More what Duchenne smiles do, less what they express.

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The paper by Sheldon and colleagues is part of the body of literature that tries to disambiguate the function of a particular facial movement regarding emotional and social processes in humans: the concurrent activation of the zygomaticus major and orbicularis oculi muscle. The resulting visible change in facial appearance is often referred to as *Duchenne Smile* (DS) in honor of Duchenne de Boulogne, who published in 1862 a series of photographs of facial behavior triggered by external electrical stimulation of individual muscles (Duchenne, 1862/1990). Some authors have argued that DS are authentic because they are difficult to produce voluntarily. Indeed, the idea of reliable facial muscles (i.e., the orbicularis oculi muscle as Duchenne marker) unique to genuine emotional experiences that are difficult to deliberately control was reinforced in the late 20th century, particularly via the work of Paul Ekman and his colleagues (e.g., Ekman, 1990; Ekman, Davidson, & Friesen, 1990). A popular notion at the time was the idea of *facial affect programs* that trigger prototypical facial configurations corresponding to the basic six emotions. In this logic, the DS is a neurobiologically hard-wired (i.e., diagnostic, spontaneous) marker of enjoyment said to activate only during felt affect. By contrast, smiles without the Duchenne marker are thought of as false, fake, or dishonest, and lacking genuine positive affect (Frank, Ekman & Friesen, 1993).

We would like to elaborate on some of the points raised by Sheldon et al. (2021) and try to clarify the arguably complicated nature of the DS. For this, it is important to closely examine the literature that has been cited in support of the authors' hypotheses and make a distinction between the production and perception of DS.

Marginal empirical support for hypotheses 1-3

Hypotheses 1 to 3 focus on the expression (production) of DS. Given that this is the most contested aspect of DS (Krumhuber & Manstead, 2009), we re-examined the cited literature to discuss the relevant findings as well as their interpretation. Table 1 provides a summary of our counter-arguments as well as a classification based on whether the study findings are a) *inconclusive* (results are mixed or statistically weak, study methodology is problematic), b) *irrelevant* (e.g., study explores the decoding – not the production – of emotional states), c) *incomplete* (only a subset of results are reported while leaving out non-supportive evidence, results are actually different from those presented), and/or d) *misread* (a different explanation is implied by the results or given by the study authors). From the 23 articles cited in support of the three hypotheses (note that Dapelo et al., 2015, was discussed twice), we found that 5 were inconclusive, 4 were irrelevant, 14 were incomplete, and 13 were misread.

There was no single (empirical) article that would unanimously support the idea that DS solely function as indicators of felt positive affect. For approximately half of the cited literature (11 articles), DS were shown within an interpersonal context, either involving an implicit social presence or arising out of social interaction. Hence, social involvement could be a major cause of smiling. In 10 articles, a social-functional explanation was given by the study authors or implied by the data, indicating that DS signal social affiliation (e.g., Gonzaga, Keltner, Londahl, & Smith, 2001; Harker & Keltner, 2001), social connectedness/bonding (e.g., Dapelo et al., 2015; Fairbairn et al., 2015) and/or the motivation to share positive affect (Zaalberg, Manstead, & Fischer, 2004). Some articles were also indicative of an intrapersonal function of DS for emotion regulation, allowing better social adjustment (e.g., Bonnano et al., 2007; Ekman, Davidson, & Friesen, 1990; Keltner & Bonnano, 1987). Together, we consider the above evidence to be insufficient for claims that a) the presence of positive emotion (*hypothesis 1*), b) the intensity of

positive emotion (*hypothesis 2*), and c) chronic positive mood (*hypothesis 3*) are reliably signaled by the DS. In the next section, we will review evidence suggesting that the connection between DS and positive affect is loose.

Production: DS and positive affect do not always co-occur

If we consider the Duchenne marker as a reliable cue of genuine positive emotionality, then it should not be found in false or voluntary smiles. Based on a sizeable body of empirical evidence accumulated in the last decades, however, this is not the case. DS can be - and often are - displayed deliberately and in the absence of positive feelings (Gosselin, Perron, & Beaupré, 2010; Gunnery, Hall, & Ruben, 2013; Schmidt, Ambadar, Cohn, & Reed, 2006; Schmidt, Bhattacharya, & Denlinger, 2009; Schmidt, Cohn, & Tian, 2003; Smith, Smith, & Ellgring, 1996). In some studies, the majority of smiles could even be classified as DS when participants felt little or no positive emotion (80%, Girard, Cohn, Yin, & Morency, 2021) or when they were instructed to pose a smile (83%, Krumhuber & Manstead, 2009; 67%, Schmidt & Cohn, 2001). DS have also been found to frequently occur in negative emotional contexts, for example when distress, pain, or sadness are felt (Aviezer et al., 2015; Harris & Alvarado, 2005; Ekman, Friesen, & O'Sullivan, 1988; Ekman et al., 1990; Kappesser & Williams, 2002; Keltner, 1995; Keltner & Bonanno, 1997; Khan, Ward, & Ingleby, 2009; Kunz, Meixner, & Lautenbacher, 2019; Lee & Beattie, 1998; Mattson, Cohn, Mahoor, Gangi, & Messinger, 2013; Namba et al., 2017; Papa & Bonanno, 2008; Schneider & Josephs, 1991). Furthermore, there is clear evidence that positive emotions are not necessarily always accompanied by DS (e.g., Crivelli, Carrera, & Fernández-Dols, 2015; Ruiz-Belda, Fernández-Dols, Carrera, & Barchard, 2003), even if complete voluntary inhibition of smiles appears to be difficult (Kappas, Bherer, & Thériault, 2000).

