	Anger and disgust most frequently shown; more expressions of disgust in people who disclosed about abuse; Expressions of disgust associated with violent abuse
Bonanno & Keltner (2004)	n=32 conjugally bereaved individuals (69% female; mostly Caucasion)	N/A	Speak freely about deceased spouse and other ongoing important relationships	Self-report	EMFACS	No	Expressions of anger and sadness co-occurred with appraisals of loss and injustice; Smiling co-occurred with pride
Matsumoto & Willingham (2006)	n=84 Olympic medalists	N/A	Winners' faces captured immediately after winning, when receiving medals, and when posing on the podium	N/A	FACS and EMFACS	No	Cross-cultural evidence for universal facial expressions of different types of smiles, contempt, disgust, fear, and sadness
Fairbairn et al. (2015)	n=720 (50% female) social drinkers	N/A	Consumed alcohol, placebo, or control beverages in groups of three	Self-report of mood and social bonding	FACS	Movements associated with smiling	Duchenne smiling "contagion" correlated with self-reported reward and typical drinking; no gender differences in Duchenne smiling contagion with alcohol consumption

Davidson, Ekman, Saron, Senulis, & Friesen (1990)	Within-subjects; n=37 (Caucasian female)	Disgust, joy, fear (not analyzed)	Video clips	Facial behavior to verify presence emotions	FACS	No	Disgust expressions associated with right-sided brain activation; joy expressions w/ left-sided activation
Ekman, Davidson, & Friesen (1990)	Within-subjects; n=37 (Caucasian female)	Positive emotions (joy); negative emotions (fear, sadness, disgust, pain)	Video clips	Self-report	FACS	AU 12; AUs 6+12	AU 6+12 occurred more with positive films; AU 6+12 associated with amusement
Gross & Levenson (1993)	Between-subjects; n=85 total	Disgust (suppression and control groups)	Video clips	Self-report; physiology	A system developed to code body movements and facial expressions	No	More disgust expressions during negative clips than neutral ones; Suppression reduced facial behavior, somatic activity, and heart rate
Mauss et al. (2005)	Within-subjects; n = 59 female; diverse sample	Amusement and sadness	Video clips	Self-report; physiology	FACS	No	Evidence for sadness and amusement expressions; Self-report and facial behavior highly correlated
Soto et al. (2005)	Between-subjects; n=94 (Chinese) and n=64 (Mexican) American college students	Startle	Aversive acoustic startle (warned, unwarned, instructed to inhibit)	Self-report; Physiology	Emotional Expressive Behavior Coding System	No	Chinese participants reported less emotion than Mexicans; No differences in positive and negative facial expressions
Lerner et al. (2005)	n=92; equal genders; diverse	Disgust, anger, fear	Stress-challenge task	Self-report, cortisol, cardiovascular responses	EMFACS	No	Fear displays associated with higher cardiovascular and cortisol responses; to stress

1.1 EXPRESSION OF EMOTION IS IN THE EYE OF THE BEHOLDER

Perceptual studies are a commonly used method for studying facial expressions of emotion (Biehl et al., 1997; Ekman & Friesen, 1971; Ekman, Sorenson, & Friesen, 1969; Ekman et al., 1987; Matsumoto, 1990). These are studies in which observers are asked to identify which emotion they see in photographs of facial expressions. In the 1960-1970s Ekman and Izard conducted the first empirical tests of Darwin's hypothesis that discrete facial expressions are related to emotion-specific experiences. They examined whether individuals from different cultures reliably distinguished between emotions based on photographs of facial expressions and hypothesized that FACS-based descriptions of facial muscle movement capture universal prototypical expressions of emotion. Overall, results from perceptual studies have indicated that individuals consistently recognize facial expressions of the six basic emotions (joy, sadness, fear, disgust, surprise, and anger; note that fear and surprise have yielded generally lower categorization rates) at better-than-chance levels, both within and across cultures (Elfenbein & Ambady, 2002; Ekman & Friesen, 1971; Ekman, 1989, 1992; Izard, 1971).

Informed by what observers in different cultures judged were the facial expression emotions, Ekman (1993) described prototypical expressions in terms of FACS as combinations of facial muscle movements (see Table 2). Since then, prototypical expressions have been the focus of both research and controversy (Ekman, 1984; Frijda & Parrott, 2011; Jack, Garrod, & Schyns, 2014). The use of posed or actor-portrayal expressions of emotion in perceptual studies presents limitations on the interpretation of the characteristics and meaning of facial expressions. Posed and un-posed facial expressions of emotion differ along at least several dimensions (e.g., neural basis, timing, morphology, and eliciting conditions) (Schmidt, Ambadar, Cohn, & Reed, 2006).

Russell (1994) and Carroll & Russell (1997) argued that the use of preselected posed images and the forced-choice response format likely influenced results obtained from perceptual studies.

Although a large part of the theory and research on emotion is based on what has been discovered through perceptual studies, these studies do not provide direct information about what facial expressions individuals produce during authentic emotional experiences (Ekman & Rosenberg, 2005; Carroll & Russell, 1997). Consequently, it remains unclear whether the prototypical facial expressions of basic emotions that Ekman defined (Ekman, 1993) occur during emotional experiences.

Table 2. Descriptions of emotion conditions and prototypical expressions

Emotions	Condition	AUs	Exemplar
Joy	Experimenter talks to participant and tells a joke	6 + 12	
Sadness	Participant hear audio of a boy calling 911 and talking to the operator	1 + 4 + 15 + 11 or 6 + 15	
Fear	Participant experiences a physical threat as a safety dart is thrown toward a target close to their face	1 + 2 + 4 + 5 + 20 + 25 + 25/26/27	
Disgust	Participant is exposed to the odor of rotten meat	9 or 10	

1.2 FACS IN APPLIED RESEARCH ON EMOTION

FACS is the most psychometrically rigorous system for measuring noticeable facial movement (Cohn, Ambadar, & Ekman, 2007; Ekman, Friesen, & Hager, 2002; Ekman & Friesen, 1978).

The contraction of individual facial muscles leads to visible changes in the appearance of the face and produces rapid signs of emotion expression (Cohn & Ekman, 2005). Specifically, thirty anatomically-based action units (AU) index unique facial muscle contractions, as well as several types of head and eye movements and additional action descriptors (e.g., tongue show, jaw thrust) (Ekman, Friesen, & Hager, 2002). For example, AU 12 denotes the contraction of the zygomatic major muscle that pulls the lip corners back and upward and produces a smile on the face.

The use of FACS in applied research on emotion requires the ability to interpret the meaning of AUs. Different approaches to interpreting the meaning of facial movement have been adopted. One is the aggregation of multiple expressions into a positive (e.g., AU 12 and 6 + 12, accompanied or not by AU 1, 2, 25, or 26) or negative category (e.g., AU 9, 10, unilateral 14, 15, 20, and 1 + 4) (Sayette & Parrott, 1999; Sayette et al., 2003). Alternatively, some researchers have used single AUs to represent one category (e.g., AU 12, indicating smiling, for positive affect and AU 4, indicating brow lowering, for negative affect) (Girard et al., 2014).

Finally, systems such as EMFACS have been proposed to link AU combinations to emotion states. EMFACS, an abbreviated version of FACS, was specifically designed to code combinations of co-occurring AUs while still relying on the objective scoring methods of FACS. EMFACS scoring is done without viewing video in slow motion and not all AUs that are present are scored (i.e., in EMFACS coders do not attend to all AUs because they look for a loosely defined subset of AUs to score an event; J. Cohn, personal communication regarding EMFACS-8 Coder Instructions, November 6, 2015). These modifications of FACS rules allow for less time consuming coding; therefore, EMFACS is a preferred choice for many researchers. Yet, the use of EMFACS poses limitations on the documentation and examination of particular AUs that occurred in a given context.

