RUNNING HEAD: THE FACIAL EXPRESSION OF SURPRISE

Facial Expressions in Response to a Highly Surprising Event Exceeding the Field of Vision: A Test of Darwin's Theory of Surprise

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Abstract

According to the affect program theory of facial displays, the evolutionary core of the human emotion system consists of a small set of discrete emotion mechanisms that comprise motor programs for emotion-specific facial displays. However, research on surprise has found that surprising events often fail to elicit the associated facial expression (widened eyes, raised eyebrows, mouth opening). The present study tested a refined Darwinian account of the facial expression of surprise, according to which surprising events cause widened eyes and raised eyebrows if they exceed the field of vision, as these facial changes increase the visual field and facilitate visual search. To test this hypothesis, we staged a surprising event that engulfed the field of vision: When the participants left the laboratory, they unexpectedly found themselves in a new room, a small chamber with bold green walls and a red office chair. In addition, to explore the role of social context for the expression of surprise, in two of three experimental conditions a stranger or a friend they had brought to the experiment was sitting on the chair. The results provided no support for the Darwinian account of the facial expression of surprise. A complete expression of surprise was observed in 5% of the participants and the individual components of the expression were shown only by a minority, regardless of social context. These findings reinforce doubts about the adequacy of affect program theory for the case of surprise.

1.0 Introduction

Research on the inference of emotions from facial expressions has found that judges show considerable agreement that a few emotions—in particular, happiness, sadness, fear, anger, disgust, and surprise—are associated with specific facial displays (for reviews, see Elfenbein & Ambady, 2002; Russell, 1994). Many emotion researchers believe that these findings constitute strong evidence for the affect program theory of facial displays (APT) proposed by Ekman (1997), Izard (1991), Tomkins (1962) and others. According to APT, the core of the human emotion system consists of a small set of phylogenetically determined, discrete emotion mechanisms that comprise motor programs for emotion-specific facial displays. These motor programs are presumably activated whenever a basic emotion is evoked, causing a tendency to show the corresponding facial expression. Unless inhibited or masked, this expressive tendency then results in the appearance of the facial display.

However, studies of the spontaneous expression of emotions have not yielded unanimous support for APT (for reviews see e. g., Russell, Bachorowski, & Fernandez-Dols, 2003; Reisenzein, Studtmann, & Horstmann, in press). Rather, this research suggests that the association between emotions and facial expression is not as strong as APT seems to imply. First, facial expressions of emotion are often absent in situations in which, at first sight at least, APT would predict them to occur (e.g., Fernandez-Dols & Ruiz-Belda, 1997; Fischer, Manstead, & Zaalberg, 2003; Russell et al., 2003; Reisenzein, 2000; Reisenzein, Bördgen, Holtbernd, & Matz, 2006). Second, if they occur, facial expressions of emotion are more often partial than complete (e. g., Carroll & Russell, 1997; Reisenzein, 2000; Reisenzein et al., 2006). Third, some allegedly emotional facial displays, notably smiling, seem to be as strongly pulled forth by the presence of other people as by the emotional state of the person

(e.g., Fridlund, 1991; Holodynski, 2004; Kraut & Johnston, 1979; Ruiz-Belda, Fernandez-Dols, Carrera, & Barchard, 2003; for reviews, see Fischer et al., 2003; Parkinson, 2005; Wagner & Lee, 1999).

A particularly strong dissociation between emotions and facial displays has been found for surprise (Reisenzein, 2000; Reisenzein et al., 2006; for a review see Reisenzein et al., in press; on surprise in general, see Reisenzein, Meyer, & Niepel, 2011). Reisenzein et al. (2006) induced surprise in adult participants in a series of laboratory studies by staging a variety of unexpected events: Sudden audiovisual changes, a simulated computer breakdown, and the unexpected appearance of a picture of one's own face as the last picture in a series of portraits that had to be rated. Whereas subjective reports and behavioral indicators suggested the presence of surprise in most of the 220 participants, evidence for the surprise expression predicted by APT—consisting, in full-blown form, of the three facial components, eyebrow raising, eye-widening and mouth opening/jaw drop—was observed only in 4%–25% in the different studies. Furthermore, most of the observed expressions consisted of eyebrow raising only; the full, three-component display was never seen. Experimental variations of surprise intensity, sociality (the presence vs. absence of the experimenter), and duration/complexity of the surprising event did not change these results. Likewise, electromyographic measurement failed to detect notably more brow raisings and, in the portrait rating study, even revealed a decrease of frontalis muscle activity in the majority of the participants. Nonetheless, reminiscent of the findings of facial judgment studies (Elfenbein & Ambady, 2002), most participants believed that they had shown a strong surprise expression.

