# Spontaneous Facial Expressions of Emotion of Congenitally and Noncongenitally Blind Individuals

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The study of the spontaneous expressions of blind individuals offers a unique opportunity to understand basic processes concerning the emergence and source of facial expressions of emotion. In this study, the authors compared the expressions of congenitally and noncongenitally blind athletes in the 2004 Paralympic Games with each other and with those produced by sighted athletes in the 2004 Olympic Games. The authors also examined how expressions change from 1 context to another. There were no differences between congenitally blind, noncongenitally blind, and sighted athletes, either on the level of individual facial actions or in facial emotion configurations. Blind athletes did produce more overall facial activity, but these were isolated to head and eye movements. The blind athletes' expressions differentiated whether they had won or lost a medal match at 3 different points in time, and there were no cultural differences in expression. These findings provide compelling evidence that the production of spontaneous facial expressions of emotion is not dependent on observational learning but simultaneously demonstrates a learned component to the social management of expressions, even among blind individuals.

*Keywords:* emotion, facial expression, blindness, Duchenne smiles, Facial Action Coding System

Emotions evolved as a rapid and coordinated response system that allows humans to quickly and efficiently respond to events that affect their welfare (Darwin, 1872/1998; Ekman, 2003; Lazarus, 1991). Facial expressions are part of that response system. The facial musculature has over 40 independent actions that can occur, which results in an extremely large number of possible expressions. But of this large potential repertoire, strong evidence now exists that a small number of specific facial configurations are universally and discretely produced when emotions are elicited (Ekman, 1993).

Questions exist, however, concerning their source. There are at least two theoretical positions that can account for universality. One suggests that universal expressions are produced by culture-constant learning. In this view, individuals around the world learn, through observational learning, modeling, and reinforcement, to associate the same facial configurations with the same emotional states or antecedent events. Facial expressions of emotion, thus, are universal because the same expressions are observed and modeled around the world in response to the same types of emotionally evocative situations.[1]

A second position suggests that universal expressions originate from an evolved emotion-response system. This position suggests that the facial configurations are genetically coded for all humans and are part of a larger response system involving cognitive, physiological, and phenomenological changes. For instance, the elicitation of anger would recruit a host of physiological responses that would prime an individual to fight (e.g., increased heart rate and respiration); gate mental activities to be alert for possible opponents; and produce threatening expressions that allowed for increased focus on objects, the baring of teeth in preparation for biting, and the perception of threat by others. According to this view, this coordinated response system is produced from a biologically resident source that requires little or no learning; facial expressions, therefore, are universal because they are a product of our evolutionary history.

Studies of normal adult humans, which comprise the bulk of research on expression to date, cannot address which of these potential sources may be correct, but other types of studies can. One is that of congenitally blind individuals. Because these individuals cannot see others' expressions from birth or shortly thereafter, they cannot

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[1] An alternative possibility would assume a role for tactile learning, where infants learn to model expressions of others by touching them as they occur. Although theoretically possible, it is highly unlikely that infants all around the world in different cultures tactilely feel the expressions of the different emotions at the precise times at which they occur and are able to learn them and their specificities so well as to produce them.

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learn to produce expressions by modeling. Thus, if congenitally blind individuals express facial emotions in the same way as sighted individuals, this would be compelling evidence for a nonvisually learned source of universal expressions. This would be especially true if blind individuals from different countries and cultures spontaneously produced the same, discrete facial expressions of emotion.

In fact, there have been 17 studies that have examined the expressive behavior of blind persons. Of these, seven examined voluntarily produced expressions and indicated that blind individuals have difficulties posing emotional expressions (Dumas, 1932; Fulcher, 1942; Galati, Scherer, & Ricci-Bitti, 1997; Mistschenka, 1933; Ortega, Iglesias, Fernandez, & Corraliza, 1983; Rinn, 1991; Webb, 1977). Of the other 10, all reported that blind individuals spontaneously produced the same types of emotional expressions as sighted individuals.[2] But five of these relied on observation by the experimenter or assistants (Charlesworth, 1970; Eibl-Eibesfeldt, 1973; Freedman, 1964; Goodenough, 1932; Thompson, 1941); thus, it is not clear as to what expressions actually occurred in these studies. The other five measured facial muscle movements. Two (Cole, Jenkins, & Shott, 1989; Ortega et al., 1983) used an abbreviated version of Ekman and Friesen's (1978) Facial Action Coding System (FACS), one used full FACS coding (Galati, Sini, Schmidt, & Tinti, 2003), one (Galati, Miceli, & Sini, 2001) used Izard's Maximally Discriminative Facial Movement Coding System (Izard, 1983), and one used an independent coding system (Peleg et al., 2006).

But important theoretical questions remain, and we address four of them here. For example, even of the studies that actually measured facial behavior, none examined the existence of specific facial configurations associated with emotions, with the exception of Duchenne smiling (Cole et al., 1989; Ortega et al., 1983). Galati et al.'s (2003) study, for instance, examined the correlation between blind and sighted individuals in the frequencies of 36 FACS codes, many of which have not been linked to emotion signals. Likewise, Peleg et al.'s (2006) study analyzed 43 facial movements, many of which were not related to emotion signaling. As mentioned earlier, of all the facial expressions humans can possibly produce, only a few are reliably related to emotion signaling, and these involve a limited number of the facial muscles in certain combinations. Thus, in a strict sense, the field still lacks compelling data demonstrating that blind individuals spontaneously produce the same facial configurations that are associated with emotion signaling as do sighted individuals.

Also, there are open questions as to whether emotion signals function in the same way for blind individuals as they do for sighted. We know, for instance, that different emotionally evocative events produce different emotional reactions and, thus, different expressions (Keltner & Bonanno, 1997; Matsumoto & Willingham, 2006). Even if facial expressions of emotion occur in blind individuals, they may be produced differently for different events or have different intrapersonal or interpersonal meaning. An evolution-based view of emotion and expression would predict that there are no differences in the function of emotional expressions between blind and sighted individuals, but this question has not yet been explored.