1.3 MOVING FORWARD

1.3.1 Joy

The experience of joy and exhilaration has been associated with the occurrence of the Duchenne smile, described by the contraction of the zygomaticus major muscle, AU 12, and the orbicularis oculi muscle, AU 6, (Bonanno & Keltner, 2004; Frank, Ekman, & Friesen, 1993; Ekman, Davidson, & Friesen, 1990). Considerable work has examined under what circumstances people smile and whether they produced the Duchenne smile. Smiles, a first facial sign of emotion expression in infancy, have significant communicative functions and occur with higher frequency throughout one's lifespan (Cohn & Schmidt, 2004). Six month old infants produced Duchenne smiles during positive interaction with their mothers. Particularly, infants produced more Duchenne smiles when their mothers were also smiling and when infants were gazing at their mother's face (Messinger, Fogel, & Dickson, 2001). Overall, research has revealed that Duchenne smiles, indicative of the experience of joy, are consistently produced by individuals of a wide age range.

In comparison with facial expressions of other emotions, the evidence for the production of Duchenne smiles is more abundant. Duchenne smiles typically follow pleasurable events (e.g., the approach of a loved one). However, the Duchenne smile story is multi-faceted. For example, Duchenne smiles occur in seemingly aversive contexts. Keltner and Bonanno (1997) showed that conjugally bereaved individuals who produced more Duchenne smiles when interviewed about their deceased spouse also reported reduced anger and increased enjoyment. This finding suggests that Duchenne smiles may appear in contexts not specific to the experience of joy.

In laboratory settings, Duchenne smiles are most commonly elicited by asking participants to watch amusing video clips or to engage in a conversation (Bonanno & Keltner, 2004). Duchenne smiles have been observed to occur during positive interpersonal interactions, as well as in settings in which participants did not interact with other individuals (i.e., non-social settings can also elicit Duchenne smiles).

1.3.2 Sadness

Facial expressions of sadness are most likely to occur in the context of experiencing negative emotions. In a laboratory setting, sadness is frequently elicited by asking participants to watch sad or distressing video clips.

Mauss, Levenson, McCarter, Wilhelm, and Gross (2005) found evidence for the occurrence of prototypical facial expressions of sadness after participants watched 5-minute video clips eliciting moderate to high levels of sadness. Facial expressions of sadness were strongly associated with self-reported sadness and modestly associated with changes in physiology. In this study facial expressions were informed by FACS; however, what particular AUs defined the prototypical expressions of sadness remains unclear. Similarly, Bonanno and Keltner (1997) found evidence for the occurrence of prototypical facial expressions of sadness when bereaved interviewees talked about their deceased spouse. Participants produced an average of 5.63 facial expressions of sadness; again, it remains unclear which AUs described these expressions because the study used EMFACS. Overall, based on what results obtained with EMFACS indicated, the facial expression of sadness (when sadness was reportedly felt) were more frequently produced than any other facial expressions (including anger, contempt, disgust, fear, and enjoyment) (Bonanno & Keltner, 1997).

The proposed prototypical combination of the sadness expression involves the co-occurrence of AUs 1 + 4 + 15 + 11 or AUs 6 + 15 (Ekman, Friesen, & Hager, 2002). However, based on previous studies that relied on EMFACS, it remains unclear whether individuals produce the proposed combination of AUs when they report feeling sad. Therefore, one of the aims of the current study is to examine the occurrence and duration of the prototypical facial expression of sadness after participants heard the voice of a boy calling 911.

1.3.3 Fear

Facial expressions of fear are most likely to occur when individuals see or hear dynamic events that are threatening (e.g., a threatening animal). Interpersonal actions can also call forth facial expressions of fear (Ekman, 1993). Rosenberg and Ekman (1994) found evidence for the production of facial expressions of fear, as well as for an association between facial expressions of fear and self-reported fear after showing participants brief video clips eliciting positive or negative emotions. Although Rosenberg and Ekman (1994) used FACS to annotate facial expressions of emotion, the information available on the occurrence of individual or combination of AUs was limited. AUs were grouped into positive or negative categories and the prototypical facial expressions of joy, fear, and disgust that were observed in response to the video clips were likely defined based on the combinations listed in the FACS Investigator's Guide and/or EMFACS.

More recently, Lerner, Dahl, Hariri, and Taylor (2007) found evidence for the production of prototypical expressions of fear during a stress-challenge task. Lerner et al. (2007) used EMFACS to code facial expressions of fear, anger, and disgust and discovered that more frequent expressions of fear were linked to increased cardiovascular and cortisol responses to stress. Similarly to Rosenberg and Ekman (1994) and other EMFACS-based studies, Lerner et al. (2007) also did not specify the combinations of AUs that defined these facial expressions of emotions.

The ambiguity of using EMFACS to code facial expressions of emotion is illustrated by Heller & Haynal (1994) in a study that used EMFACS to examine the facial expressions of suicidal and non-suicidal depressed patients during psychiatric interviews. EMFACS yielded 60 different combinations of facial expressions that were placed into one of the following categories: sadness, anger fear, unspecified negative, joy, unfelt joy, disgust, contempt, and no prediction (Heller & Haynal, 1994). It is difficult to evaluate the occurrence of prototypical facial expressions of emotion without specifying which particular combinations of AUs were hypothesized to occur. Overall, evidence for the production of the prototypical facial expression of fear remains relatively sparse and based on EMFACS. We aim to test whether individuals produced the prototypical expression of fear (AUs 1 + 2 + 4 + 5 + 20 + 25/26/27) (Ekman, Friesen, & Hager, 2002) when fear was elicited by throwing a safety dart towards participants' face, a physically threatening act (Zhang et al., 2014)

1.3.4 Disgust

The experience of disgust is associated with feelings of being contaminated or poisoned, both in a literal and metaphoric sense. Experiencing disgust is related to something aversive in one's physical environment, particularly when there is an attempt to violate the integrity or purity of one's body (Bonanno et al., 2002). Unlike other emotions, disgust has been studied almost entirely by looking at individuals' facial expressions (Rozin, Lowery, & Ebert, 1994).

Darwin first described characteristics of the facial expression of disgust (Darwin, 1872/1998; Rozin et al., 1994). Facial movements around the mouth and nose are central to disgust (e.g., AU 10, retraction of the upper lip, and AU 9, nose wrinkle), perhaps because the experience of disgust frequently arises in relation to aversive gustatory or olfactory stimulation (Rozin et al., 1994). In a laboratory setting, disgust is reliably elicited through films or smells (Bonanno & Keltner, 2004; Rosenberg & Ekman, 1994; Zhang et al., 2014). When disgust is produced by moral elicitors, the facial expressions of disgust are frequently accompanied by expressions of anger (Rozin et al., 1994).

Empirical evidence for the production of prototypical facial expression of disgust suggests that this expression does occur; however, direct evidence that the proposed AU 9 and 10 are associated with disgust remains incomplete. Rosenberg and Ekman (1994) showed participants brief video clips that elicited disgust and joy. Results from their study revealed that facial expressions of disgust were correlated with self-reported disgust, thus providing evidence that spontaneous facial expressions of disgust were associated with the subjective experience of disgust (Rosenberg & Ekman, 1994). However, Rosenberg & Ekman did not indicate which AUs were used to describe the facial expressions of disgust. Similarly, Davidson et al. (1990) found evidence for the association between facial expressions of disgust and right-sided brain activation in the frontal and anterior cortical regions. Although Davidson et al. (1990) emphasized on the important of using FACS to define behavioral indicators of disgust, the occurrence and frequency of specific disgust-related AUs (e.g., 9 or 10) was not reported in their study. However, this study is central in highlighting the utility of using facial behavior to verify the presence of emotion in light of the fact that different patterns of brain activation patterns were observed after participants watched clips eliciting disgust or joy.

More recently, Lerner, Dahl, Hariri, and Taylor (2007) used a stress-challenge task and found that facial expressions of anger and disgust were associated with lower cardiovascular and cortisol responses to stress. Although Lerner et al. (2007) used EMFACS to study the production of these facial expressions, the frequency or duration of particular expressions was not reported, neither was information about the AU combinations that defined these expressions. Finally, Bonanno et al. (2002) also used EMFACS to study what facial expressions survivors of childhood sexual abuse produced during open ended narrative interviews about the most distressing events in their lives. Facial expressions of disgust were more common in participants who voluntarily disclosed about the abuse. Facial expressions of disgust were also more stronly associated with the experience of violent than non-violent abuse. Although no specific AUs were listed, descriptive statistics for the disgust (and other) prototypical facial expressions were presented. Out of the total 137 participants, 87 participants produced an average for 2.84 disgust experssions. However, the particular AUs that defined these expressions were not specified (Bonanno et al., 2002).

