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Facial expressions, smile types, and self-report during humour, tickle, and pain

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The nature of ticklish smiling and the possible emotional state that accompanies it have been pondered since the ancient Greeks. The present study is arguably the first to systematically examine facial behaviour and self-reports of emotion in response to tickling. Using a within-participants design, 84 participants' responses to being tickled were compared to their responses when experiencing a painful stimulus and their responses to comedy. Overall results for both self-report and facial action coding showed that the tickle condition elicited both pleasure and displeasure. Facial action during tickling included ''Duchenne'' smiles plus movements associated with negative emotions. Results suggest that tickle-induced smiling can be dissociated from positive affect. Accounts of tickle are discussed.

Tickling and the smiling it induces, at first blush, seem like child's play. However, tickle, along with crying and startle responses, falls into the category of poorly understood affect-related phenomena. One intriguing aspect of tickle is that a physical stimulus can elicit a response that appears to closely resemble that of humour.[1] The apparent similarity of the smiling and laughter induced by tickle and by humour has led many writers to hypothesise that the two expressions reflect the same internal emotional state. One champion of this view was Charles Darwin (1872/1965), who claimed that in order for laughter to be elicited in either case, there must be an element of surprise, a pleasant hedonic state, and the elicitor must be either a light touch or light topic. In essence, he argued, tickle is a physical joke.

[1] The term ''tickle'' appears to refer to two distinct phenomena (Hall & Allin, 1897): knismesis, a ''moving itch'' which can be readily elicited in the self (e.g., Ruggieri, Milizia, Sabatini, & Tosi, 1983); and gargalesis, the laughter-inducing tickle that cannot be elicited in oneself. This paper focuses exclusively on the latter form.

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Much contemporary writing on the topic echoes Darwin in assuming that ticklish laughter and smiling result from a positive affective state (e.g., Panksepp, 2000; Weisfeld, 1993). This view of tickle is consistent with one approach to emotion, which holds that nonverbal displays are veridical readouts of affective states. Research employing the Facial Action Coding System (FACS; Ekman & Friesen, 1978), which catalogues distinct combinations of observable muscle movements into 44 numbered appearance changes called ''action units'' (AUs), suggests that the facial expression that accompanies amusement or pleasure is composed of both the smile (upturned lips produced by activation of the zygomatic major) and a crinkling of the eyes, referred to as the ''Duchenne'' smile. These smiles tend to be symmetrical, have a smooth onset, and usually last between 0.5 and 4 seconds whereas non-Duchenne smiles are either faster or slower (Ekman, Davidson, & Friesen, 1990; Frank, Ekman, & Friesen, 1993). Symmetrical Duchenne smiles also accompany humourous laughter; with funnier jokes, this display can last longer than 4 s (Ruch, 1990; cited in Ruch, 1994). Particularly high correlations between funniness ratings and AU12 (lips upturned) as well as AU6 and AU7 (both tighten the eye region) have been found by taking into account variability across stimuli and participants (Ruch, 1995).

The hypothesis that tickle responses reflect amusement has been based primarily on the assumption that the smiling that occurs during tickling is indeed the same as that which occurs during humour. However, no study has closely analysed tickle-induced smiling to determine whether it differs from that of humour. This is important given that smiling also occurs during some other emotions. Detailed analysis of nonverbal displays appears to be one avenue to help disambiguate smiling and felt emotion. For example, while smiling occurs during both humour and embarrassment, the latter state includes several other behaviours such as ''smile controls'' (muscular movements that either obscure a potential smile or counter the upward pull of the zygomatic major), frequent gaze shifts to the left, looking down, and touching the face (Harris, 2001; Keltner, 1995). No such work exists comparing tickle to humour. Hence, the facial expressions involved in tickle-induced laughter and smiling remains an open question, along with the underlying state.