We also do not know if and how blind individuals manage and modify their expressions in different social conditions. For example, sighted individuals who experience negative emotions may smile to conceal their feelings if the context dictates that it is not appropriate to express those emotions (Ekman, 1972; Matsumoto & Kupperbusch, 2001), and blind and sighted children as young as 4 years of age have learned to mask their feelings in this way (Cole, 1986). But smiles can be used in many nuanced ways (e.g., with or without facial controls or blended with other emotions), and people presumably learn how to manage their expressions in these various ways. No study has examined whether blind individuals' expressions in a social situation use smiles in the same nuanced and complex ways that sighted individuals do. If they did, it would raise interesting questions about how such expression regulation comes about, given that blind individuals cannot learn such regulation through observation.

Finally, to date, there has been no study comparing the spontaneous expressions of congenitally blind individuals with those of individuals born with sight but who later became blind (e.g., through accidents, late onset of disease). Mistschenka (1933) did compare the posed expressions of congenitally and noncongenitally blind children aged 4–18 years, who were instructed to voluntarily pose specific facial actions. Expressions produced by congenitally blind persons were different from spontaneously produced expressions with increasing age, probably because of the progressive loss of control over facial motility, and less deterioration was evident in children who became blind later in life. Because these were voluntarily posed expressions, however, the degree to which noncongenitally blind individuals' spontaneous expressions may have been altered because of the blindness is not known. It is possible that earlier onset blindness may produce alterations to spontaneous facial behaviors, which would implicate some function for experientially based learning of facial expressions. Consonant with this idea, the blind children in Galati et al.'s (2003) study produced more closed eyes (Action Unit [AU] 43), open mouths (AU 26), eyebrow raises (AUs 1 and 2), and head raises (AU 53) than did the sighted children. Later onset blindness may be associated with less extraneous facial movements. This opens the door for the possible existence of unique emotional expressions of blind individuals.

## Overview of the Current Study

These four questions have important theoretical implications for our understanding of emotion and expression. To investigate them, we examined the spontaneous expressions produced by blind judo athletes at the 2004 Athens Paralympic Games. A previous study of sighted athletes at the 2004 Athens Olympic Games judo competition served as a comparison (Matsumoto & Willingham, 2006). There, expressions that occurred immediately at the end of a gold or bronze-medal match in 84 athletes from 35 countries were captured by high-speed photography and were FACS coded (Ekman & Friesen, 1978). Winners of the gold-medal matches obtained the gold, whereas losers settled for silver; winners of the bronze-medal match obtained the bronze, whereas losers went home without a medal. Because two bronze medals are awarded in judo, losers of the bronze-medal match take fifth place. Eighty-six percent of the athletes produced at least one expression at match completion, and the type of expression differentiated the results. Winners (gold and bronze medalists) were much more likely to

[2] The emotions elicited and expressions examined in these studies overlap considerably with those that have been found to be universal: smiling, laughing, crying, sadness and distress, surprise, and disgust. A table summarizing these previous studies is available from David Matsumoto upon request.

display Duchenne smiles, smiles involving innervation of both zygomatic major (AU 12) and orbicularis oculi (AU 6); this smile has been associated with signs of enjoyment (Frank, Ekman, & Friesen, 1993). Defeated athletes (silver medalists and fifth placers) were more likely to display sadness, contempt, or no emotion.

The expressions of the medalists were also captured at two times during the medal ceremonies. During these periods, almost all athletes smiled in response to the highly social nature of the ceremonies. But the specific *type* of smile differentiated their performances. Gold and bronze medalists were more likely to display uncontrolled Duchenne smiles; silver medalists displayed controlled Duchenne smiles, non-Duchenne smiles, or other expressions. Non-Duchenne smiles involve only zygomatic major (AU 12) and are more commonly known as social smiles. Controlled Duchenne smiles are those that involved the actions of buccinator (AU 14), sometimes in combination with mentalis (AU 17) and/or orbicularis oris (AU 28). These lower face actions give the appearance that expressers are making a conscious effort to control their facial behaviors and/or words, as if they are "biting their lip."

The Paralympic Games is an optimal comparison for the Olympic Games. Both are the pinnacle of sporting events. Both occur only every 4 years, in the same settings at about the same time (the Paralympic Games generally occur a few weeks after the Olympic Games, in the same city, using the same venues). Both use the same rules of competition. Participating athletes typically have been engaged in sport for most of their lives and give up major portions of their lives leading up to the Games. Thus, winning or losing a medal match is a highly emotionally charged event. In the 2004 Paralympic Games, there were 13 categories of competition, producing 13 gold medalists, 13 silver medalists, and 25 bronze medalists (one category gave only one bronze medal).

Facial expressions of these athletes were captured using the same methods used in Matsumoto and Willingham's (2006) study. The athletes were classified according to whether or not they were congenitally blind, and their spontaneous expressions were examined at the same three points in time: immediately at the end of the medal match, when receiving their medal from a dignitary during the medal ceremonies, and on the podium posing with other medalists. Their faces were FACS coded, and the expressions were classified, using an emotion dictionary called Emotion FACS (EMFACS; Ekman & Friesen, 1982), according to the emotion displayed. On the basis of the literature reviewed above, we examined the following research questions:

1. Were there differences in the spontaneous expressions of congenitally blind, noncongenitally blind, and sighted athletes? We compared the facial activity among these three groups of athletes at the three points in time when expressions were captured.[3]

2. Did facial configurations associated with emotion signaling occur in the blind athletes?

3. Did the expressions of the blind athletes differ as a function of place finish and setting? We examined whether the expressions of the blind athletes, like those of the sighted athletes, differed according to place finish and social situation.