Rozin et al. (1994) pointed out that although there might be different “versions” of the disgust face, AU 9 (nose wrinkle), AU 10 (uper lip raiser), and AD 19 (tongue protrusion) were most reperesentative of the facial expression of disgust. This is consistent with the proposed AU descriptions of disgust in the FACS Investigator’s Guide that include AU 9 and/or 10 as defining elements of the prototypical facial expression of disgust (Ekman, Friesen, & Hager, 2002), a hypothesis that we aim to test.

1.4 HYPOTHESES

This study's aim is to provide a direct test of Ekman's hypothesis that prototypical facial expressions of emotion occur under circumstances in which the corresponding basic emotions are experienced. A set of four hypotheses examine differences between the occurrence and proportion of occurrence, or duration, of the prototypical expressions of joy, sadness, fear, and disgust both within and across conditions that elicit these emotions. Table 1 provides FACS-based definitions of the prototypical expressions and descriptions of each emotion condition. Based on previous research and theory, we hypothesized that:

1.4.1 Hypothesis 1

Between conditions, prototypical expressions will occur in more participants in the target condition than in other conditions (e.g., more participants will show prototypical joy in the joy condition than in other conditions).

1.4.2 Hypothesis 2

Within each condition, the corresponding prototypical expression will be the one that occurs in the most participants (e.g., in the joy condition, more participants will show prototypical joy than other prototypical expressions).

1.4.3 Hypothesis 3

Between conditions, prototypical expressions will have the highest proportion of occurrence in the corresponding condition than in other conditions (e.g., prototypical joy will occur more often in the joy condition than in other conditions).

1.4.4 Hypothesis 4

Within each condition, the corresponding prototypical expression will have the highest proportion of occurrence (e.g., in the joy condition, the prototypical joy will occur more often than other prototypical expressions).

2.0 METHOD

The method for this study is described in detail in the following sections.

2.1 DATABASE

Data was drawn from the Binghamton-Pittsburgh 4D Spontaneous Expression Database (BP4D) (Zhang et al., 2014), a freely available database of spontaneous facial expressions during procedures designed to elicit authentic emotional experiences. BP4D is structured by participant with digital video from 41 participants in eight emotion elicitation conditions.

2.2 PARTICIPANTS

Participants were recruited from the departments of psychology, computer science, and engineering at the State University of New York at Binghamton. Forty-one participants (M_{age} = 20.20; SD_{age} = 2.57; 44% male) with diverse ethnic background (47.8% White; 26.8% Asian; 14.6% Black; 9.7% Latino/Hispanic) completed all emotion elicitation conditions. Participants provided informed consent to the procedures and use of their video and self-report data.

2.3 PROCEDURE

Participants took part in a series of 13 conditions intended to elicit basic emotions. Conditions were presented in the same order for all participants. Joy, sadness, fear, and disgust conditions were 1, 3, 7, and 13 in the series of 13 conditions. The conditions had been vetted in previous research (Coan & Allen, 2007; Zhang et al., 2014) and in pilot studies. Sessions were administered by a professional actor and director. Table 1 describes each condition. Participants were video recorded with a Di3D dynamic capturing system positioned approximately 51 inches away from their face. The Di3D system consisted of two stereo cameras and a texture video camera arranged vertically. For the current study, only video from the latter camera was used.

2.4 MEASURES

2.4.1 Self-reported Emotions

Following each condition, participants used a handheld tablet computer to rate their subjective experience for 12 emotions on 6-point Likert scales (where 0 referred to *none* and 5 referred to *extremely*). The emotion terms included the four target emotions of joy, sadness, fear, and disgust, as well as some closely related emotion states (i.e., embarrassed, in pain, surprised, startled/shocked, angry/upset, sympathetic, nervous, and relaxed).

2.4.2 Facial Action Coding System (FACS)

Facial behavior was manually coded by certified and highly experienced FACS coders at the University of Pittsburgh. FACS (Facial Action Coding System) describes facial muscle activity on the basis of 44 unique action units (AU) and several types of head and eye movements (Ekman, Friesen, & Hager, 2002a). AU presence or absence was coded for 34 commonly occurring AUs during a pre-identified 15-second segment in each of the emotion conditions. These segments were the most facially expressive of each video and were identified by preliminary visual inspection by a certified FACS coder. Coders used a stop-frame procedure, in which they could freeze frames and view repeated segments at regular speed or slow motion. AU were coded as present if they occurred at an A-level of intensity or higher. A-level is the minimal intensity possible in FACS. Coders were blind to the type of condition and coded AU from video without sound. Table 3 provides descriptions of the coded AUs.

Inter-observer agreement was quantified using Cohen’s Kappa (Cohen, 1960) and Kappa Q (Bennett, Albert, & Goldstein, 1954). These metrics provide correction for chance agreement. Cohen's Kappa is more frequently used in the literature but is biased when distributions are highly skewed (Jeni et al., 2013). Kappa Q, is unaffected by skew. Both metrics range from 0 (indicative of lack of agreement) to 1 (indicative of perfect agreement). Using Altman’s criteria (Altman, 1991), both metrics indicated very good inter-rater agreement (all but one Cohen’s Kappa values > .6; all Kappa Q values > .8; see Figure 1). Note that we calculated Cohen’s Kappa (Cohen, 1960) and Kappa Q (also referred to as S Index) values for all AU that occurred. Note that, among all chance-adjusted reliability metrics, Kappa Q (Bennett, Albert, & Goldstein, 1954) is robust to skewed based rates and is appropriate for use with binary occurrence coding (Zhao, Liu, & Deng, 2012).

Table 3. Verbal descriptions of AUs

AU	Description	Appearance Changes
1	Inner Brow Raise	Gives the eyebrows a circular shape
2	Outer Brow Raise	Stretches the eyelid
4	Brow Lowerer	Brows are lowered and pulled together; eyelid is pushed down
5	Upper Lid Raise	Widens eye aperture
6	Cheek Raise	Skin around temple and cheeks drawn together; eye aperture narrowed
9	Nose Wrinkle	Pulls skin along the sides of the root of the nose upwards
10	Upper Lip Raiser	Upper lip drawn up; central portion raised higher than lower portions
11	Nasolabial Furrow Deepener	Pulls the upper lip upward and laterally at the midpoint between the philtrum and outer lip corners
12	Oblique Lip Corner Raise	Lip corners pulled back and upwards
15	Lip Corner Depressor	Pulls the corners of the lips down
20	Lip Stretch	Lips pulled back sideways; mouth looks enlongated
25	Lips Part	Lips parted slightly; jaw remains closed
26	Jaw Drop	Jaw opened and space between teeth can be seen
27	Mouth Stretch	Mandible is pulled down