As documented in Reisenzein et al. (in press), similarly low frequencies of surprise expressions have been observed in several other studies with adults (e.g., Ludden,

Schifferstein, Hekkert, 2009; Reisenzein, 2000; Vanhamme, 2000). Furthermore, these findings confirm and extend the results of studies on surprise expressions in children (e. g., Bennett, Bendersky, & Lewis, 2002; Charlesworth, 1964; Hiatt, Campos, & Emde, 1979; Parrott & Gleitman, 1989; see Reisenzein et al., 2006, for a review). Taken together, the available evidence suggests that the surprise expression is more likely a rarely occurring "ideal type" than a regular concomitant of surprise (see also, Horstmann, 2002). Apparently, other than predicted by APT, the presence of the emotion of surprise and the absence of attempts to inhibit its facial expression are not sufficient for a surprise display to occur. Rather, the surprise expression seems to occur only if additional conditions are met. However, at present it is unknown what these additional conditions are (see Reisenzein et al., 2006, for a discussion).

The experiment reported in the present article is a further attempt to clarify this question. Specifically, it continues previous investigations of the surprise expression with two goals in mind. The first goal was to test an evolutionary-functional hypothesis concerning the necessary and sufficient conditions for the facial expression of surprise derived from a proposal by Darwin (1872/1998). Darwin argued that, as

> "surprise is excited by something unexpected or unknown, we naturally desire, when startled, to perceive the cause as quickly as possible; and we consequently open our eyes fully, so that the field of vision may be increased, and the eyeballs moved easily in any direction. But this hardly accounts for the eyebrows being so greatly raised as is the case, and for the wild staring of the open eyes. The explanation lies, I believe, in the impossibility of opening the eyes with great rapidity by merely raising the upper lids. To effect this the eyebrows must be lifted energetically" (Darwin, 1872/1998, p.

280f).

Darwin thus sought to account for both the occurrence of the facial expression of surprise, and the specific form that it takes, in terms of the functions of the expression: According to Darwin, the opening of the eyes and raising of the eyebrows serve to increase the field of vision and to facilitate visual search.

Our refinement of Darwin's functional account of the surprise expression also rests on functional considerations. Our reasoning is as follows: An increase of the field of vision and the facilitation of eyeball movements can aid the analysis of surprising events or objects only if they (a) are large enough to exceed the person's field of vision or (b) approach rapidly, thus occupying increasing areas of the visual field, until they eventually exceed it. If these conditions are not met, then an increase of the field of vision by raising the eyebrows and widening the eyes is usually not beneficial. On the contrary, if a surprising event or object is well within the person's current field of vision, increasing the field of vision can even interfere with visual exploration. In this case, focusing the gaze on the surprising event or object is better.

This refined Darwinian account of the expression of surprise (at least of eyebrow raising and eye-widening) offers an explanation for the finding of Reisenzein and co-workers (Reisenzein, 2000; Reisenzein et al., 2006) that most participants did not show expressions of surprise even when highly surprised: All surprising events used in these studies were visual in nature, and all remained clearly within the participants' field of vision, as they never exceeded the size of the computer screen. The same explanation seems viable for the results

of most other studies on the spontaneous expression of surprise (see Reisenzein et al., in press).