4. Did the expressions of the blind athletes differ as a function of social context?

## Method

### *The Setting*

Judo competition was held at the Ano Liossia Competition Hall in Athens, Greece. There were two competition areas in the field of play, each composed of an 8-m × 8-m contest area, with a 3-m safety area bordering three of the outside edges and a 4-m safety area in between the common edges of the contest areas. A large runway ran around the entire competition areas for athlete and staff entrances and exits on one side and for all technical officials on the other three sides. The main spectator seating areas were along three sides of the competition area; the fourth side was reserved for VIPs and broadcast companies. The main television cameras were situated on the side of the spectators in between the competition areas. Bob Willingham, who is a professional photographer and was the official photographer of the International Judo Federation, was situated in between both competition areas on the side of the technical officials, that is, opposite the main spectator seating and the main television cameras. Thus, it was impossible for the photographer to obtain expressions when the athletes faced the crowd.

There were seven weight categories for men and six for women, and competition occurred for 3 days. Competition occurred in a standard elimination system, in which winners proceeded through preliminary rounds and then quarterfinal, semifinal, and final rounds. Athletes who lost to the semifinalists were placed in a loser's bracket (known as the repechage) and competed in an elimination system. The gold medalist is the athlete who wins the final round (thus not having lost any matches); the silver medalist is the loser of the final round. Bronze medals are awarded to the winners of the match between the winner of the repechage and the loser of the semifinals. Because there are two semifinals and two repechages, two bronze medals are awarded; the losers of the bronze medal matches are awarded fifth place.

During the preliminary, semifinals, repechage finals, and bronze-medal matches, contests occurred on both competition areas; thus, the photographer (Bob Willingham) took shots on both mats, alternating between one and the other, depending on the action and the athletes competing. Gold-medal matches, however, occurred one at a time; thus, the photographer was able to focus all attention to those matches.

The photographer took action shots during the contests. But for the purposes of this study, the photographer also took shots of the athletes from immediately before each match was over through the awarding of the match by the referee, a time period that generally occurred within 15–30 s, thus allowing for essentially continuous capture of potential expressions. The photographer was told that the focus of the study was on expressions, but no information was given about what specific type of expression or channel; no mention was made of emotion, and he had no formal training in psychology and did not know the literature related to the study or the specific hypotheses to be

[3] The Matsumoto and Willingham (2006) study examined only EMFACS categories produced by the sighted athletes, and not their individual FACS AUs. Thus, the data, analyses, and findings reported below involving the comparison of the individual FACS AUs between the blind and sighted athletes are entirely new in the literature.

tested. And in any case, he could not possibly have influenced the expressions that occurred. The only limiting factor was that, because athletes separated at the end of matches to go back to their starting positions, the photographer had to alternate shooting between winners and the defeated. Thus, potential expressions of one athlete were lost when the focus was on the other athlete. In particular, the photographer tended to take shots of winners immediately after the matches, which is common in sport photography; therefore, the potential for not having captured more expressions of the defeated athletes is greater, and readers should interpret the findings below with this caveat in mind. (And, as mentioned above, bronze-medal matches occurred simultaneously, so if the matches ended at the same time, expressions could not be captured throughout for all athletes.) Nevertheless, this procedure prohibited the photographer from seeing expressions and then shooting them selectively. Moreover, it would have been impossible to do so, because by the time one sees an expression, makes a decision to shoot it or not, and voluntarily shoots it, it may have already disappeared. Note that the procedures employed here were exactly the same as those used with the sighted athletes (Matsumoto & Willingham, 2006).

Medal ceremonies occurred about 30 min after the completion of the last match of the day. Athletes were marched in single file, stood behind the podium, stepped up onto the podium when their names were called, and received their medal and wreath from a dignitary. After all athletes had received their medals, they stood for the playing of the national anthem of the gold medalist and then gathered on the gold-medal podium for a group photo.

### Photographic Equipment

The camera used was a Nikon D2H professional digital camera. It has a high frames/s rate (8 frames/s, with 37-ms shutter time lag) and high resolution (4.1 megapixels effective). The camera was set to use auto focus and manual exposure using available light and shooting in JPEG file format. The International Organization for Standardization range used was between 400 and 800, giving shutter speeds around 1/500 s. A variety of interchangeable Nikkor lenses were used, including 28-70 f2.8, 70-200 f2.8, and 300mm f2.8.

### Photo Selection

Approximately 4,800 total shots were taken. Of these, we examined all shots taken immediately at the end of each medal match, from the time when the match was over to the time the decision was announced by the referee, a span of approximately 15–30 s. Shots were also examined at two times during the medal ceremonies: when the athlete received the medal from the dignitary and when the four athletes (gold, silver, and two bronze medalists) were posing on the medal stand.

Photos were selected for detailed FACS coding if there was at least a clear profile view of the face of the athlete and if any facial muscles were contracted, which was our criterion for the existence of an expression. To isolate specific expressions for coding, we examined the series of photographs that depicted the beginning of the expression to its end and selected the photograph in which the expression had reached its apex for FACS coding. According to standard FACS criteria, if an expression was already on a face, a new expression was determined to exist if different facial muscles were contracted or existing facial muscles changed by at least two FACS intensity levels (Ekman & Friesen, 1978). This resulted in the selection of 123 photographs for FACS coding, 68 from the medal matches and 55 from the medal ceremonies. (The number of photos examined did not match the number of athletes, because some shots involved more than one athlete.)

### Athlete Participants

The pool of individuals who competed in the medal matches were the 76 gold, silver, bronze, and fifth-place winners. They represented 23 countries from six continents and constituted the most culturally diverse sample of blind individuals in whom spontaneous expressions that occurred in a highly charged, emotional event in three situations have been examined. Athletes were classified according to whether they were congenitally blind or not, according to their self-reports.[4] Of the 59 athletes who provided expressions for analyses (below), the number of athletes classified as congenitally blind or not did not differ significantly across the place finishes, $\chi^2(3, N = 59) = 1.23$, *ns* (see Table 1). The same analyses computed separately for only the first expressions produced at match completion, when receiving the medal from the dignitary, and when posing on the podium also produced nonsignificant results, $\chi^2(3, N = 39) = 2.04$, *ns*; $\chi^2(3, N = 51) = 0.19$, *ns*; and $\chi^2(3, N = 51) = 0.17$, *ns*; respectively. Thus, the numbers of congenitally and noncongenitally blind athletes did not differ according to place finish in the data set.[5]

### Expression Coding and Emotion Predictions

Expressions were coded using Ekman and Friesen's (1978) FACS, which identifies each of the functionally anatomical facial muscle movements (AUs) that can occur independently, as well as head and eye positions. All expressions were coded by two certified FACS coders (one was David Matsumoto; the other was blind to the hypotheses, goals of the study, and athlete performances); interrater reliability was calculated according to standard procedures outlined in the FACS Investigator's Guide and was .86.