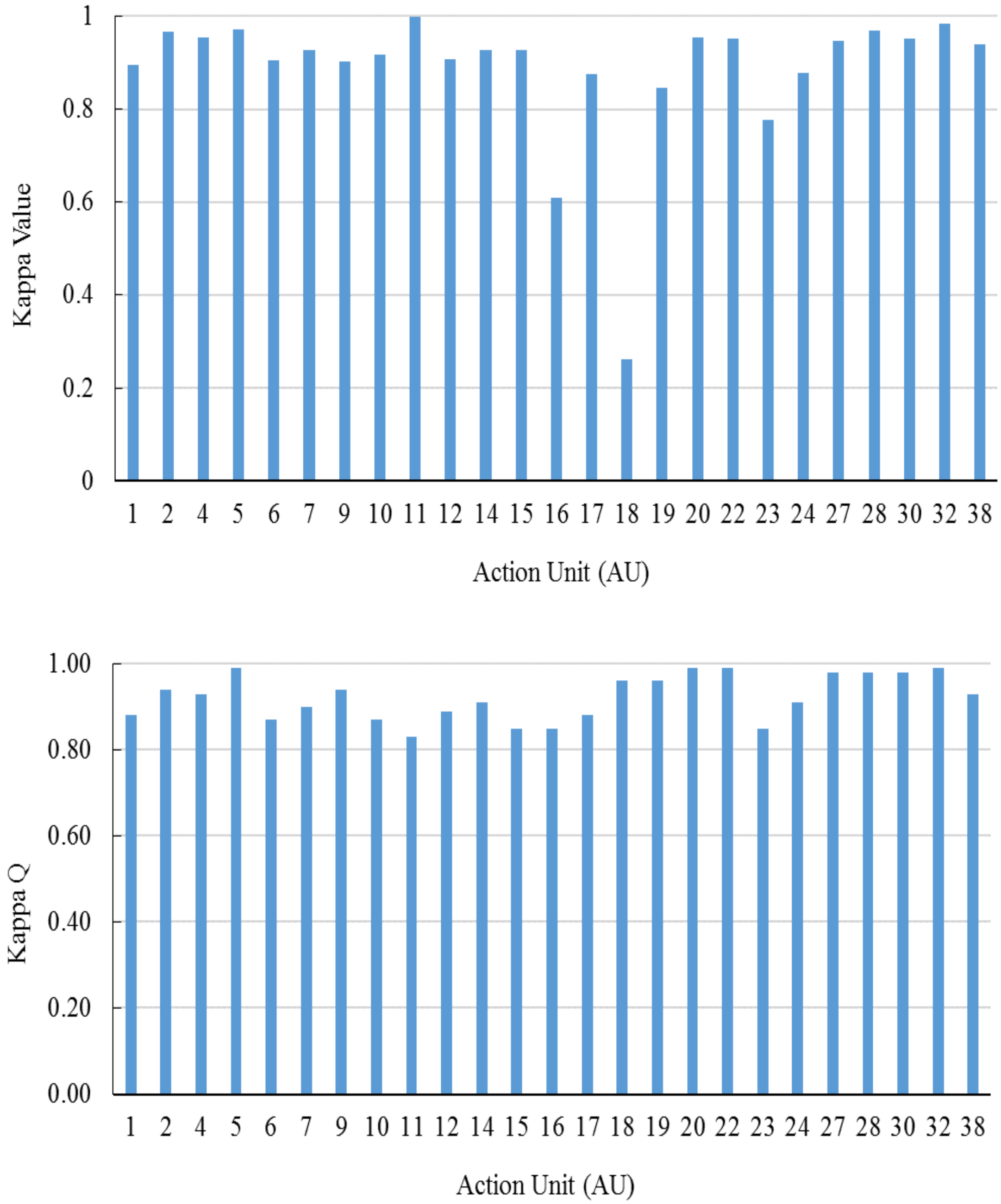

Figure 1. Inter-observer agreement in BP4D

2.4.3 Prototypical Expressions

Following Ekman (Ekman, Friesen, & Hager, 2002b; Ekman, 1993) prototypical expressions were defined as per Table 1. The onset (or start) of a prototypical expression was defined as the first video frame in which all requisite AU occurred. The offset (or end) of a prototypical expression was the first subsequent frame in which one or more of the requisite AUs failed to occur. MATLAB, a programming language and interactive computing environment, was used to obtain these measures from the previously FACS-coded video segments.

Participants received a score of 1 if a given expression occurred at all in at least one video frame in a FACS-coded video segment, and a score of 0 if that expression failed to occur in the segment. Note that each video segment represents data from a single participant. Since the total number of participants was 41, the maximum total value for the occurrence of a prototypical expression in the sample was 41 (i.e., in a given condition, a prototypical facial expression occurred in all participants).

Because slight variation could occur in the number of video frames coded, duration was computed as the proportion of time during a segment in which AU or prototypical expressions occurred (Bakeman & Gottman, 1997; Forbes, Cohn, Allen, & Lewinsohn, 2004; Girard et al., 2014). Note that the same mean proportions, the mean proportion of coded frames in a given condition involving a given prototypical expression, were used to test hypotheses three and four.

3.0 ANALYTIC PLAN

Statistical analyses were performed with the IBM SPSS Statistics Software, Version 22. Preliminary analyses of the self-report data were conducted to verify that the target emotion was successfully elicited in each condition. First, we obtained the number of participants who endorsed the expected emotion in each condition. Second, we conducted four multivariate analyses of variance (MANOVAs), one for each emotion condition, to examine whether there were differences between the mean reported intensity of the target emotion (e.g., joy in the joy condition) relative to the other emotions. Gender (Male/Female) and race (White/Non-White) were entered as between-subjects variables. Mean intensities of emotion ratings were within-subjects dependent variables. Significant omnibus MANOVA tests were followed-up by paired samples t-tests comparing the mean intensity of the target emotion versus the mean intensities of the second two highest rated emotion term in a given condition. Note that gender and race were included only in preliminary analyses of self-reported emotions.

To examine Hypothesis 1, that prototypical expressions will occur in more participants in the target condition than in other conditions, we used four omnibus non-parametric Cochran's Q-tests for each prototypical expression. The Cochran's Q-test is an appropriate choice for within-subjects designs with binary dependent variables (i.e., occur or not occur). Following a significant omnibus test, three pairwise Cochran's Q-tests were performed. Mathematically, the Cochran's Q-test in the case of two related groups is equivalent to a two-tailed sign test.

To examine Hypothesis 2, that, within each condition, the corresponding prototypical expression will be the one that occurs in the most participants, we paralleled the analytic strategy for Hypothesis 1 and used Cochran's Q-tests. Four omnibus Cochran's Q-tests were conducted, one for each condition. Following a significant omnibus test, three pairwise Cochran's Q-tests were performed.

To examine Hypothesis 3, that prototypical expressions will have the highest proportion of occurrence in the corresponding condition than in other conditions, we used one-way repeated-measures analysis of variance (ANOVA) tests. We chose to use ANOVA tests because the dependent variable in this case measures proportion of occurrence and is thus continuous. Four omnibus ANOVA tests, one for each prototypical expression, examined effects of condition on the proportion of occurrence of prototypical expressions. Significant omnibus tests were followed up by three planned paired samples t-tests comparing the proportion of occurrence of a prototypical expression against its proportion of occurrence in the remaining conditions. For example, the proportion of occurrence of prototypical joy in the joy condition was compared against its proportion in the sadness, fear, and disgust conditions.

To examine Hypothesis 4, that, within each condition, the corresponding prototypical expression will have the highest proportion of occurrence, we paralleled the analytic strategy for Hypothesis 3 and applied ANOVA tests. Four one-way repeated measures ANOVA tests, one for each condition, compared differences in the proportion of occurrence of the different prototypical expressions. Significant omnibus tests were followed up by three planned paired samples t-tests comparing the proportion of occurrence of the prototypical expression against the remaining prototypical expressions in the same condition. For example, in the joy condition, the proportion of occurrence of the prototypical expression of joy was compared against the proportion of the sadness, fear, and disgust expressions in this condition.

4.0 PRELIMINARY RESULTS

4.1 SELF-REPORTED EMOTIONS

The intended target emotion was endorsed by the largest percentage of participants (over 90%) in three of the four conditions: joy, sad, and disgust. In the fear condition, an equal percentage (88%) endorsed both fear and the closely related state of nervous.

MANOVA tests revealed differences in the mean intensity ratings of endorsed emotion terms in each condition (all $p < .001$ and $F > 26.415$). For all conditions, pairwise comparisons revealed that the emotions of joy, sadness, and disgust had the highest mean intensity ratings in the conditions aimed to elicit joy, sadness, and disgust, respectively (all $p < .05$). The only exception was the fear condition in which participants reported feeling more nervous than scared/afraid or startled/shocked.

Except for the fear condition, there were no gender or racial differences in the ratings (all *p-s* > .05. In the fear condition, there was a non-significant trend ($p < 0.10$) whereby Non-White participants had higher ratings for feeling nervous ($M_{Non\text{-}white} = 3.619$; $M_{White} = 2.700$) and afraid ($M_{Non\text{-}white} = 2.690$; $M_{Non\text{-}white} = 2.300$) and afraid ($M_{Non\text{-}white} = 2.690$; $SD_{Non\text{-}white} = 1.569$) than did White participants.

Figure 2 shows that all omnibus F-tests were significant (all *p-s* < .001) and followed up with two pairwise t-tests comparing the target emotion with the second two highest rated emotions.