To test the proposed, refined Darwinian account of the facial expression of surprise, we staged the following surprising situation: When our participants left the laboratory, they unexpectedly found themselves, not in the familiar corridor, but in a new room: a small chamber with bold green walls with posters attached to each wall, a red office chair, and a bulb hanging from the ceiling. In addition, in two of three experimental conditions, either a stranger or a friend they had brought to the experiment sat on the chair facing them, without saying a word. The vista of the green room and its contents clearly exceeded the participants' field of vision; in fact, they completely engulfed the participants' view. This surprising situation should therefore benefit from an increase of the visual field and the facilitation of eyeball movements that, according to Darwin, are enabled by the expression of surprise. We therefore predicted that—if the refined Darwinian account of the facial expression of surprise is correct—a prototypical surprise expression should occur in most participants. At least, we predicted to find widened eyes and raised eyebrows. However, it seems that Darwin believed that the facial expression of surprise, if it is called forth at all, also includes its third component, mouth-opening: According to him, the facial movement of surprise "must be coordinated", because otherwise the expression "results in a meaningless grimace" (Darwin, 1872, p. 278). This suggests that, if the refined Darwinian hypothesis is right, the green room should also elicit mouth-opening.

At the same time, we expected that the green room would not just cause surprise, but surprise of high intensity, thus ruling out the possibility that participants failed to show a

(visible) facial expression because this expression occurs only if surprise intensity exceeds a threshold (see Reisenzein et al., 2006, for a discussion).

The second aim of the present study was to further explore the role of social context for the expression of surprise (Fridlund, 1994). As mentioned earlier, it is now well established that social context—the presence of other people, in particular of friends—has a potent effect on some facial expression, in particular smiling and laughter. In contrast, what limited data exist on the matter suggest that the facial expression of surprise is remarkably uninfluenced by social context. In particular, Reisenzein et al. (2006; studies 3, 6, and 8) found no evidence for an effect of experimenter presence (vs. absence) on the facial expression of surprise, even though experimenter presence had the expected intensifying effect on smiling and laughter. However, this still leaves the possibility that the surprise display could be facilitated by the presence of *friends*. To test this hypothesis, and more generally to further explore the role of social context for expressions of surprise, three social context conditions were compared in the present study: an alone condition, a stranger condition, and a friend condition. One third of the participants were alone when they entered the new room; one third encountered a stranger sitting on the office chair in the room and facing them; and the final third met a friend they had brought to the laboratory. We speculated that the presence of a friend might facilitate the display of surprise relative to the alone condition, whereas the presence of a stranger might inhibit it. If so, social context could provide yet another (not necessarily exclusive) explanation for the low incidence of surprise expressions observed in the studies by Reisenzein and co-workers (Reisenzein, 2000; Reisenzein et al., 2006).

2.0 Method

2.1 Participants

The participants were 39 female and 21 male students with a mean age of 24.3 years (*SD* = 5.6). They were recruited at the public places of the University and were not paid for their participation. Participants were randomly assigned to one of three experimental conditions: the alone condition, the stranger condition, and the friend condition. There were 20 participants in the alone condition, 19 participants in the stranger condition and 21 in the friend condition. The participants in the friend condition were asked to come to the laboratory with a close friend of their choice to serve as a partner in the experiment.

2.2 Procedure

The participants were seated at a table in a dimly lit laboratory room. In the friend condition, the partner was asked to wait outside the room for an alleged later stage of the experiment. The experiment was introduced as a memory test. The participants were informed that they would be listening to a short story presented via headphones. To this end, they were instructed to start a recording on a CD player after the experimenter had left the room. After listening to the story, they were to contact the experimenter, who would wait outside of the room. The experimenter would then give them a short questionnaire assessing their recall of the story. The short story was “Vor dem Gesetz [Before the law]” from Franz Kafka’s “Meistererzählungen [Great stories]” and lasted 4.15 minutes.

While the participants were listening to the story through the soundproof headphones, the experimenter and an assistant set up a new room outside the lab room, using prefabricated

elements (walls, ceiling etc.). Thus, when the participants opened the door to contact the experimenter, they found themselves in this new room instead of the familiar corridor through which they had come to the laboratory. We did not include a no surprise control group because we were willing to grant to APT that unsurprised people would not show a facial expression of surprise. Note that this is a generous assumption for APT, because previous experiments actually found low percentages of facial surprise components in unsurprised controls (e.g., Reisenzein et al., 2006, Study 1).