We then compared all AU combinations with the Emotion FACS (EMFACS) dictionary to obtain emotion predictions (Ekman & Friesen, 1982; Matsumoto, Ekman, & Fridlund, 1991). EMFACS identifies AUs that are theoretically related to facial expressions of emotion posited by Darwin (1872/1998) and

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[4] These were obtained by the research team after the competition, via telephone and e-mail.

[5] In this competition, the degree of visual impairment of the athletes was classified according to standards established by the International Blind Sports Association (IBSA) into one of three categories (judo is one of the few sports that integrates competitors in all three categories): B1 = from the nonexistence of light perception in both eyes to some light perception, but with the inability to recognize the shape of a hand at any distance or in any direction; B2 = from the ability to recognize the shape of a hand up to visual acuity of 2/60 and a vision field of less than five degrees; B3 = visual acuity from 2/60 to 6/60 and/or a vision field between 5 and 20 degrees. A separate study on visually impaired judo athletes indicated that the most common causes of impairment were congenital glaucoma, congenital cataracts, macular degeneration, retinitis pigmentosa, atrophy of the optic nerve, and Stargardt's disease (Carmeni, 1997). These categories of blindness would render the ability to see major facial configurations up close in detail virtually impossible.

Table 1
*Frequencies of Athletes Born Blind or Not, According to Place Finish*

| Place | Blind status | | Total |
|---|---|---|---|
| | Congenitally blind | Noncongenitally blind | |
| Gold | 6 | 7 | 13 |
| Silver | 5 | 8 | 13 |
| Bronze | 11 | 14 | 25 |
| Fifth place | 5 | 3 | 8 |
| Total | 27 | 32 | 59 |

Tomkins (1962, 1963) and are empirically validated by studies of spontaneous expression and judgments of expressions (Ekman, Davidson, & Friesen, 1990; Ekman & Friesen, 1971; Ekman, Friesen, & Ancoli, 1980; Ekman, Friesen, & Ellsworth, 1972; Ekman, Friesen, & O'Sullivan, 1988; Ekman, Sorenson, & Friesen, 1969). The facial configurations associated with the emotion predictions were first listed in Ekman (1972) and in the original FACS Manual (Ekman & Friesen, 1978); prototypic examples of the emotion facial configurations are described in Ekman and Friesen's (1975) *Unmasking the Face* and are portrayed in their *Pictures of Facial Affect* (Ekman & Friesen, 1976) and the *Japanese and Caucasian Facial Expressions of Emotion* (Matsumoto & Ekman, 1988) sets.

## Results

### *Were There Differences in the Spontaneous Expressions of Congenitally Blind, Noncongenitally Blind, and Sighted Athletes?*

*Individual FACS AUs.* At match completion, there were usable photos for 39 athletes (11 gold, 8 silver, 12 bronze, and 8 fifth placers), and all produced at least one expression. Of these, 17 provided two expressions, eight provided three, four provided four, and one provided five expressions that were FACS codable. During both periods of the medal ceremonies, there were usable photos for all 51 participating athletes (13 gold, 13 silver, 25 bronze; only one bronze was awarded in female heavyweight).

Table 2 lists the frequencies of sighted, congenitally blind, and noncongenitally blind athletes producing each of the individual FACS AUs. (For all analyses at match completion, we used only the first expression displayed by the athletes, ensuring that each athlete contributed only one expression to the analyses to avoid problems with the independence of the data.) The frequencies appeared different across groups because of differences in the sample sizes, which are noted at the top of the table. Because of sample-size differences, we tested differences between both blind groups and the sighted athletes separately for each AU using a difference in proportions test for all AUs with frequencies $\geq 5$. None was significant, indicating that there were no absolute differences across the three groups in the proportion of times they produced each individual AU at match completion.

To examine possible differences in the relative proportion in AUs, we computed profile correlations on the frequencies of AU usage in Table 2 among the three groups. Because these may have been affected by non-normal distributions of the data, we computed both Pearson and Spearman correlations. All correlations were statistically significant, and in most cases, high (see Table 3, top; Pearson correlations on top, Spearman's on the bottom in parentheses). When the data for the blind athletes were combined, the correlations between the blind and sighted athletes' AUs were $r(32) = .94$, $p < .01$; $r(32) = .98$, $p < .01$; and $r(32) = .96$, $p < .01$, for match completion, receiving medal, and on the podium, respectively. (Using Spearman's, they were .84, $p < .01$; .41, $p < .05$; and .70, $p < .01$; respectively.) The analyses were also computed separately according to place finish and produced essentially the same results. These findings indicated a high degree of concordance in the relative proportions of the individual AUs between congenitally and noncongenitally blind athletes and between blind and sighted athletes.

*Total facial activity.* We compared the total number of AUs displayed between congenitally and noncongenitally blind athletes separately for each of the three time periods by summing the total number of AUs produced by each athlete. There were no differences in total facial activity between these two groups at any of the three times, $t(37) = 1.54$, *ns*; $t(49) = .32$, *ns*; and $t(49) = .07$, *ns*, for match completion, receiving medal, and on the podium, respectively. We therefore combined them into a single group and compared their total facial activity with that of the sighted athletes. Blind athletes ($M = 3.95$, $SD = 1.52$) produced more overall facial activity than did sighted athletes at match completion ($M = 3.36$, $SD = 1.16$), $t(104) = 2.0$, $p < .01$, and when receiving the medal (blind $M = 3.55$, $SD = 0.95$; sighted $M = 2.98$, $SD = 0.93$), $t(104) = 3.11$, $p < .01$, replicating the findings of Galati et al. (2003). There were no differences in total facial activity on the podium, $t(104) = 1.13$, *ns*, although the same trend was present (blind $M = 3.06$, $SD = 1.14$; sighted $M = 2.82$, $SD = 1.13$).