Post-hoc comparisons revealed that the emotions of joy, sadness, and disgust had the highest rating in each of the target conditions (all *p-s* < .05). The only exception was the fear condition in which participants reported feeling significantly more nervous than afraid. Note that in the fear condition, both feeling *afraid* and *nervous* received significantly higher ratings than *startled*, which was the next most endorsed item.

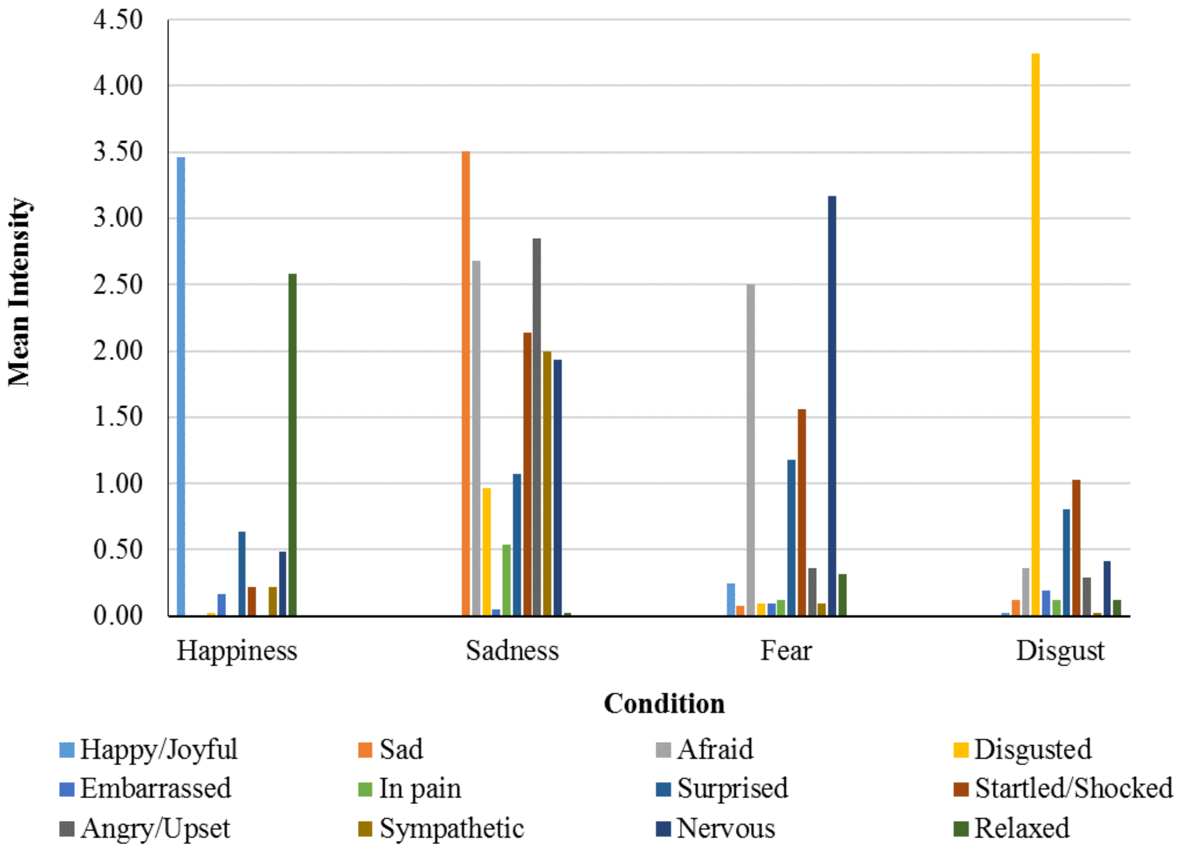

Figure 2. Self-reported emotions in BP4D

4.2 PROTOTYPICAL EXPRESSIONS

To assess distributional characteristics prior to conducting ANOVAs for Hypotheses 3 and 4, we conducted a series of Mauchly's tests of sphericity and Shapiro-Wilk tests of normality to assess assumptions of sphericity and normality, respectively. The assumptions of sphericity and normality were found wanting (see Table 4). Because ANOVA is considered robust to violations of the latter when sample size is adequate, a correction for only sphericity (Greenhouse-Geisser corrections to the degrees of freedom of the omnibus *F*-values) was applied.

Table 4. ANOVA assumptions for hypotheses 3 and 4

	Prototypical Joy S-W (p-value)	**Prototypical Sadness S-W (p-value)**	**Prototypical Disgust S-W (p-value)**	**Hypothesis 4 Mauchly's $\chi^2(2)$ (p-value)**
Joy Condition	.979 (.646)	.651 (.001)	.155 (.014)	.891 (.105)
Sadness Condition	.144 (.001)	.160 (.001)	.308 (.001)	.162 (.001)
Fear Condition	.958 (.129)	.699 (.001)	.203 (.001)	.876 (.076)
Disgust Condition	.880 (.001)	.859 (.001)	.162 (.001)	.933 (.257)
Hypothesis 3 Mauchly's $\chi^2(2)$ (p-value)	.747 (.046)	.787 (.099)	.943 (.808)	

Note. Results are for Shapiro-Wilk (S-W) tests of normality (four tests for each prototypical expression) and Mauchly's test of sphrecity (one omnibus test for Hypothesis 3 and 4, reported column-and row-wise, respectively). Note that Shapiro-Wilk tests for the prototypical expression of fear were not conducted since this expressions did not occur.

5.0 RESULTS

5.1 HYPOTHESIS 1

We found evidence for the occurrence of some but not all prototypical expressions. Prototypical expressions of joy, sadness, and disgust occurred in both target and non-target conditions. The prototypical expression of fear failed to occur in the fear (or any other) condition. The prototypical expression of sadness occurred for only two participants in the sadness condition; however, this expression occurred for more than half of the participants in all other conditions. Table 5 shows results from omnibus and pairwise Cochran's Q-tests.

Table 5. Number of subjects who showed prototypical expressions

Condition	Prototypical Joy Expression	Prototypical Sadness Expression	Prototypical Fear Expression	Prototypical Disgust Expression
Joy	40_c^a	31_d^b	0	40_c^a
Sadness	1_c^b	2_c^a	0	18_d^b
Fear	41_c^a	28_d^b	0	40_c^a
Disgust	26_d^b	30_d^b	0	41_c^a

Note. The total number of participants was 41. Higher numbers indicate more participants for whom an expression occurred at least once during a given emotion condition. Row-wise entries with different subscripts and column-wise entries with different superscripts differ at the p = .05 level by Cochran's Q-test.

5.2 HYPOTHESIS 2

In the joy condition, more participants showed prototypical expressions of joy than sadness, but not disgust. In the sadness condition, more participants showed prototypical expressions of joy and disgust than sadness. In the fear condition, more participants showed expressions of joy than sadness, and the same number of participants showed expressions of joy and disgust. Finally, in the disgust condition, more participants showed expressions of disgust than joy and sadness. Table 6 shows results from omnibus and pairwise Cochran's Q-tests.

Table 6. Cochran's Q-test results for hypotheses 1 and 2

Comparison	Cochran's Q	Df	P-value
Prototypical Joy (Omnibus)	91.941	3	< .001
Joy vs. Sad Condition	39.000	1	< .001
Joy vs. Fear Condition	1.000	1	.317
Joy vs. Disgust Condition	12.250	1	< .001
Prototypical Sadness (Omnibus)	53.837	3	< .001
Sadness vs. Joy Condition	29.000	1	< .001
Sadness vs. Fear Condition	26.000	1	< .001
Sadness vs. Disgust Condition	28.000	1	< .001
Prototypical Disgust (Omnibus)	61.603	3	< .001
Disgust vs. Joy Condition	1.000	1	.317
Disgust vs. Sad Condition	23.000	1	< .001
Disgust vs. Fear Condition	1.000	1	.317
Joy Condition (Omnibus)	14.727	2	.001
Joy vs. Sadness Prototypical Expression	9.000	1	.003
Joy vs. Disgust Prototypical Expression	0.000	1	1.000
Sadness Condition (Omnibus)	30.333	2	<.001
Sadness vs. Joy Prototypical Expression	0.333	1	.564
Sadness vs. Disgust Prototypical Expression	17.000	1	<.001
Fear Condition (Omnibus)	22.429	2	<.001

Joy* vs. Sadness Prototypical Expression	13.000	1	<.001
Joy* vs. Disgust Prototypical Expression	1.000	1	<.001
Disgust Condition (Omnibus)	22.625	2	<.001
Disgust vs. Joy Prototypical Expression	15.000	1	<.001
Disgust vs. Sadness Prototypical Expression	11.000	1	<.001

Note. Cochran's Q tests examined omnibus and pairwise differences in the occurrence each prototypical expression, both across (Hypothesis 3) and within (Hypothesis 4) conditions. We used Bonferroni corrected *p*-value ($p = .05/3 = .017$) for pairwise comparisons. *In the fear condition, prototypical expressions of joy occurred in the most number of participants and were compared against the remaining expressions that occurred in that condition.