2.3 The new room

The new room consisted of three walls, 2.20 m high and 1.40 m wide, painted in bold green, and a white ceiling. It was illuminated by a 60-Watts light bulb hanging from the ceiling. Towards the rear end of the room was a red office chair. Depending on experimental condition, either nobody (alone condition), a person unknown to the participant (stranger condition) or the participant's partner (friend condition) sat in the office chair, facing the participant, but without saying a word. The stranger (a confederate of the experimenter) and the friend had been informed that the aim of the experiment was to test people's reactions to a very unexpected, unusual situation, and were asked to maintain a solemn look for at least 10-15 seconds (the duration of the observation period) to guarantee a constant level of interpersonal interaction in the two social conditions.

Two posters on the rear wall helped camouflage the lens of a small spy camera affixed to the wall from the outside, that allowed to film the participants' facial expressions and body movements. Approximately one minute after they had opened the door, the participants were asked to return to the laboratory room by the experimenter, who had been waiting outside the

new room (invisible to the participants). There, the participants completed a short questionnaire concerning their thoughts and feelings when they entered the green room.

2.4 Material

In the questionnaire, the participants were first asked to state whether they had encountered anything unexpected when they left the laboratory room and if yes, what exactly had been unexpected. Next, they were asked to rate the intensity of their surprise about the unexpected event on a ten-point rating scale ranging from 1 (somewhat) to 10 (very strongly surprised). Third, the participants were asked whether they believed that their surprise had shown in their face and if yes, how it had shown (raising of the eyebrows, widening of the eyes, mouth opening, blinking). These questions were answered using a yes/no response format (see Reisenzein et al., 2006). Finally, the participants rated how startled, astonished, irritated and confused they were by the unexpected event on ten-point rating scales ranging from 1 (somewhat) to 10 (very strongly). Astonishment can be regarded as a prolonged form of surprise. Confusion is another frequently reported reaction to surprising events, especially if sense-making processes fail (e. g., Reisenzein et al., 2006; Schützwohl & Krefting, 2001). Startle and irritation may also occur in some surprising situations (Reisenzein et al., 2011).

2.5 Coding of facial expressions and eye movements

Following Reisenzein et al. (2006), a present/absent coding scheme with four categories was used to code facial expressions. Three categories referred to surprise displays. In accord with Darwin (1872/1988), a full facial display of surprise was defined to consist of three components: raising of the eyebrows (action units [AUs] AU1/AU2 of Ekman, Friesen, &

Hager's [2002] *Facial Action Coding System*), widening of the eyes (accomplished by raising of the upper eyelid; AU5), and jaw drop/opening of the mouth (AUs 25, 26). The remaining two facial expression categories comprised eyebrow knitting (AU4) and smiling (AU12), and were suggested by previous studies (Reisenzein, 2000; Reisenzein et al., 2006). In addition to facial expressions, verbal expressions of surprise (e. g., "Oh"), laughter, and speaking were coded as present or absent. Finally, eye movements were coded to test the hypothesis that an unexpected event exceeding the visual field elicits visual search. An eye movement was defined as a gaze shift to the left, right, up or down, or back to the initial gaze position.

Previous research (Reisenzein, 2000; Reisenzein et. al. 2006) found that facial expressions of surprise occur within 1-3 seconds after a surprising event, if they occur at all. This was also the case in the present study. Furthermore, beginning with second 5, many participants returned to the laboratory room. Therefore, evaluation of facial expressions was restricted to the first four seconds after the participant opened the door to the green room.