Inspection of the individual AU frequencies (see Table 2), however, suggested that the differences in total facial activity occurred because of AUs related to head and eye movements (AUs 53 and higher), and not the facial musculature. Indeed, when differences between blind and sighted athletes in total facial activity *without* head and eye movements were tested, there were no differences, $t(104) = .57$, *ns*; $t(104) = .62$, *ns*; and $t(104) = 1.15$, *ns*, for match completion, receiving medal, and on the podium, respectively. These findings extend those of Galati et al. (2003) by demonstrating that blind individuals' greater FACS activity is related to movements of the head and eyes, and not of the facial musculature.

### *Did Facial Configurations Associated With Emotion Signaling Occur in Blind Athletes?*

The number of blind athletes displaying each of the expressions classified by EMFACS is provided in Table 4, separately for each of the three time periods and place finish. Blind athletes produced facial expressions associated with anger, contempt, disgust, sadness, surprise, and multiple types of smiles and smile blends. The range and type of emotion signals displayed were comparable to those produced by sighted athletes in the same situations (Matsumoto & Willingham, 2006). These data provided support for the notion that the facial configurations associated with emotion signaling did occur with the blind individuals.

We computed correlations to examine similarities in the relative proportions of the EMFACS categories between the congenitally blind, noncongenitally blind, and sighted athletes' EMFACS fre-

Table 2
*Frequencies of Sighted, Congenitally Blind, and Noncongenitally Blind Athletes Producing Each of the FACS AUs*

| | Match completion | | | Receiving medal | | | On podium | | |
|---|---|---|---|---|---|---|---|---|---|
| AU | Congenitally blind | Noncongenitally blind | Sighted | Congenitally blind | Noncongenitally blind | Sighted | Congenitally blind | Noncongenitally blind | Sighted |
| *N* | 17 | 22 | 67 | 22 | 29 | 56 | 22 | 29 | 56 |
| 1. Inner brow raiser | 4 | 8 | 26 | 0 | 1 | 2 | 1 | 0 | 3 |
| 2. Outer brow raiser | 2 | 4 | 6 | 0 | 0 | 0 | 0 | 0 | 1 |
| 4. Brow lowerer | 3 | 3 | 15 | 0 | 0 | 1 | 0 | 0 | 0 |
| 5. Upper lid raiser | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6. Cheek raiser | 7 | 15 | 37 | 17 | 25 | 51 | 13 | 15 | 45 |
| 7. Lid tightener | 1 | 1 | 4 | 0 | 1 | 0 | 1 | 0 | 0 |
| 9. Nose wrinkler | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10. Upper lip raiser | 3 | 1 | 5 | 1 | 1 | 0 | 0 | 4 | 1 |
| 12. Lip corner puller | 8 | 13 | 32 | 20 | 29 | 54 | 16 | 25 | 51 |
| 14. Dimpler | 2 | 5 | 16 | 4 | 5 | 6 | 5 | 7 | 19 |
| 15. Lip corner depressor | 0 | 1 | 8 | 1 | 0 | 2 | 1 | 2 | 4 |
| 16. Lower lip depressor | 0 | 2 | 3 | 0 | 0 | 1 | 0 | 1 | 0 |
| 17. Chin raiser | 2 | 2 | 11 | 4 | 1 | 3 | 7 | 7 | 10 |
| 20. Lip stretcher | 5 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 23. Lip tightener | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 24. Lip pressor | 1 | 2 | 4 | 3 | 3 | 0 | 4 | 1 | 0 |
| 25. Lips part | 1 | 2 | 4 | 8 | 16 | 24 | 13 | 10 | 20 |
| 26. Jaw drop | 11 | 13 | 30 | 6 | 7 | 13 | 0 | 5 | 3 |
| 27. Mouth stretch | 0 | 2 | 2 | 1 | 0 | 0 | 1 | 0 | 0 |
| 28. Lip suck | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 41. Lid droop | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 42. Slit | 0 | 1 | 0 | 3 | 0 | 0 | 3 | 0 | 0 |
| 43. Eyes closed | 2 | 1 | 1 | 1 | 2 | 0 | 1 | 0 | 0 |
| 44. Squint | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 53. Head up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 54. Head down | 1 | 3 | 4 | 3 | 6 | 0 | 0 | 1 | 0 |
| 55. Head tilt left | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 58. Head back | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 61. Eyes turn left | 1 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| 62. Eyes turn right | 1 | 1 | 3 | 0 | 1 | 0 | 0 | 5 | 1 |
| 63. Eyes up | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 64. Eyes down | 3 | 4 | 8 | 5 | 3 | 0 | 1 | 2 | 0 |
| Total | 59 | 94 | 224 | 77 | 105 | 159 | 69 | 89 | 158 |

*Note.* FACS = Ekman and Friesen's (1978) Facial Action Coding System; AU = action unit.

quencies, separately for the three time periods (see Table 3, bottom). As with the individual FACS data presented above, these findings also indicated a high degree of concordance in the facial emotion configurations defined by EMFACS between all three groups of athletes.

### *Did the Expressions of the Blind Athletes Differ as a Function of Place Finish and Setting?*

Given the high degree of concordance between the expressions of congenitally blind, noncongenitally blind, and sighted athletes, we then examined whether or not the expressions of the blind athletes functioned in ways similar to those of sighted athletes. For these analyses, we combined the congenitally and noncongenitally blind athletes into a single group.