According to Francis Bacon (1677), ''men even in a grieved state of mind, yet cannot sometimes forbear laughing'' when tickled (p. 151). Thus, one alternative hypothesis is that ticklish smiling has little to do with positive emotion but rather is some type of complex reflex, fixed action pattern, species-typical stereotyped motor pattern (Black, 1984; Harris, 1999; Provine, 2000; Stearns, 1972) or other yet unspecified class of behaviour. Recent findings provide some support for the hypothesis that tickle-induced smiling and laughter need not reflect a positive hedonic state. First, exposure to humorous stimuli enhanced subsequent responses to humor but did not alter tickle responses (Deckers, Buttram, & Winsted, 1989; Harris & Christenfeld, 1997). Second,

tickle-induced smiling emerges in infants even when it has not been paired with playful interactions (Leuba, 1941) and can be elicited in noninterpersonal situations (i.e., when subjects are tickled by what they believe to be a machine, Harris & Christenfeld, 1999). Finally, tickling can serve as an unconditioned stimulus to elicit laughter in Pavlovian conditioning (Newman, O'Grady, Ryan, & Hemmes, 1993; see also Hoshikawa, 1991).

Finally, it is also possible that tickle elicits negative affect as well as smiling. Socrates proposed that tickling elicited pleasure but also, to a greater degree, pain (cited by Gregory, 1924). Bacon (1677) suggested that it was painful and ''not well endured'' (p.161). Others have proposed that the most ticklish areas are those that are most vulnerable in hand-to-hand combat, and therefore argue that tickling confers an adaptive advantage by motivating one to protect these areas, presumably by eliciting a disagreeable sensation (Gregory, 1924; Hall & Allin, 1897). Harris (1999) suggested that tickle may elicit discomfort in the one being tickled in order to motivate the developing primate to avoid the tickling and may, at the same time, elicit smiling to encourage the tickler to continue (thereby promoting rough-and-tumble play). Thus, tickle might elicit displays that include negative elements along with smiling. However, no research has examined whether facial displays during tickling contain movements that are associated with negative affect or pain. The pain literature suggests that four facial actions are generally associated with pain: (1) levator contraction (AU9/10); (2) orbit tightening (AU6/7); (3) brow lowering (AU4); and (4) to a lesser extent eye closure (AU43). However, work to date has not examined whether these actions co-occur (Prkachin, 1992). Thus, while each of these muscle movements can be associated with pain, it is unclear whether they form a distinct pain expression. In the case of tickling, finding evidence of these AUs would help support the hypothesis that tickling elicits some discomfort.

In sum, no work has tested for negative aspects of tickle or tried to determine what internal states drive ticklish laughter and smiling. Therefore, the previously presented hypotheses regarding tickling, for the most part, remain untested.

Present research

The aim of this investigation was to gather behavioural and self-report data that bear on the hypotheses described above. This work provided the first micro-analysis of the facial movements that occur during tickling and is the first to examine the emotional states reported during the experience of being tickled. A within-participants design was used to examine behaviour and self-reported emotional responses of 84 participants across three conditions: (1) being tickled for 10 seconds; (2) listening to a series of recorded comedy routines; and (3) immersing one hand in a bucket of circulating cold water for as long as tolerable. We included painful and humourous stimuli to examine whether tickle responses most resemble amusement or contain painful or unpleasant aspects.

METHOD

Participants

A total of 84 healthy University of California, San Diego students (61 females), who had not recently taken analgesic medications, participated to fulfil a class requirement. Mean age was 20.3 (*SD* = 1.8) years. Based on self-descriptions, the ethnicity of the sample was 43% Asian, 40.5% Caucasian, 6% Hispanic, 1% African American, and 9.5% other.

Procedures

Participants were tested individually. The experimenter did not know any of the participants. After informed-consent documents that included permission for videotaping were signed, participants were told: ''As described in your consent form, we are interested in your reactions to a variety of stimuli, which will include listening to an audiotape, being tickled, and putting your hand in cold water. The cold water will probably elicit some discomfort or pain. If it becomes too unpleasant, just let the experimenter know and she will stop the task. Throughout the experiment, please behave and respond as naturally as you can''. Condition order (i.e., tickle, humour, pain) was counterbalanced across participants. After each condition, the participant filled out an emotion inventory. Facial behaviour was recorded by a videocamera placed in front of the participants. Only the lens of the camera was exposed; the rest of the camera was hidden behind a large board, which contained colourful pictures.