Using this coding system, the videotapes of the participants were coded by a student unaware of the nature of the study and the existence of the different experimental conditions (which could not be inferred from the video tapes because they only showed the participant, not the room). The coder had participated in a one-semester psychology course on the facial expression of emotions that included the teaching of basic FACS codes on the basis of descriptions of the coding categories, pictures and video clips of prototypical expressions, and she had extensive experience as a coder in previous facial expression studies. For the present study, the coder received additional instruction for the coding categories used. To estimate the reliability of the facial expression codings, which were of central interest, the second author recoded all videos (again blinded to the experimental conditions). The raw

proportion of agreement and the chance-corrected agreement (Cohen's [1960] Kappa) were used as agreement statistics. Interrater agreement for the different categories was .88 (Kappa = .63) for brow raising (AU1/2); 88 (.71) for eye widening (AU5); .75 (.52) for mouth opening; 83 (.67) for smiling (AU12) and .92 (.69) for brow knitting (AU4). According to guidelines proposed by Landis and Koch (1977), the chance-corrected agreements qualify as "substantial" for brow raising, eye widening, smiling and brow knitting, and as "moderate" for mouth opening; according to Fleiss (1981), all values are "fair to good". The results reported below are based on the codings of the first coder; however, to be on the safe side, the analyses were repeated using the codings of the second coder. With one small exception concerning smiling, reported below, the results of the two analyses were extremely similar.

3.0 Results

3.1 Subjective reactions to the unexpected event

All participants reported that the new room constituted an unexpected event for them. The results for the intensity ratings of the feelings elicited by the new room are shown in Figure 1 in the form of violin plots, which combine a box plot with a kernel density plot (essentially a smoothed histogram of the distribution) (Hintze & Nelson, 1998; Kastellec & Leoni, 2007). Violin plots are more informative than box plots because they show not only the central tendency and variability of a variable, but also contain detailed information about its distribution, including skewness and outliers. As can be seen from Figure 1, the participants reported high levels of surprise (overall M = 8.14 on the 1-10 scale; one participant failed to provide a surprise rating. Note that the white circles in Figure 1 represent medians, not means). Of the 59 participants with valid surprise ratings, all had ratings ≥ 3 on the 10-point

scale ranging from 1 to 10, 49 (83%) had surprise ratings > 7, and 30 (51%) even had ratings > 8. In addition to surprise, participants also reported high astonishment (M = 7.18), irritation (7.65) and confusion (6.48). In contrast, the mean startle ratings were much lower (4.25). Separate one-way analyses of variance (ANOVAs) comparing the ratings in the three experimental conditions revealed only one marginally significant effect of the experimental condition for the confusion ratings, $F_{2, 57} = 2.73$, $P = .074$; all remaining Fs < 1.44. Post-hoc multiple comparisons revealed that the participants were significantly more confused in the friend than in the stranger condition (7.62 vs. 5.79).

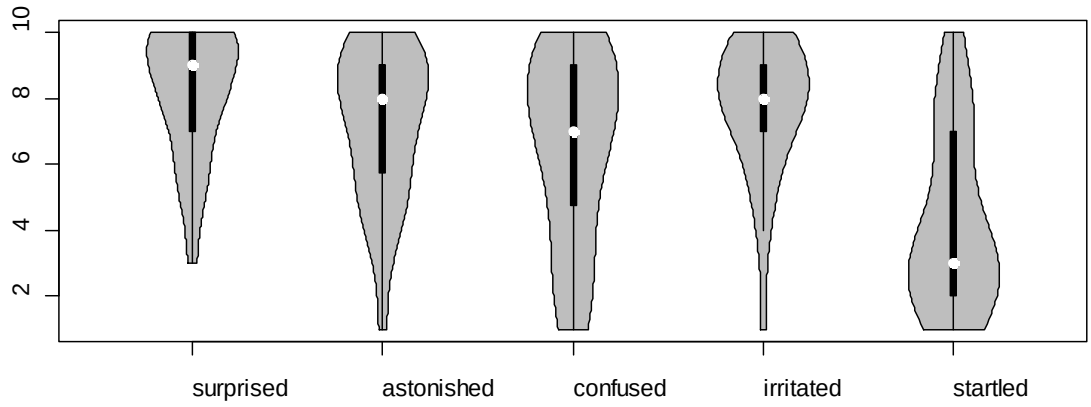

Figure 1. Violin plots of the feelings elicited by the new room. The median is shown as a white circle.

Taken together, the results obtained for the subjective ratings confirmed that, as intended, (a) the green room was an unexpected and highly surprising event for nearly all participants; and (b) there was no significant difference in the surprise experienced in the different sociality conditions. The latter finding is important because it means that potential differences in the frequency of facial expression between social conditions, should they be

found, cannot be attributed to differences in surprise intensity elicited by the different situations.