5.3 HYPOTHESIS 3

Three one-way repeated measure ANOVAs revealed effects of condition on the proportion of occurrence of prototypical expressions of joy, sadness, and disgust, respectively (all *p-s* < .001; see Table 7). Pairwise comparisons following each ANOVA test used a Bonferroni corrected *p*-value of .017.

The proportion of occurrence of the prototypical expression of joy in the joy condition was higher than in the sadness and fear conditions, $t(40) = 15.897$ and 4.844, respectively, both *p-s* < .01. The proportion of occurrence of the joy prototype in the joy condition did not differ from its duration in the disgust condition, $p > .05$.

The proportion of occurrence of the prototypical expression of sadness in the sadness condition was lower than its duration in the joy, fear, and disgust conditions, $t(40) = -3.989$, -3.943, -6.053, respectively, all *p-s* < .001.

The proportion of occurrence of the prototypical expression of disgust was higher in the disgust than in the sadness condition, $t(40) = .996$, $p < .01$. There were no differences between the proportion of occurrence of the prototypical expression of disgust in the disgust and joy conditions, as well as between the disgust and fear conditions, all *p-s* > .05.

Table 7. Average duration of time with which prototypical facial expressions of emotion lasted

Condition	**Joy Prototype M (SD)**	**Sadness Prototype M (SD)**	**Disgust Prototype M (SD)**	**Row-wise F-test (F; p; ηp2)**
Joy	**.596ca (.037)**	**.128db (.207)**	**.714da (.043)**	**F(2, 80) = 91.882; .000*; .697**
Sadness	**.001cb (.008)**	**.012ca (.072)**	**.162db (.047)**	**F(1.088, 43.516) = 11.612, .000*; .225**
Fear	**.565da (.048)**	**.167db (.250)**	**.761ca (.045)**	**F(2, 80) = 66.988, .000*; 626**
Disgust	**.320db (.045)**	**.226db (.238)**	**.757ca (.034)**	**F(2, 80) =90.627, .000*; .694**
Column-wise F-test (F; p; ηp2)	**F(2.615, 104.595) = 61.105; .000*; .604**	**F(3, 120) = 12.761; .000*; .242**	**F(3, 120) = 70.384; .000*; .638**	

Note. Paired-samples t-tests indicated that column-wise entries with different superscripts differed at the *p* = .05 level from the respective target prototypical expression in that column. Row-wise entries with different subscripts differed at the *p* = .05 level from the prototypical expression with the highest average duration compared against the remaining two expressions (due to the lack of data for the fear expression). Column-wise F-test statistics correspond to Hypothesis 2 analyses; row-wise F-test statistics to Hypothesis 3 analyses.

5.4 HYPOTHESIS 4

Four one-way repeated measures ANOVAs revealed differences between the average proportion of occurrence of the joy, sadness, and disgust prototypical expressions, separately in each condition (all *p-s* < .001; see Table 5). Note that, although there were no analyzable data for the prototypical facial expression of fear, we were still able to examine differences between the proportion of occurrence of the remaining prototypical expressions in the fear condition.

Follow-up pairwise comparisons of the omnibus tests indicated that in the joy condition the prototypical expression of joy had higher proportion of occurrence than the prototypical expression of sadness, $t(40) = 10.848$, $p < .001$ but not prototypical expression of disgust, $p > .05$.

In the sadness condition, there was no difference proportion of occurrence between prototypical expressions of sadness and joy, $p > .05$. In this condition, however, the prototypical expression of disgust had higher proportion of occurrence duration than prototypical expression of sadness, $t(40) = -3.474$, $p = .001$. In the fear condition, the prototypical expression of disgust had higher proportion of occurrence than the prototypical expression of sadness, $t(40) = 9.788$, $p < .001$, and the prototypical expression of joy, $t(40) = 4.017$, $p < .001$. Finally, in the disgust condition, the prototypical expression of disgust had higher proportion of occurrence than the prototypical expressions of joy, $t(40) = 9.259$, $p < .001$, and sadness, $t(40) = 13.492$, $p < .001$.

5.5 POST-HOC POWER ANALYSES

In order to assess the probability of detecting significant effects with the sample size and design of the current study, we conducted post-hoc power analyses for the hypotheses with continuous outcome variables with the program G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). For Hypothesis 3, the effect sizes ranged .242 to .638 considered large effect sizes (Cohen, 1988). The power to detect effect sizes in this range was 1.000. For Hypothesis 4, the effect sizes ranged from .255 to .697, again considered large effect sizes. The power to detect effect sizes in this range was 1.000. This indicates that our study was able to detect significant effects 100% of the time.

6.0 EXPLORATORY RESULTS

Exploratory analyses were motivated by the lack of findings for the occurrence of the prorotypical expression of fear and the low occurrence rates for the prorotypical expression of sadness. The definition of the prototypical expression of fear required the largest number of co-occuring AUs. We decided to examine modified versions of the prorotypical fear expression in order to explore whether that would lead to changes in occurrence rates of this expression. To do so, we obtained the proportion of occurrence of individual AUs (see Table 8) to determine the sequential order of excluding AUs from the original definition of prototypical fear. Table 8 shows the number of participants for whom less comprehensive versions of prorotypical fear occurred. We found that the combination of AUs 1 + 4 + 5 occurred for a very small number of participants in the joy, sadness, and fear conditions. The combination of AUs 1 + 4 occurred for approximately half of the participants in the sadness, fear, and disgust conditions.

Next, we explored the number of participants for whom AUs 6 + 12 occurred without 9, 10, or 11. Table 9 shows that, in all four conditions, there was a diffence between the number of participants who produced AUs 6 + 12 and AUs 6 + 12 without 9, 10, or 11 with fewer participants producing AU 6 + 12 when we considered these “spoiler” AUs. Finally, we compared the number of participants for whom each version of the prototypical expression of sadness occurred (i.e., AUs 6 + 15 or AUs 1 + 4 + 11 + 15). We found that when prorotypical expressions of sadness occurred, they were described by the combination of AUs 6 + 15. We also obtained the number of participants for whom the combination of co-occuring AUs 1 + 4 + 15 (rather than 1 + 4 + 11 + 15) occurred because AU 11 did not occur at all in the sadness condition (see Table 8). We found that the combination of AUs 1 + 4 + 15 occurred for more than half of the participants in the joy, fear, and disgust conditions, and for only four participants in the sadness condition (see Table 11).

Table 8. Proportion of occurrence for individual AUs

Condition	1	2	4	5	6	9	10	11	12	15	20	27
Joy	.14	.16	.07	.02	.62	.01	.71	.09	.82	.16	.01	.01
Sadness	.22	.09	.44	.07	.07	.00	.16	.00	.02	.06	.00	.01
Fear	.39	.28	.11	.05	.60	.07	.76	.05	.79	.23	.01	.00
Disgust	.21	.13	.43	.01	.48	.28	.72	.07	.49	.36	.01	.00

Note. Cell entries show the average proportion of occurrence for individual, rather than combinations of, AUs in the sample.