Tickle condition. The experimenter gave the following instructions: ''I'm going to stand behind you and tickle you on your sides, anywhere from your armpits to your waist. I'll tickle you until my timer goes off. If the tickling sensation becomes too intense, just say stop. Please try to behave as naturally as you can''. The experimenter and participant could not see each other's faces and the participant did not know the exact moment the tickling would begin. Tickling was continuously administered for 10 seconds. No participant asked to stop.

Comedy condition. Participants listened to an audiotape of a series of 12 jokes by various comedians (e.g., Seinfeld, Cosby). The first two jokes were used as practice stimuli.

Pain condition. The participant's left hand was immersed in a bucket of circulating cold water (1–5 C°). Participants were instructed to press a button when they first started to feel pain and then to press it again when they could no longer tolerate the pain, at which point they withdrew their hand from the water. One participant continued for 3 min at which time the experimenter terminated the task.

Dependent measures

Facial action coding. Participants' facial movements were coded using FACS (Ekman & Friesen, 1978). Although all 44 action units were coded, we limited our analyses to the 12 specific ''action units'' (AUs) that have previously been associated in the literature with humour, pain, and selected negative emotions (e.g., anger, embarrassment). Additional AUs, including head and eye movements, blinks, and certain smile controls, such as AU 29 (jaw thrust), AU 34 (cheek puff), and AU 32 (lip bite) either showed no significant differences across conditions or were too rare to be useful to our analyses.

Types of smiles were divided into four categories defined empirically by the presence of specific AUs. A non-Duchenne smile consisted of pulling the lip corners back (AU12) without any other AU activity. The Duchenne smile was defined by the actions of AU6 + AU12 (cheek raise added). A controlled smile was defined empirically as AU12 together with another lower facial movement whose action physically functioned to counteract or obscure the smile (i.e. turning the lips down (AU15) or pressing the lips together (AU24), both of which appeared with highest frequency in Keltner's (1995) catalogue of smile controls). Finally, a mixed smile was defined as an AU12 occurring in the presence of AUs that are commonly associated with negative affective states (e.g., AU10, AU1+4, or AU20).[2] Following FACS standards, AUs were coded as co-occurring when additional AUs appeared at or before the apex of the first AU.

Given the inherent temporal differences in the nature of the stimuli that give rise to pain, humour, and tickle, it was not possible to make the three manipulations completely comparable. However, the amount of time during which behaviour was coded across conditions was equated as follows: the 10 s of tickling; the 10 s immediately before removing the hand from cold water; and 1 s following each of the identified punchlines of the 10 jokes (totalling 10 s). To further adjust for differences across the conditions, we computed and analysed the proportion of AUs across events rather than their absolute frequencies. An event is defined as a set of AUs overlapping in time and forming a configuration held on the face together before fading (Ekman, 1997).

Self-report ratings. After experiencing each condition, participants described their subjective states using a series of rating scales labeled with the names of emotions and feelings. They used a scale of 0 (not at all) to 7

[2] We avoid the term ''masking'' smile because it assumes the intention to hide emotion, to ''mask'' negative affect by smiling. The additional AUs beyond AU12 are then considered ''leakage'' of some intentionally concealed negative emotional state. ''Mixed'' smile seems a more appropriate term because it is based simply on empirical observation without requiring assumptions about the participant's intentions.

(extremely) to rate how much they had felt anxious, happy, angry, embarrassed, and amused and to rate how much they found the experience unpleasant and painful. In the tickle condition, participants also rated how ticklish and unpleasant they found the sensation of being tickled. At the end of the experiment, participants were asked, ''Do you enjoy being tickled?''

RESULTS

There were no sex differences on any of the measures except that men had higher amusement ratings and lower pain ratings. Women rated the tickle as more ticklish and unpleasant. Laughter (including both voiced and unvoiced exhalations) was coded in the tickle condition as a manipulation check: 70% of the males and 75% of the females laughed, providing corroborative evidence that our tickle manipulation was successful.