At match completion, the expressions produced by the blind athletes included Duchenne smiles, Duchenne smiles in combination with other emotions, non-Duchenne smiles, contempt, disgust, sadness, surprise, undifferentiated negative emotions, and uninterpretable expressions. Kruskal-Wallis tests on the frequencies of the expressions as a function of place finish indicated that differences occurred for all smiles, $\chi^2(3, N = 39) = 24.19$, $p < .001$; Duchenne smiles, $\chi^2(3, N = 39) = 18.47$, $p < .001$; sadness, $\chi^2(3, N = 39) = 12.64$, $p < .01$; and all negative emotions combined, $\chi^2(3, N = 39) = 9.51$, $p < .05$. Because these analyses merely indicated that a difference existed somewhere among the place finishes, we compared the winners (gold and bronze medalists) and defeated (silver and fifth placers) in a series of single-degree-of-freedom comparisons. Winners displayed all types of smiles $t(37) = 6.93$, $p < .001$, $d = 7.53$, as well as Duchenne smiles, $t(37) = 5.89$, $p < .001$, $d = 7.14$, more frequently than did the defeated athletes. Defeated athletes displayed more disgust, $t(37) = 1.78$, $p < .05$, $d = 1.52$; sadness, $t(37) = 1.94$, $p < .05$, $d = 1.75$; and combined negative emotions, $t(37) = 3.20$, $p < .001$, $d = 2.88$, than did the winners (see Figure 1).

When receiving the medal, all 51 athletes provided at least one codable expression, which included controlled and uncontrolled Duchenne smiles, Duchenne smiles in combination with other emotions (contempt, disgust, and sadness), non-Duchenne smiles, disgust, and uninterpretable expressions. (As mentioned above, controlled Duchenne smiles included smiles in combination with

Table 3
*Pearson and Spearman (in Parentheses) Correlations Between Congenitally Blind, Noncongenitally Blind, and Sighted Athletes on Relative Proportions of Individual FACS AUs (Top Right) and EMFACS Categories (Bottom Left)*

| Blind status | Congenitally blind | Noncongenitally blind | Sighted |
|---|---|---|---|
| Match completion | | | |
| Congenitally blind | — | .88** (.74**) | .85** (.77**) |
| Noncongenitally blind | .63* (.56*) | — | .96** (.83**) |
| Sighted | .29 (.26) | .82* (.44†) | — |
| Receiving medal | | | |
| Congenitally blind | — | .97** (.71**) | .96** (.51**) |
| Noncongenitally blind | .99** (.47†) | — | .98** (.38*) |
| Sighted | .99** (.48†) | .99** (.48†) | — |
| On podium | | | |
| Congenitally blind | — | .90** (.37*) | .92** (.51**) |
| Noncongenitally blind | .94** (.69*) | — | .95** (.71**) |
| Sighted | .98** (.71*) | .95** (.68*) | — |

*Note.* FACS = Ekman and Friesen's (1978) Facial Action Coding System; AU = action unit; EMFACS = Emotion FACS (Ekman & Friesen, 1982).
† $p < .10$. * $p < .05$. ** $p < .01$.

AU 14, 17, and/or 28.) Kruskal-Wallis tests indicated that differences occurred for all smiles, $\chi^2(2, N = 51) = 5.97$, $p < .05$; Duchenne smiles, $\chi^2(2, N = 51) = 8.09$, $p < .05$; and non-Duchenne smiles, $\chi^2(2, N = 51) = 5.68$, $p < .05$. Winners (gold and bronze) displayed all types of smiles and Duchenne smiles more frequently than did the defeated (silver medalists), $t(51) = 2.58$, $p < .01$, $d = 1.44$, and $t(51) = 2.61$, $p < .01$, $d = 2.14$, respectively. The defeated athletes, however, displayed more non-Duchenne smiles, $t(51) = 2.46$, $p < .05$, $d = 1.61$ (see Figure 2).

On the podium, the 51 athletes produced controlled and uncontrolled Duchenne smiles, Duchenne smiles in combination with other emotions (contempt), non-Duchenne smiles, anger, contempt, sadness, and uninterpretable expressions. Kruskal-Wallis tests indicated that differences occurred for all smiles, $\chi^2(2, N = 51) = 5.57$, $p < .05$; Duchenne smiles, $\chi^2(2, N = 51) = 17.02$, $p < .001$; and non-Duchenne smiles, $\chi^2(2, N = 51) = 12.63$, $p < .001$. The winners displayed all types of smiles and Duchenne smiles more frequently than did the defeated, $t(51) = 2.30$, $p < .05$, $d = 1.92$, and $t(51) = 5.00$, $p < .001$, $d = 6.25$, respectively. The defeated athletes, however, displayed more non-Duchenne smiles, $t(51) = 3.41$, $p < .001$, $d = 2.52$; contempt, $t(51) = 1.70$, $p < .05$, $d = 1.12$; and controlled expressions, $t(51) = 2.02$, $p < .05$, $d = 1.66$ (see Figure 3).

There were several noteworthy nonfindings. The proportion of expressions that were not interpretable according to the EMFACS emotion dictionary was .13, which is comparable with the proportion of noninterpretable expressions produced by sighted athletes (Matsumoto & Willingham, 2006), as well as with the uninterpretable responses produced by American and Japanese participants in a laboratory setting (Ekman, 1972). We also tested differences between winners and defeated athletes in the total number of facial actions produced; there were no differences at any of the three time periods. Thus, the findings cannot be explained by differential amounts of overall facial movement, nor by disproportionate amounts of interpretable expressions.