3.2 Beliefs about facial expressions of surprise

All but one of the participants (in the stranger condition) believed that their surprise had shown on the face. This result replicates findings of Reisenzein et al. (2006). Also replicating Reisenzein et al., the majority of the participants in all three experimental conditions believed that they had raised their eyebrows (68%) and widened their eyes (80%), and about half also believed that they had opened the mouth (45%). In addition, a minority (17%) believed they had blinked. Significant differences between experimental conditions were only found for blinking, χ^2 (2; N = 60) = 6.62, P = .037: More participants in the friend than in the stranger and alone conditions believed that they blinked (33% vs. 10% and 5%, respectively)—possibly because confusion is associated with blinking in common-sense psychology. All other comparisons failed to reach significance, all χ^2s < 2.

3.3 Eye movements

As predicted, the new room elicited much eye movement. The mean number of eye movements in the alone, stranger, and friend conditions during the coded 4 seconds were M = 5.50, 5.74, and 6.05. A one-way ANOVA failed to reveal a significant difference between the experimental groups, $F_{2, 57}$ = 0.40, ns.

3.4 Smiling and speaking

Confirming previous findings (see Fischer et al., 2003), social context had a significant effect on smiling, χ^2 (2; N = 60) = 8.12, P = .017. In agreement with our speculations concerning the effects of the friend versus stranger conditions on facial expression, the presence of a friend increased smiling (71%) compared to the alone condition (50% smiling), whereas the presence of a stranger decreased smiling (26%). However, it should be noted that for smiling, the codings of the second rater yielded a much less pronounced difference between the friend condition and the alone condition (76%, 70%, and 32% for the friend, alone and stranger condition), χ^2 (2; N = 60) = 14.77, P < .001).

The rather high percentage of smiling in the alone condition could be due to the presence of an implicit audience (Fridlund, 1991), as the participants expected to find the experimenter outside of the laboratory room. Unexpectedly, somewhat more participants in the alone condition (40%) showed signs of speech (including “Oh”) than in the stranger and friend condition (11% and 29%, respectively), but this difference was not significant, χ^2 (2; N = 60) = 4.38, P = .11.

3.5 Facial expressions of surprise

The observed percentages of raised eyebrows and widened eyes in the three groups are shown in Figure 2. They varied between 21% and 33%, with no significant differences between the groups, χ^2s < 1. Mouth opening that was not immediately followed by smiling, laughing or speaking was very rare, ranging from 0% in the alone condition to 16% in the stranger condition. Mouth opening *preceding* smiling and speaking was observed in 10%, 16% and 24% of the participants in the alone, stranger and friend condition, respectively. Finally, if

mouth openings involving the exclamation “Oh” are counted as facial surprise expressions (but not those that co-occurred with laughing or speaking), an open mouth was coded in 20%, 21% and 33% of the participants in the three conditions (see Figure 2). None of the between-groups comparisons concerning mouth opening were significant, χ^2s < 3.3.