Analysis of self-report ratings

Self-reported ratings of the emotional state elicited during tickling (see Figure 1) appear to generally support Socrates' suggestion that tickle is capable of eliciting both positive and negative affect. Paired two-tailed *t*-tests of each rated emotion were used to compare ratings during tickle to those during pain and

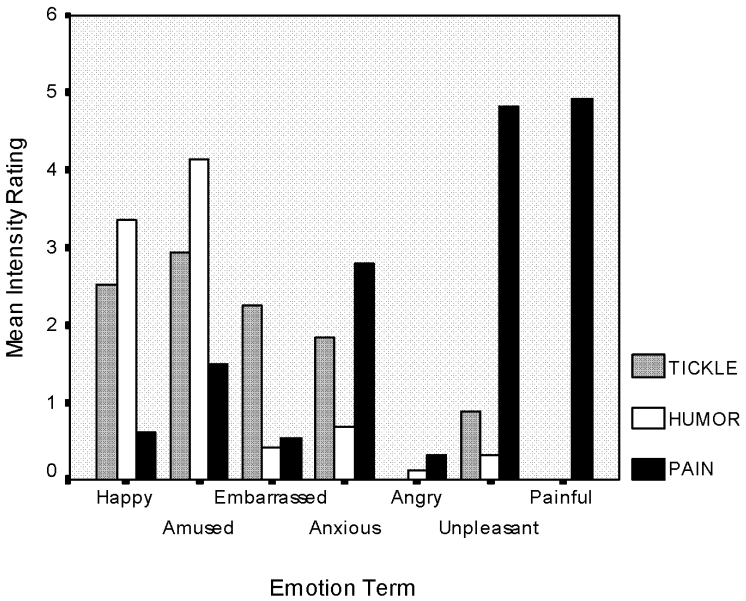

Figure 1. Self-report ratings of emotion.

humour. ''Happy'' and ''amused'' ratings for the tickle condition were significantly higher than those reported in the pain condition: $t(83) = 9.70$, $p < .001$; $t(83) = 5.57$, $p < .001$, respectively, and significantly lower than those reported in the humour condition: $t(83) = 3.87$, $p < .001$; $t(83) = 5.11$, $p < .001$, respectively. ''Anxious'' and ''unpleasant'' ratings for the tickle condition also fell between the pain and humour conditions; tickle elicited significantly higher ratings than humour stimuli: $t(83) = 5.67$, $p < .001$; $t(83) = 4.03$, $p < .001$, respectively, and significantly lower ratings than the pain stimulus: $t(83) = 3.49$, $p < .002$; $t(83) = 19.52$, $p < .001$, respectively. However, participants described tickle as more ''unpleasant'' rather than as ''painful''. The tickle condition elicited virtually no self-reported anger but did elicit significantly more embarrassment than the pain, $t(83) = 8.07$, $p < .001$, or humour, $t(83) = 8.29$, $p < .001$, conditions. In short, relative to the humour and pain conditions, tickle elicited intermediate levels of self-reported positive and negative affect across individuals.

Analysis of facial behaviour

Two analyses of facial behaviour were performed. First, relative frequency of occurrence of individual AUs per event was analysed across conditions. [Total number of events varied by condition: Pain = 443; Tickle = 513; Humour = 1089; $\chi^2(2, N = 2045) = 368.7$, $p = .001$.] Second, smiles were classified by smile type and these types were compared across the three conditions.

Individual AUs. Table 1 displays the mean frequency of occurrence of relevant AUs per event. Several AUs were more common during both tickle and pain compared to humour. These included the following: wrinkling the nose: (AU9), $t(1600) = 4.72$, $p < .001$ for tickle vs. humour; $t(1530) = 2.91$, $p < .005$ for pain vs. humour; raising the upper lip: (AU10), $t(1600) = 2.25$, $p < .03$ for tickle vs. humour; $t(1530) = 3.33$, $p < .002$ for pain vs. humour; lip press: (AU24), $t(1600) = 3.56$, $p < .001$ for tickle vs. humour; $t(1530) = 2.30$, $p < .03$ for pain vs. humour; tightening the eyelids: (AU7), $t(1600) = 5.38$, $p < .001$ for tickle vs. humour; $t(1530) = 5.63$, $p < .001$ for pain vs. humour; and the lower lip stretch: (AU20), which gives the appearance of a grimace, $t(1600) = 6.22$, $p < .001$ for tickle vs. humour; $t(1530) = 6.67$, $p < .001$ for pain vs. humour.