Table 9. Occurrence of modified prototypical facial expressions of fear

Condition	AUs 1 + 2 + 4 + 5 + 20	AUs 1 + 4 + 5 + 20	AUs 1 + 4 + 5	AUs 1 + 4
Joy	0	0	2	9
Sadness	0	0	7	17
Fear	0	0	1	20
Disgust	0	0	0	18

Note. We obtained the number of participants for whom modified versions of the prototypical fear expression occurred. The full definition of the prototypical expression of fear included AUs 1 + 4 + 5 + 20 + 27. Here we systematically reduced the number of required AU based on the decreasing individual length of time of each AU. These analyses were informed by the results in Table 6 (e.g., AU 27 did not occur at all in the fear condition; average duration was .000). The total number of participants in the sample was 41.

Table 10. Occurrence prototypical expression of joy with spoiler AU

Condition	AU 6 + 12	AU 6 + 12 (without 9, 10, or 11)
Joy	40	18
Sadness	1	0
Fear	41	14
Disgust	26	3

Note. The total number of participants was 41. Higher numbers indicate that more participants in the sample showed the combination of interest.

Table 11. Occurrence of the two variations of the prototypical facial expression of sadness

Condition	AUs 6 + 15	AUs 1 + 4 + 11 + 15	AUs 1 + 4 + 15
Joy	31	0	32
Sadness	2	0	4
Fear	28	1	28
Disgust	30	3	32

Note. The prototypical expression of sadness was defined as the co-occurrence of AUs 6 + 12 or AUs 1 + 4 + 11 + 15. This table shows the number of participants who showed one of these expressions in the different emotion eliciting conditions. The total number of participants was 41 and higher number indicate that more participants showed an expression. Additionally, due to the fact that the average duration of AU 11 was .000 in the sadness condition (see Table 6), we also obtained the occurrence of the fear prototypical expression without AU 11.

7.0 DISCUSSION

This study investigated whether people show prototypical expressions of joy, sadness, fear, and disgust, defined by FACS criteria, when these emotions are elicited. We used emotion elicitation procedures based on previous research and pilot testing and also referred to self-reported ratings of emotions to assess the validity of the procedures. We considered four specific hypotheses related to the occurrence and proportion of occurrence of these expressions, within and across conditions. In particular, we hypothesized that prototypical expressions would occur in the most participants and would have the highest proportion of occurrence in the target condition than other conditions (Hypothes 1 and 3) and also when compared to other prorotypical expressions within a target condition (Hypotheses 2 and 4).

Despite the fact that Likert-type ratings indicated that the target emotions or closely related emotion terms received the highest ratings in each condition, we failed to find evidence for strong correspondence between prototypical expressions and condition. Of the four prototypical expressions, none passed all four hypotheses we posed. The prototypical expression of fear did not occur at all, and sadness occurred with low rates and did not pass any hypotheses. The prototypical expression of joy satisfied some hypothesized post-hoc pairwise comparisons in Hypotheses 1-3, and the prototypical expression of disgust satisfied Hypotheses 2 and 4.

We found the most evidence, although dispersed, for the prototypical expressions of joy and disgust. As compared to the remaining expressions, the prototypical expression of disgust was the only expression that occurred in the most participants and with the highest proportion of occurrence in the disgust condition (e.g., therefore satisfying Hypotheses 1 and 3). However, prorotypical expressions of disgust occurred for a large number of participants and with high proportion of occurrence in other conditions as well. Therefore, protototypical expressions of disgust were not necessarily specific to the target condition.

Similalry, we found that prototypical expressions of joy were not specific to the target condition because these expressions occurred for many participants and with relatively high prorportion of occurrence across conditions (all conditions but sadness). Prototypical joy, for example, was the most frequently occuring expression in the fear condition. Although in the joy condition prototypical joy occurred for more participants than did prototypical sadness, we found that prototypical joy and disgust occurred for the same number of participants in this condition. Consequently, although some of the hypothesized pairwise comparisons were met for prototypical joy, this expression was also not specific to the target condition.

What might have accounted for the results that we obtained in this study? Our findings invite discussion of challenges involved in studying non-verbal representations of emotion in laboratory settings, as well as for outlining directions for future work, both within the BP4D database and for researchers interested in facial expression of emotion in general.

7.1 ELICITING BASIC EMOTIONS IN BP4D

One possibility is that the four basic emotions that we studied were not elicited properly. Because we expect that the different components of emotion (e.g., facial expression, physiology, appraisal) become correlated (Scherer, 2001) during the experience of emotion, we used available self-report data to assess the validity of the emotion induction procedures. As shown in Figure 1, in the conditions eliciting joy, sadness, and disgust, participants reported experiencing the target emotions with the highest intensity, among other emotion terms that were endorsed. One exception was the fear condition in which participants reported feeling nervoursness more intensely than fear or startle/shock.

In addition, in all four conditions, the second and third most intensely rated emotion terms were related to the target emotion. Although participants endorsed six to seven emotion terms after each condition, most of these were consistent with the emotional valence of the respective condition. For example, participants in the joy condition endorsed feeling relaxed with the second highest intensity after happy/joyful. In the disgust condition, participants endorsed feeling startled/shocked second to feeling disgusted. In the conditions eliciting sadness and fear, participants reported the experience of several negative negative affective states (e.g., startled/shocked, afraid, angry/upset) with intensity approximately as high as the intensity of the experience of the expected target emotion. Non-target emotion terms that were endorsed with high intensity in each condition were consistent with the type of procedure that participants engaged in. For example, the condition eliciting joy involved an informal conversation that concluded with a joke. It comes as no surprise, therefore, that participants also reported feeling relaxed (perhaps because they felt more comfortable in the interaction over time) and surprised (perhaps because they did not expect to hear a joke). Similalry, when a dart was thrown at a target behind the participant, reporting startle/shock and nervoursness matches the circumstances. In the sadness condition, participants reported feeling intensely angry/upset and afraid, again, emotion terms that one might expect based on the 911 conversation they heard.

Note that the fact that participants endorsed a high number of emotions after each condition is consistent with previous literature suggesting that laboratory procedures elicit the simultaneous experience of several emotions or emotion-related states (Ekman, 1984; Davidson et al., 1990). Overall, with possible exception of fear, findings from self-report seem to contraindicate the possibility that the target basic emotions were not elicited properly.

7.2 NUMBER AND TYPE OF PROCEDURES USED

In this study, we used a single emotion eliciting procedure for each emotion. We recognize that a single procedure may not sample the entire set of conditions required for a prototypical expression to occur; however, many studies on emotion utilize one procedure per emotion.

In addition, it is also possible that our laboratory setting failed to elicit sufficiently strong emotion. The emotion elicitation procedures used in the BP4D database were vetted in pilot research and participants' self-reports of felt emotions, yet some of these procedures differed from what procedures previous studies used. A common approach to emotion elicitation, specifically, of joy, disgust, and fear, in previous studies has been showing participants humorous or upsetting video clips (Ekman, Friesen & Ancoli, 1980; Rosenberg & Ekman, 1994; Gross & Levenson, 1993). Another common type of emotion elicitation procedure in past studies involved open-ended interviews (e.g., Heller & Haynal, 1994; Bonanno & Keltner, 1997;

Bonanno et al., 2002). Finally, we found two that studies used a stress-challenge task (Lerner et al., 2005) and an aversive acoustic startle (Soto et al., 2005) and documented displays of negative emotion and fear. In this study, joy was elicited by engaging participants in an informal conversation during which a joke was told; disgust was elicited by asking participants to smell rotten meat; fear was elicited by throwing a safety dart at the participant's face; and sadness was elicited by playing a distressing recording of a child calling 911.

Finally, an additional methodological consideration is that the order of emotion elicitation conditions was not counterbalanced. Counterbalancing in a within-subjects design is a preferred way of controlling for order effects. In our study, participants received the joy, sadness, fear, and disgust manipulation in this respective order and these conditions were first, third, seventh, and thirteenth in the series of all conditions. With the same order of conditions administered to all participants, we were unable to examine carry-over effects of the order of administration of conditions.

Related to order effects is the possibility that participants became less facially expressive due to fatigue. Data in Table 6 fails to suggest that there was less facial activity over time. There does not appear to be a systematic reduction in the proportion of occurrence of individual AUs across the four conditions (i.e., column-wise, from joy to disgust conductions). Note that, in this case, the four target conditions serve as time-stamps because of their order of administration among all conditions. However, it is beyond the scope of the current project to assess declines in facial expressivity in the BP4D database in general, particularly because not all thirteen conditions have been FACS-coded to date. Future effort in this database should focus on expanding the availability of FACS-coded conditions to enable the investigation of a larger number of emotions, as well as in changes in facial expressivity over time.