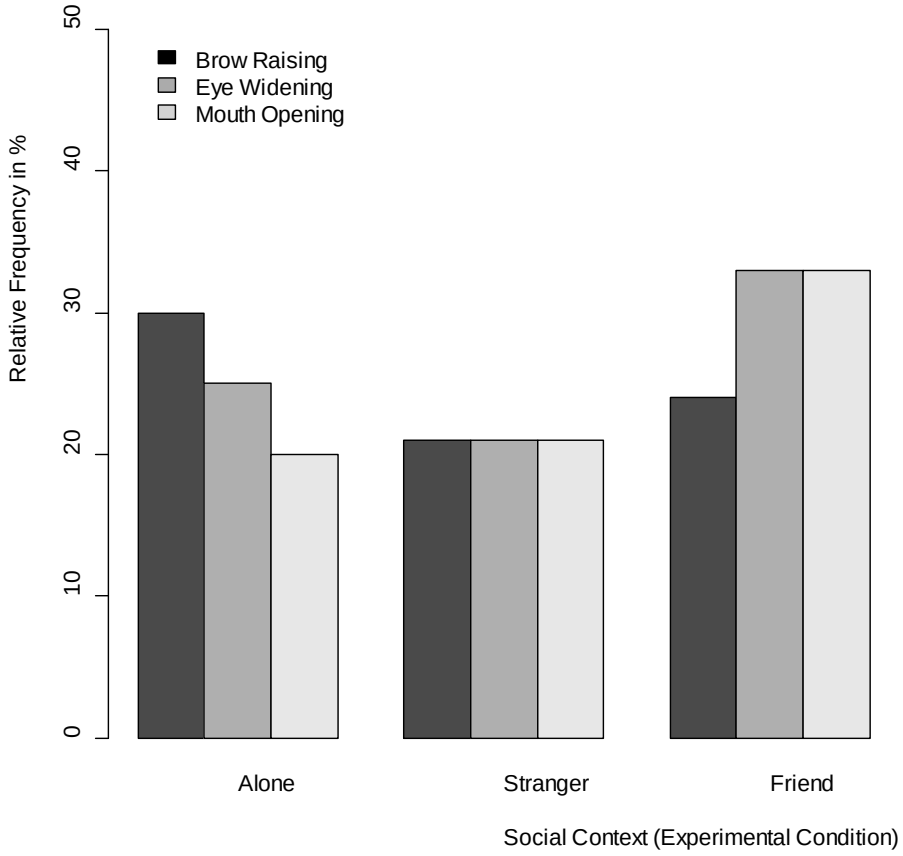

Figure 2. Frequency of facial expression components

Three participants showed the full-blown surprise expression consisting of raised eyebrows, widened eyes and an open mouth, one in the absence of laughing and speaking and two where laughing followed the full expression after two seconds. Additionally, one of them was in the stranger condition and two in the friend condition. Another 7 (12%) participants showed a two-component expression; hence 10 (17%) showed at least a two-component expression. A comparison between the surprise expressions of the 20 participants who

reported maximal surprise (10 on the rating scale) with the remaining participants, both across and within the experimental groups, revealed no significant differences, χ^2s < 2.55, *p*s > .11. Additionally, the point-biserial correlations between felt surprise intensity and facial surprise expressions were all low and nonsignificant, *r*'s < .18, *N* = 60. These findings further support the conclusion that the missing facial expressions of surprise were not due to insufficient surprise intensity.

Brow-knitting (AU4) in response to the surprising event occurred nearly as often as brow-raising: 15% in the alone, 20% in the stranger, and 24% in the friend condition, $\chi^2 < 1$. Given that brow-knitting was highest in the friend condition, which was also characterized by the highest mean level of confusion and irritation, it seemed possible that brow-knitting reflected confusion and irritation. However, the correlations between AU4 and ratings of confusion and irritation were negative rather than positive ($r = -.28$, $p < .05$; $r = -.29$, $p < .05$, and $r = -.36$, $p < .01$). We also explored the hypothesis that irritation and confusion might interfere with surprise, or its expression. Contrary to the interference hypothesis, confusion and irritation correlated positively with felt surprise ($r = .43$, $p < .001$, and $r = .22$, *ns*), and were not significantly correlated with the surprise display.

4.0 Discussion

According to our refined Darwinian account of the facial expression of surprise, the function of eye widening and eyebrow raising is to increase the visual field and to facilitate visual search if a surprising event or object exceeds the field of vision. The green room met these requirements: It constituted a highly surprising object that engulfed the participants' field of vision, thus demanding an increase of the field of vision, and it elicited visual search,

as documented by the many eye movements of the participants. Hence, if the proposed functional account of the surprise expression is correct, the green room should have caused eye-widening and eyebrow-raising. In addition, if one accepts Darwin's reasoning that the facial expression must be "coordinated", the green room should also have caused mouth opening, resulting in a full-blown facial expression of surprise.