Tickle shared movements not only with pain but also with humour. Relative to pain, lips parting/jaw dropping (AU 25/26) was more frequent in tickle, $t(954) = 6.27$, $p < .001$, and humour, $t(1530) = 6.79$, $p < .001$. The two AUs that comprise the Duchenne smile accounted for more of the movements in the humour and tickle conditions than in the pain condition: (AU6), $t(954) = 10.90$, $p < .001$ for tickle vs. pain and $t(1530) = 12.48$, $p < .001$ for humour vs. pain; (AU12), $t(954) = 16.91$, $p < .001$ for tickle vs. pain, and $t(1530) = 16.81$, $p < .001$ for humour vs. pain.

TABLE 1
Mean occurrence of AUs per event across conditions

	*Condition**		
Action	*Tickle*	*Humour*	*Pain*
AU1: Inner brow raise	.06[a]	.06[a]	.11[b]
AU4: Brow lower	.05[a]	.04[a]	.09[b]
AU6: Cheek raise	.24[a]	.28[a]	.01[b]
AU7: Lids tight	.08[a]	.02[b]	.08[a]
AU9: Nose wrinkle	.05[a]	.01[b]	.03[a]
AU10: Upper lip raise	.08[a]	.05[b]	.10[a]
AU12: Lip corner pull	.61[a]	.57[a]	.14[b]
AU15: Lip corner depress	.16[a]	.10[b]	.07[b]
AU20: Lip stretch	.05[a]	.01[b]	.06[a]
AU24: Lip press	.11[a]	.06[b]	.09[a]
AU25/26: Lips part, Jaw drop	.38[a]	.37[a]	.20[b]
AU43: Eyes closed	.10[a]	.05[b]	.07[ab]

* Values with a different superscript (a or b) significantly differ from each other ($p < .05$), two-tailed *t*-test.

The two AUs that typically characterise distress accounted for a significantly greater number of the AUs in the pain condition than in the other two conditions: AU1 (inner brow raise), $t(954) = 2.91$, $p < .005$ for pain vs. tickle and $t(1530) = 2.75$, $p < .007$ for pain vs. humour; AU4 (lowered brow), $t(954) = 2.79$, $p < .006$ for pain vs. tickle and $t(1530) = 4.51$, $p < .001$ for pain vs. humour.

Smile types. To determine whether tickle-induced smiling qualitatively differed from humor-induced smiling, we examined the degree to which different AUs co-occurred with smiling (AU12) across conditions. As shown in Figure 2, the pattern of smile types varies across conditions. The proportion of Duchenne smiles relative to other smile types was significantly different across conditions: $\chi^2(2, N = 1001) = 56.84$, $p < .001$. Duchenne smiles never occurred in the pain condition while comprising 40% of the smiles that occurred during humour and 24% of the smiles that occurred during tickle. Frequency of Duchenne smiling was correlated in the humour and tickle conditions (Spearman $r = .40$, $p = .001$. The range of Duchenne smiles was 0–7 per person during tickle and 0–11 per person during humour.) Proportion of mixed smiles differed significantly across the three conditions $\chi^2(2, N = 1001) = 81.35$, $p < .001$, being the most frequent smile type during pain (51%), relatively common during tickle (24%), but relatively infrequent during humour (10%). Frequency of mixed smiles in the humour and tickle conditions were correlated (Spearman $r = .24$, $p = .03$), but neither were correlated with mixed smiles in the pain condition. (The