### *Did the Expressions of the Blind Athletes Differ as a Function of Social Context?*

Most of the gold and bronze medalists (i.e., those who won their medal matches) produced a Duchenne smile at match completion (74%) and also subsequently produced a Duchenne smile when receiving their medal (97%) and posing on the podium (76%). These findings replicated Matsumoto and Willingham's (2006) research with sighted athletes. The more interesting comparison, however, concerned the silver medalists, who lost their medal matches. It is interesting to note that none of them produced a Duchenne smile at the end of their medal match; 85% of them, however, produced some kind of smile when receiving their medal, and 54% of them produced a smile when on the podium posing. We tested these two latter proportions against the proportion of silver medalists who smiled at match completion using a McNemar nonindependent differences in proportions test, and both were signif-

Table 4
*Frequencies of Blind Athletes Displaying the Expressions Classified by the EMFACS Dictionary at Three Points in Time*

| Type of expression | Athlete place finish | | | |
|---|---|---|---|---|
| | Gold | Silver | Bronze | Fifth |
| Match completion | | | | |
| Duchenne smiles | 7 | 0 | 7 | 0 |
| Duchenne smile + Surprise | 1 | 0 | 1 | 0 |
| Duchenne smile + Sadness | 1 | 0 | 0 | 0 |
| Non-Duchenne smile | 2 | 1 | 0 | 0 |
| Contempt | 0 | 0 | 0 | 1 |
| Disgust | 0 | 1 | 0 | 1 |
| Negative | 0 | 0 | 0 | 1 |
| Sadness | 0 | 4 | 0 | 0 |
| Surprise | 0 | 1 | 0 | 0 |
| Not in dictionary | 0 | 1 | 4 | 5 |
| Total | 11 | 8 | 12 | 8 |
| Receiving medal | | | | |
| Uncontrolled Duchenne smiles | 12 | 5 | 15 | |
| Duchenne smile + Contempt | 0 | 1 | 2 | |
| Duchenne smile + Disgust | 0 | 0 | 1 | |
| Duchenne smile + Sadness | 0 | 0 | 1 | |
| Controlled Duchenne smile | 1 | 2 | 5 | |
| Non-Duchenne smile | 0 | 3 | 1 | |
| Disgust | 0 | 1 | 0 | |
| Not in dictionary | 0 | 1 | 0 | |
| Total | 13 | 13 | 25 | |
| On podium | | | | |
| Uncontrolled Duchenne smile | 8 | 0 | 15 | |
| Controlled Duchenne smile | 1 | 1 | 4 | |
| Non-Duchenne smile | 3 | 6 | 0 | |
| Duchenne smile + Contempt | 0 | 0 | 1 | |
| Anger | 0 | 1 | 1 | |
| Contempt | 0 | 2 | 0 | |
| Sadness | 0 | 0 | 1 | |
| Not in dictionary | 1 | 3 | 3 | |
| Total | 13 | 13 | 25 | |

*Note.* EMFACS = Emotion FACS (Ekman & Friesen, 1982).

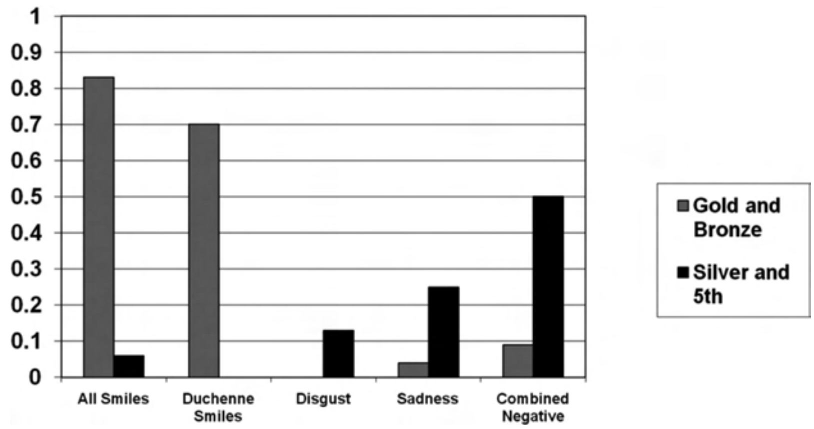


*Figure 1.* Proportion of occurrence of specific facial expressions at match completion.

icant, $z = 2.83$, $p < .01$, and $z = 2.33$, $p < .01$, respectively. These findings are commensurate with those reported by Matsumoto and Willingham (2006) for sighted silver medalists. Thus, it appeared that blind athletes who were probably not entirely joyful because they had lost their last match smiled during the medal ceremonies. Moreover, they produced the same types of differentiated smiles as sighted athletes did to distinguish their place finish.

## Discussion

This study addressed four central questions concerning the potential source of universal facial expressions of emotion. First, the spontaneous facial expressions of emotion produced by congenitally and noncongenitally blind individuals at three points in time did not differ between each other, or with those of sighted individuals. This was true when differences were examined on the level of single AUs, as well as emotion configurations. Moreover, the relative frequencies of the various AUs produced were comparable for blind and sighted athletes. The similarities on the level of individual AUs replicate previous findings (Galati et al., 2003; Peleg et al., 2006), and the findings on emotion configurations are new to this literature. Although differences were found between blind and sighted individuals in total facial activity, these differences were isolated to head and eye movements, and not the facial musculature. Thus, any appearance changes in blind individuals' expressions may be due to differences in the frequencies of head and eye movements, which may occur because of greater attempts at orientation (e.g., to maximize information obtained from audio stimuli), but not emotion signaling.

Second, facial configurations associated with emotion signaling occur in blind individuals. That there were no differences between congenitally and noncongenitally blind individuals suggests that the cause or timing of the onset of blindness had no effect on spontaneous expressions. The only previous study that compared the expressions of congenitally and noncongenitally blind individuals was Mistschenka's (1933), which examined voluntarily posed expressions and reported that congenitally blind children had more difficulty posing the expressions than did noncongenitally blind children. Our findings suggest that there are little or no differences, however, in spontaneous expressions and, in particular, specific emotion configurations.