These predictions were not borne out. Rather, replicating the findings of previous studies using different surprising events (e. g., Reisenzein, 2000; Reisenzein et al., 2006), the individual components of the surprise expression were only shown by a minority of the participants. Furthermore, confirming previous findings which suggest that the full-blown, three-component expression of surprise is not the modal facial reaction to surprising stimuli, but a rarely occurring "ideal type" (Horstmann, 2002), only 3 of the 60 participants (5%) showed the three-component display; and only 17% showed a two-component display, in all cases consisting of brow raising and eye-widening. Instead, about 20% showed brow knitting as a response to the surprising event. Finally, again replicating previous findings (Reisenzein et al., 2006), the participants in all conditions grossly overestimated their surprise expressivity. Reisenzein and Studtmann (2007) provided experimental and correlational evidence that the overestimation of surprise expressions is due to the fact that participants, rather than reporting remembered expressions, inferred their likely facial expressions to the surprising event from the subjective experience cause by the event, and folk-psychological beliefs about emotion-face associations. That is, the participants apparently reasoned that, since they felt surprised, and since surprise is associated with a characteristic facial display, they must have shown this display. In most cases, this inference was erroneous.

Taken together, then, our findings do not support the refined Darwinian account of the facial expression of surprise described in the introduction. Nor do our findings support the second hypothesis about the conditions of surprise tested in our study, that the surprise expression requires the presence of friends to be shown. Note that the manipulation of social context *did* have the expected effects on smiling (a reduction of smiling in the stranger condition, and an increase or at least a tendency toward an increase in the friend condition), attesting to the potency of the social context manipulation. Nonetheless, social context did not influence the expression of surprise. This finding confirms the results of the few previous studies (Reisenzein, 2000; Reisenzein et al., 2006) that tested the effects of social context on the expression of surprise. Taken together, the available data suggest that the expression of surprise differs from smiling in being insensitive to social influence. At the same time, the lack of difference between the experimental conditions in the frequency of the surprise expression supports the conclusions drawn from previous studies (Reisenzein et al., 2006), that the low incidence of surprise expressions in surprised people is not due to the deliberate inhibition of the expression in an attempt to conform to display roles (see Ekman, 1997). For in this case, one should have seen more surprise expressions in the alone condition than in the social conditions, or at least in the stranger condition.

Thus, our findings mean that two more candidates for factor X—the factor that is necessary, in addition to surprise and the absence of control, for a surprise expression to occur—have been ruled out, or at least rendered unlikely: Most surprised people do not show a surprise display even when the surprising event exceeds the visual field and when friends are present. Several other candidates for factor X have already been tested, and ruled out, in the studies by Reisenzein et al. (2006), including the duration/complexity of the surprising event and the intensity of the surprise elicited by the unexpected event. The present study

once again confirmed that insufficient intensity is unlikely to be responsible for the low incidence of surprise expressions: The average intensity of reported surprise was extremely high, and there was no significant correlation between surprise intensity and the occurrence of the facial expression components. Furthermore, as in the studies by Reisenzein et al. (2006), the surprising event was not only unexpected but also novel to the participants (see Scherer, Zentner, & Stern, 2004).

This does not mean, of course, that all possible candidates for factor X have been ruled out. For example, it is still possible that the surprise expression is reliably elicited by an unexpected event that not only exceeds the visual field, but does so by approaching rapidly towards the person. Likewise, it is possible that the surprise expression is shown if a larger audience is present (in all studies conducted so far, only one other person was present). And it is possible that yet other factors, such as the goal relevance of the surprising event influences the display of surprise—although finding oneself unexpectedly in a new, strange room should surely be of potential relevance to one's well-being (see also Reisenzein, et al., 2006). Finally, in view of the observed dissociation not only between the feeling and the expression of surprise, but also between the different components of the surprise expression (see also, Reisenzein et al. 2000, 2006), future studies should test in more depth the hypothesis hat the different components of the surprise expression are in part controlled by different mental states (e. g., Scherer et al., 2004). In particular, it seems conceivable that the mouth-opening observed in some cases of surprise is actually a side-effect of the interruption of ongoing mental processes characteristic for this emotion (see Reisenzein et al., 2011). Specifically, mouth opening might occur when people who are preparing to speak and open their mouth for this purpose, are suddenly hit by surprise. An experimental investigation of this hypothesis seems feasible.

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