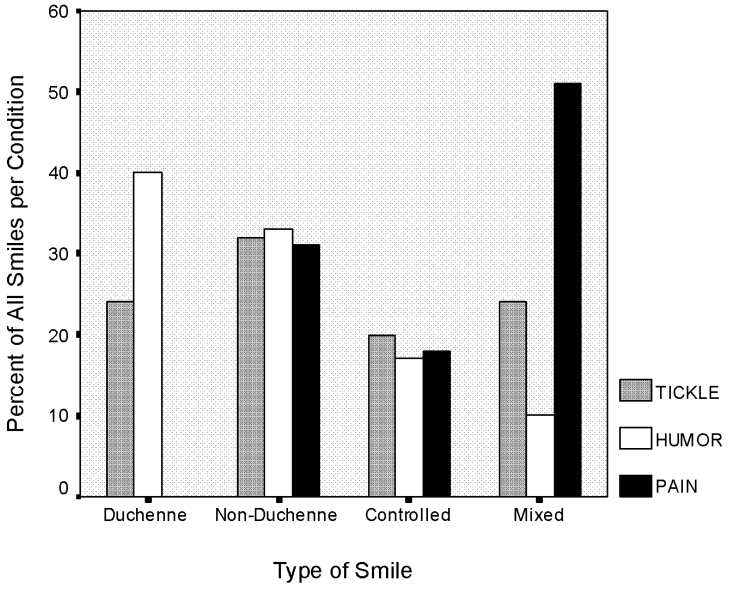

Figure 2. Percentage of smile types (relative to all smiles) in each condition.

range of mixed smiles per person was 0–7 during tickle and during humour and 0–3 during pain.) The proportion of non-Duchenne and controlled smiles did not significantly differ across the three conditions, $\chi^2(2, N = 1001) = 0.11$ and $\chi^2(2) = 1.54$, respectively.

Given that Duchenne smiles and mixed smiles were the smile types that showed a different pattern across conditions, the next analyses focused on the relationship of these two smiles to self-report of emotion, using Spearman correlations. In the tickle condition, Duchenne smiles were correlated with happiness ($r = .30$, $p = .006$) and amusement ($r = .22$, $p = .04$) and with finding the tickle sensation ticklish ($r = .34$, $p = .002$) and unpleasant ($r = .24$, $p = .03$). Amusement and unpleasantness ratings were not correlated ($r = -.10$), suggesting that during tickling, Duchenne smiles were associated with positive internal states for some participants and negative internal states for others. This conclusion was also supported by Schimmack's (2001) minimum intensity test (min. value = .67). Similar results were obtained for happiness and unpleasantness ratings ($r = -.10$; min. value = .61). Mixed smiles were correlated only with happiness ratings ($r = .23$, $p = .04$).

In the humour condition, Duchenne smiles correlated with happiness ($r = .19$, $p = .08$) and amusement ratings ($r = .28$, $p = .01$) as did mixed smiles ($r = .34$, $p = .002$ for happiness; $r = .19$, $p = .09$ for amusement). In the pain condition,

there were no Duchenne smiles and mixed smiles were not significantly correlated with any of the emotion rating scales.

Open-ended responses to ''Do you enjoy being tickled?'' were categorised as yes (32%), mixed/neutral (32%), or no (36%). The three groups did not differ in number of Duchenne and mixed smiles. If anything people who reported that they disliked tickle produced slightly more Duchenne smiles ($M = 1.21$) than those who reported liking it ($M = 0.89$).

Embarrassment. Our last analyses tested for embarrassment displays. As reported earlier (see Table 1), the lip press (AU 24) was more common during tickle. However, other AUs associated with embarrassment were more frequent during humour than during tickle. To facilitate comparison with earlier work, these data are presented as the percentage of people displaying each relevant AU. During humour, as opposed to tickle, more people gazed down (57% vs. 23%), shifted their eyes to the left (64% vs. 37%), and moved their heads (83% vs. 60%).

DISCUSSION

This work was the first to provide a detailed analysis of the facial and affective reactions to tickle and to compare these to those of humour and pain. Several findings bear on the hypotheses presented in the introduction.