Third, the types of expressions produced by the blind athletes differentiated the winners from defeated athletes at all three time periods, and these were generally the same expressions that did so for sighted athletes. Moreover, the differences were associated with very large effect sizes, and the results in both studies were found with a very culturally diverse sample of individuals. As with sighted athletes, these findings strongly suggest that blind individuals produce spontaneous facial expressions of emotion in response to emotionally

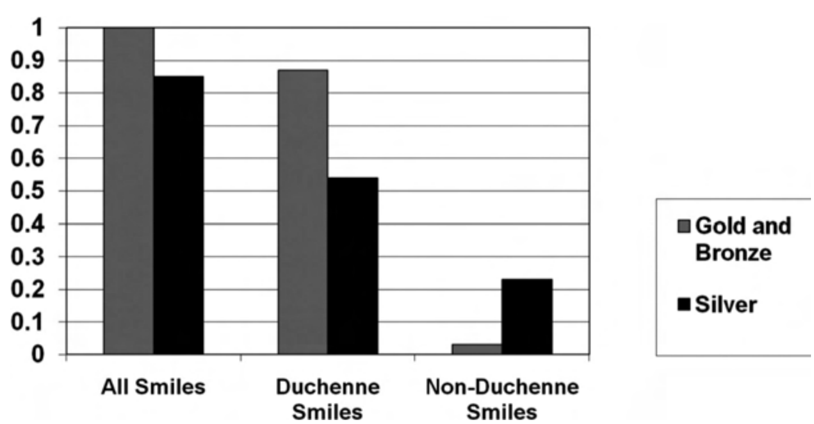


*Figure 2.* Proportion of occurrence of specific facial expressions when receiving medal.

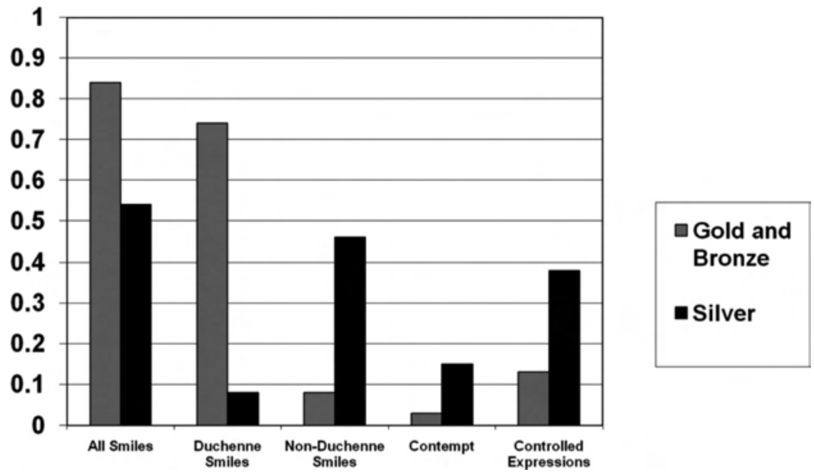


*Figure 3.* Proportion of occurrence of specific facial expressions on the podium.

evocative situations in naturalistic settings and that emotional expressions serve the same functions in both blind and sighted.

Fourth, the expressions of the blind athletes, and especially the silver medalists, differed as a function of social context. They produced Duchenne and non-Duchenne smiles and smiles in different combinations with other emotions and with facial controls. These findings are commensurate with findings for sighted athletes (Matsumoto & Willingham, 2006) and blind children who mask their feelings (Cole et al., 1989). They raise important new questions concerning the mechanisms by which individuals, blind or not, learn to manage their emotional displays. The traditional way of understanding expression regulation is through the concept of display rules (Ekman & Friesen, 1969; Matsumoto, Yoo, Hirayama, & Petrova, 2005). That smiles are the preferred expression of social politeness or masking is strengthened by the fact that control of zygomatic major may be structured differently neurologically than other facial muscles (Rinn, 1991) and may be on a different evolutionary tract than other spontaneous emotional expressions (Rinn, 1991; Van Hoof, 1972). Also, the greater neural representation of the lower face muscles, compared with the muscles of the upper face (Matsumoto & Lee, 1993), especially given the need to eat and talk, facilitates voluntary movements of the smiling muscle and other muscles related to facial controls, which would allow for learning to occur. That blind athletes used the smile and facial controls in social situations in this study in the same ways that sighted athletes did suggests that observation is not necessary for individuals to learn how to regulate their expressions. Other learning mechanisms, such as general reinforcement not involving visual modalities, may be sufficient for individuals to learn the display rules to regulate their expressions. Future studies of deaf and/or mute individuals, for whom lashing out with words or hearing statements that reinforce the nonvisual learning of display rules is not an option, may shed some light on this issue.

Cumulatively, these findings offer compelling evidence that spontaneously produced facial expressions of emotion of blind individuals are the same as those for sighted individuals in the same emotionally evocative situations and that they function in the same ways. They strongly suggest that the universality in emotional expression observed in numerous studies involving adult humans originates from an evolved, potentially genetic source and that all humans, regardless of gender or culture, are born with this ability. We come to this conclusion because the blind athletes, especially those born blind, could not possibly have learned to produce those exact facial configurations from modeling the expressions of others in culture-constant learning. At the same time, our findings implicate new ways of understanding the potential mechanisms by which individuals learn to regulate their emotional displays, suggesting that visual observation may not be necessary for such learning to occur.

Finally, we offer a caution to readers that our findings do not bear on the debate on the meaning of expressions, that is, whether they are readouts of underlying emotional states (Buck, 1984; Ekman, 1993) or communicators of behavioral intent (the behavioral ecology view of facial displays; Fridlund, 1997). Interpretations of emotion–expression linkages would require additional data, such as self-reported subjective experiences or observer judgments, which we did not obtain in this study. (Observer judgments of the sighted athletes' expressions by members of four cultural groups, however, did corroborate the EMFACS emotion predictions for them; Matsumoto, Olide, Schug, Willingham, & Callan, 2007). The purpose of this study was to examine similarities in expressions between congenitally blind, noncongenitally blind, and sighted individuals to implicate the source of the expressions. Providing evidence that the source of facial expressions (displays) is rooted in evolution, as suggested by our data, does not necessarily argue against the behavioral ecology theory, for instance, because that theory conceivably could be based on biologically sourced expressions (that are produced in social situations). In fact, Fridlund (1994) has offered similar views about the evolutionary origin of expressions within his viewpoint. Our data speak only to the issue of the source of the expressions, which we believe to be rooted in evolved emotion-response systems and not culture-constant learning. At the same time, our data also suggest a strong learned component on emotion-expression management, which heretofore has not been reported.

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