7.3 DEFINING PROTOTYPICAL EXPRESSIONS.

Another possible explanation for the mixed and non-conclusive findings is that each of the prototypical expressions was defined in terms of a fixed combination of co-occurring AUs with compound expressions explicitly ruled out (i.e., expressions that do not clearly fit one prototypical definition; Du, Tao, & Martinez, 2014). The reason to do so was because the current study attempted to test directly the idea that prototypical facial expressions of emotion occur, regardless of counter indicative or compounded actions. In addition, the definitions of the prorotypical expressions ranged from requiring the co-occurrence of one or two (e.g., joy and disgust) to at most six AUs (e.g., fear). Perhaps the complexity and variability in these definitions posed an additional challenge for the detection of the prorotypical expressions, especially those of sadness and fear. This is consistent with our findings showing that prototypical expressions of joy and disgust occurred with high frequency across conditions, while prototypical expressions of sadness and fear occurred rarely.

Expoloratoty analyses for the expressions of sadness and fear investigated whether particular AUs might have influenced our findings. In regards with prototypical fear, we systematically reduced the number of AUs required for this expression and reported the occurrence of these modified fear expressions in Table 7. We reduced the number of required AUs, one by one, based on the decreasing proportion of occurrence of individual AU (e.g., AU 27 was excluded first since it occurred 0% of the time; note that AUs 25 and 26, also part of the original prototypical definition, were not included in the FACS coding protocol for BP4D). The reduction of required AUs for prototypical fear did not lead to increases in the occurrence of modified facial expressions of fear. However, we discovered that AUs 1 + 4 occurred for approximately half of the participants in the conditions eliciting fear, sadness, and disgust and for only nine participants in the joy condition. This finding is consistent with previous work suggesting that certain AUs reflect negative emotion (e.g., AU 9, 10, 1 + 4, unilateral 14, 15, and 20) (Sayette & Parrott, 1999; Sayette et al., 2003). The prototypical expression of sadness was defined as one of two combinations of co-occurring AUs (i.e., 6 + 15 or 1 + 4 + 11 + 15). Table 9 shows that, when the sadness prototypical expression occurred, this expression was more frequently in of the form AUs 6 + 15; again, consistent with the idea that certain AUs, perhaps more so than others, are indicative of negative emotion.

In addition, we explored changes in the occurrence of prototypical joy, this time by adding exclusionary AU criteria (also "spoilers"). These analyses were motivated by previous work suggesting that certain AUs might act as "spoilers" of an expression (e.g., smile controls during joy, smiles with cheek raising during the expression of intense pain, etc.) (Ambadar, Cohn, & Reed, 2009; Keltner, 1995). Our results showed that when we insisted that AUs 9, 10, or 11 did not co-occur with the expression of joy, the overall occurrence of prototypical joy was lower (see Table 8). More importantly, the occurrence of prototypical joy with exclusionary criteria had lower rates in the conditions eliciting negative emotions.

Exploratory analyses suggested that the morphology of prototypical expressions may be more complex in that, based on context, prototypical expressions may co-occur or overlap with other expressions. Indeed, data in Table 5 suggests that compound prototypical expressions occurred frequently (i.e., sums of proportions of co-occurrence the prototypical expressions exceed 100% when values are summed row or column-wise). For example, in the condition eliciting joy, the duration of the joy prototype was .596 and of the disgust prototype .714, indicating that there existed overlap between these two expressions. Recent research in the area of facial expression of emotion draws attention to the fact that a variety of facial expressions are used by humans during conditions eliciting discrete emotions (Du, Tao, & Martinez, 2014).

7.4 FUTURE DIRECTIONS

Since the 1990s, FACS-based descriptions of basic emotions have attracted the attention of many researchers who study the behavioral correlates of emotion. Despite existing limitations, the BP4D database is a rich source of spontaneously occurring facial expressions of emotion. The availability of high quality FACS coded data allowed us to design a study that analyzed the occurrence of facial behavior with a precise and scientifically rigorous approach that previous studies may have lacked. With the help of lead researchers in the Affect Analysis Group, future work with this database will focus on expanding the amount of data analyzed by applying automated approaches to FACS coding to obtain FACS data for the full length of the videos (rather than 15-20-second-long segments), as well as for more emotion conditions. Because all existing video will be coded, we will be able to narrow the window of time during which we expect a prototypical expression to occur (i.e., immediately after the experimenter threw a dart versus anywhere in the video).

More broadly, given the constraints that researchers face in laboratory studies, one might choose to seek out alternative ways of "capturing" facial expressions as they occur in everyday life. Without the intervention of an experimenter and a set of experimental manipulations, a more naturalistic approach to studying emotion may inform us of the ecological validity of the occurrence, duration, and frequency of prototypical expressions. This is important because perhaps both our procedures and those used in previous studies may have failed to induce basic emotions with sufficient intensity. For example, we know that participants in laboratory studies inhibit certain facial expressions because of social display rules (Reisenzein, Studtmann, Horstmann, 2013).

Surprisingly, the correlation between emotions and their predicted prototypical expressions remained relatively weak even in some naturalistic studies; see review by Fernández-Dols and Crivelli (2013). For example, Bonnano and Keltner (1997) studied facial expressions of emotion in conjugally bereaved individuals and found that expressions of sadness and anger correlated moderately with conversations about loss; expressions of anger correlated with self-reported anger; and Duchenne smiles did not appear to correlate with self-reported joy. Scherer and Ceschi (2000) examined the facial expressions of passengers who lost their luggage at a major airport. These passengers produced a large number of heterogeneous facial expressions and only smiles were produced with sufficient frequency to be analyzed. Only Duchenne smiles correlated modestly with self-reported appraisals of humor. Yet another example of naturally occurring facial expressions is highlighted in a study by Fernández-Dols and Ruiz-Belda (1995) in which facial expressions of sadness were produced by Olympic gold medalists during the non-interactive phase of the award ceremony. These findings suggest that even in the "wild" prototypical expressions of emotion co-occur or overlap with other expressions, thus providing further support for the idea of examining compound expressions.

Based on our findings we may ask what the meaning of a person smiling is when they report having felt disgusted or showing signs of negative affect when experiencing joy? Facial expressions serve varying interpersonal and communicative functions, bear different meanings based on context, and may appear as a response to a number of different types of elicitors (Fernandez-Dols & Crivelli, 2013). Perhaps prototypical facial expressions of basic emotions do not appear in their "purest" form, even when individuals report experiencing basic emotions. Future work is needed to consider evidence for prototypical expressions of emotion by adding exclusionary criteria and examining compound or overlapping expressions (Ambadar, Cohn, & Reed, 2009).

Although studies of emotion expression in naturally occurring settings pose limitations on our ability to record facial behavior in a uniform manner, these studies are grounded in perhaps more emotionally laden contexts (Fernández-Dols & Crivelli, 2013). May we be able to adopt creative experimental designs that resemble more closely conditions in which signs of emotion appear naturally? Laboratory procedures that allow participants to engage in spontaneous and more naturalistic interpersonal interaction and activities highlight the need for adapting the ways in which emotions are traditionally elicited in the laboratory. Fairbairn, Sayette, Aalen, and Frigessi (2015) discovered that both Duchenne and non-Duchenne smiles were produced when participants in groups of three interacted with each other, with or without alcohol consumption. Importantly, the spreading of Duchenne smiles was instrumental in examining the influence of gender and alcohol during interpersonal group interaction.

On a daily basis, we all smile, frown, pout our lips, and produce a myriad of facial expressions that, anecdotally, seem to be strong indicators of certain emotions. How do we reconcile our everyday experiences and knowledge of emotion expressions with the inconclusive scientific evidence linking facial expressions with felt emotions? Perhaps, an important next step for facial expression researchers will be to bridge the gap between laboratory and naturalistic approaches (Fernández-Dols & Crivelli, 2013) and, more importantly, between what we know about the differences in the timing, morphology, and duration of certain facial expressions in emotionally laden contexts.

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