At first blush, the hypothesis that tickle elicits positive affect (either humour or joy), which then gives rise to smiling would seem supported by the current finding that tickling can clearly elicit Duchenne smiles, which have been associated with positive hedonic states in other work (Frank et al., 1993). However, several of our findings weigh against this interpretation. First, the relative proportion of Duchenne and mixed smiles changed across conditions, suggesting that there are some differences between tickle-induced smiling and humour-induced smiling. Second, Duchenne smiles were correlated with finding the tickle sensation unpleasant as well as with positive affect ratings. Yet, unpleasantness ratings were not correlated with positive affect. In other words, some people showed Duchenne smiles even though they did not report feeling happy or amused. This suggests that during tickling, such smiles can be dissociated from positive affect. Finally, people who reported that they generally enjoyed being tickled did not show more Duchenne smiles than people who reported that they generally did not like being tickled. If anything, this latter group produced slightly more Duchenne smiles. The dissociation between smiling and self-reported pleasure during tickle provides some support for the hypothesis that, in tickle, Duchenne smiles can arise as automatic responses to a physical stimulus that need not be mediated by positive affect. However, given that some of these data are correlational and that, as in almost all facial

expression research, self-reports and behaviour were not time-locked, such conclusions are offered only tentatively.

The current work also showed that tickle and pain share some important facial movements, thus providing behavioural support for the hypothesis that tickling can elicit some negative affect or discomfort. These movements include wrinkling the nose (AU9) and raising the upper lip (AU10), both of which are associated with the expression of disgust (Rozin, Lowery, & Ebert, 1994) as well as tightening the region around the eye (AU7). These same AUs have also been found in previous work on pain (Prkachin, 1992). However, this earlier work did not separate AU6 and AU7 since both tighten the eye region. The present study found that AU6 was more frequent during tickle and humour, while AU7 was more characteristic of tickle and pain. The lip stretch or grimace (AU20) was a more typical movement during tickle and pain, as was the lip press (AU24). Hence, tickling appears to elicit several facial displays similar to those elicited by pain.

Mixed smiles, defined as smiling in the presence of AUs associated with negative affect, were as common as Duchenne smiles in the tickle condition but were relatively infrequent in the humour condition (accounting for less than 10% of the smiles). When smiling did occur in the pain condition, it usually took the form of a mixed smile. Mixed smiles are open to a variety of interpretations. One is that across all conditions in this study, they served as masking smiles (attempts to conceal negative emotion). Naturally, such assumptions about participants' motivations are difficult to directly assess. Nonetheless, this hypothesis would be consistent with such smiles being proportionally most prominent during pain, present but less prominent in tickle, and rare during humour. The case for viewing mixed smiles as masking smiles seems best supported in the pain condition because here the mixed smiles were not correlated with any self-report measures of emotion but were associated with an individual's coping style (Alvarado & Harris, 2005; Harris & Alvarado, 2002).

Some other findings, however, might suggest that mixed smiles reflect different motivational/emotional states in the three conditions. During the humour condition, mixed smiles were positively correlated with happiness and amusement. Rather than serving to intentionally mask negative affect, such smiles may reflect positive affect accompanied by a negative judgement about the questionable taste of a particular joke (e.g., a somewhat off-colour joke elicited the strongest disgust expressions of any joke, along with smiles and substantial ratings of funniness). In the case of tickling, a mixed smile might be produced to mask negative affect, as in pain, or it might reflect unintentional smiling combined with discomfort. While it is also possible that these smiles reflect positive affect combined with discomfort, one finding weighing against this is that mixed smiles were not more readily produced by those who liked tickling than those who did not.

Another interesting feature of the data involved high reports of embarrassment during the tickling condition. Despite these reports, participants' facial displays differed in several respects from those found in previous work on embarrassment (Harris, 2001; Keltner, 1995). For example, several features of embarrassment (gazing down and to the left, moving the head) were more common during humour than during tickle. One possibility is that since people make these self-reports after the tickling, their reports incorporate judgements of the situation as embarrassing in addition to reflecting how much embarrassment they actually experienced. Future work that incorporates a separate embarrassment manipulation as well as a tickle manipulation could provide further useful data.

The current data seem most consistent with the hypothesis that the smiling associated with tickling does not depend on a positive hedonic state. According to this view, the negative AUs found during mixed smiles reflect the discomfort elicited during tickling just as they do during pain.[3] However, the smile (AU12), whether embedded in a Duchenne smile or in a mixed smile, is an automatic behaviour that is not necessarily reflective of a positive emotional reaction. (Again, these interpretations are offered tentatively given the limited number of tickle studies and the correlational nature of some of the data.)

CONCLUSIONS

While these data generally support the hypothesis that smiles elicited by tickle are not necessarily dependent on a positive hedonic state, the exact process or state that underlies the tickle phenomenon remains an open question. One possible interpretation is that tickle is a type of complex reflex or fixed action pattern (Harris, 1999). Interestingly, tickle shares features with another phylogenetically old reflex, startle. One can no more tickle oneself than startle oneself (at least, without the use of some external aid, such as a gun). Another similarity is that startle and tickle both appear to elicit facial expressions that resemble the types of expressions elicited during emotional states. However, just as Ekman, Friesen, and Simons (1985) have proposed that the startle expression is not the result of an emotional state, we suggest that ticklish smiling can arise without any positive emotional state being present. This need not imply the tickle response is unmodifiable. Even the startle response can be inhibited by a faint warning signal (Dawson, Schell, Swerdlow, & Filion, 1997) and potentiated by negative emotion (Bradley, Lang, & Cuthbert, 1993). Furthermore, ''fixed

[3] In the tickle and pain conditions, the correlations of self-report ratings with negative AUs were complex. Due to space limitations, these data are not presented here. Other researchers have noted a lack of correlation between self-report and specific pain AUs and have suggested that different measures may assess different aspects of pain (Craig, Hyde, & Patrick, 1991; Patrick, Craig, & Prkachin, 1986).

action patterns'' also permit substantial behavioural variability (Shepherd, 1994).

One might wonder why such a reflex or fixed action pattern would exist, a question that seems more straightforward for startle, with its orienting and defensive functions. The notion that it evolved to promote caregiver and infant bonding is intriguing (Alexander, 1986; Fridlund & Loftis, 1990), but does not explain why tickle also elicits a sensation that many find aversive. Similarly, the hypothesis that tickle evolved to promote protection of vulnerable body areas can explain the pulling away and fending off movements frequently encountered during tickling, but does not address why tickling elicits a facial expression that is usually associated with positive affect. To reconcile these facts, as mentioned in the introduction, Harris (1999) suggested that tickle may elicit smiling to encourage conspecifics to perform the tickling and may elicit discomfort in the one being tickled in order to motivate the developing primate to avoid the tickling (possibly conferring some adaptive advantage). Naturally, testing such hypotheses regarding ultimate mechanisms is notoriously difficult. However, what does seem to be emerging from current research is a recognition that tickle is not merely a special case of amusement.

LIMITATIONS

It is possible that our findings regarding the negative aspects of tickle may be limited to adults being tickled by strangers. Future work with children and friends could test the possibility that under other circumstances, negative affect or physical discomfort is not elicited. However, one reason to predict that our findings might generalise to these other contexts is that casual observations suggest that, even among children, tickling is associated with withdrawal and defensive movements. Furthermore, childhood is when most first experience the displeasure of ''tickle-torture'' in which several friends or siblings hold down and tickle one child. Although it has been proposed that tickle-induced laughter and smiling arises from positive affect in children (Panksepp, 2000), this assumption remains empirically untested.

Given the paucity of research on this topic, many interesting issues remain unexplored. While sex differences are sometimes found on self-reports such that males report more pleasant affect to tickle (in this work and Provine, 2000), no such sex differences have emerged for facial displays and behaviour here or elsewhere (Harris & Christenfeld, 1997, 1999). However, lab studies have not included both male and female ticklers, which leaves open the possibility that the sex of the tickler and subject might impact reactions.

In closing, the present conclusion that ticklish smiling is not necessarily the result of a positive affective state does not mean that tickling is always devoid of positive emotions. Depending on the social setting (e.g., who does the tickling, how long it lasts, the mood of the person tickled), tickling may be capable of

eliciting a variety of reactions, some enjoyable and some unpleasant (see Provine, 2000, for descriptive data). Some of the confusion that has arisen over the relationship of smiling and laughter and affect during tickling may reflect an erroneous assumption that these positive aspects of the situation are responsible for the smiling observed in tickling. The present results, along with recent findings mentioned in the introduction, lend support to the notion that ticklish smiling need have no closer a connection to mirth and merriment than crying when cutting onions has to sorrow and sadness. We offer such conclusions tentatively and hope that this research will inspire further examination of this intriguing and little studied phenomena.

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