Let us assume the analogy in which the flu is accompanied by fever. This does not mean that someone with fever has the flu because there are other conditions that can cause fever. This would be true even if every single instance of the flu is accompanied by fever, which is also unlikely to be the case. Hence, a doctor will use several symptoms to diagnose the flu. If the DS was a reliable and diagnostic indicator of positive affect, then the probability of positive affect being present given the presence of a DS should be 1. We know that it is not 0 because there are instances in which the DS indeed co-occurs with how happy or amused people report feeling. Based on the above cited research, however, we also know that it is <1. As such, the probability of the presence of positive affect given a DS is far less than certain. This highlights the intricate nature of the DS and the difficulty in inferring transient states or dispositions/traits, such as chronic positive mood, on the basis of a single facial muscle action alone. In conclusion, there is a clear disconnect between DS and positive affect.

Perception: What DS actually convey

Just as researchers often grant DS a marker status, so do people in regular interaction. Widespread evidence has shown that DS lead to favorable interpersonal perceptions and positive emotional responses (for a meta-analysis, see Gunnery & Ruben, 2016). If DS are indeed unreliable indicators of genuine positive affect, why are they habitually interpreted by observers in those terms? It is important to consider the anatomical dependency between the zygomaticus major and orbicularis oculi muscle, causing them to frequently co-occur especially in intense smiles (Gosselin et al., 2010; Krumhuber & Manstead, 2009; see also Gunnery & Hall, 2015). As a general signal of intensity, the Duchenne marker may then contribute to perceptions of greater affective intensity and arousal. This was found in the context of positive as well as negative

expressions, with orbicularis oculi activity causing smiles to look happier and more positive and sad/cry faces to look sadder and more negative (Bolzani-Dinehart et al., 2005; Miller, Krumhuber, & Dawel, 2020; Malek et al., 2019; Messinger, Mattson, Mahoor & Cohn, 2012).

Furthermore, people may hold socially shared ideas of what constitutes an authentic expression, similar to beliefs about how emotional cues reveal dishonest behavior. From deception research we now know that gaze avoidance is widely believed but not diagnostic for distinguishing liars and truthtellers (DePaulo et al., 2003). Accordingly, the DS could be an idealized prototype of genuine positive emotionality - an 'artistic truth' (Fernández-Dols & Ruiz-Belda, 1997) - that becomes a learned signal part of societal and cultural rules. Supportive evidence comes from studies showing that the Duchenne marker influences observer ratings over and above the variance explained by perceived emotional or smile intensity (Girard et al., 2021; Miller et al., 2020). That is, people assume that DS uniquely reflect genuine positive affect. They also hold a priori beliefs regarding the likely occurrence of authentic smiles (Maringer, Krumhuber, Fischer, & Niedenthal, 2011), and misremember (non-Duchenne) smiles as more Duchenne-like in appearance when previously viewed in a genuine happy situation (Krumhuber, Hyniewska, & Orlowska, 2021). Hence, there are culturally shared beliefs about the smile and specifically DS as indicators of positive affect, but this expressive stereotype is not indicative of the actual co-occurrence between affect and expression.

The perceptual salience of DS may further derive from an overreliance on physical features where stimuli are produced to 'look' authentic regardless of how they were elicited initially (Zloteanu & Krumhuber, 2021). In many instances DS are posed by actors who did not feel the emotion they were asked to portray, with stimuli being carefully selected based on the presence/absence of the Duchenne marker (Kappas, Krumhuber, & Küster, 2013). DS and NDS

of this type are usually more difficult to discern compared to those produced naturally (Gunnery & Ruben, 2016), probably because they lack other cues relevant for judgments of authenticity (Krumhuber & Manstead, 2009). Such pre-selection of stimuli imposes constraints as to which smile exemplars are regarded as representative of genuine positive affect and reinforces socially shared beliefs borne out by perception studies (Zloteanu, Krumhuber, & Richardson, 2020).

This tendency is exacerbated by categorization tasks that prompt viewers to separate stimuli into different classes and assign pre-defined labels (e.g., posed vs spontaneous, genuine vs fake). Ratings of DS and NDS typically diverge to a greater extent when response scales are dichotomous rather than continuous (Gunnery & Ruben, 2016). In that vein, observers are merely asked to categorize stimuli as having a certain characteristic rather than indicating what they think the person is really feeling at that moment (Krumhuber, Kappas, & Manstead, 2013). We think that such type of measurement predominantly reflects an observer's ability to systemize by extracting common patterns of facial behavior that are assumed to reflect genuine positive affect. This is not to deny that there are behavioral consequences of DS – for example with regard to mimicking behavior (Krumhuber, Likowski, & Weyers, 2014). However, if no specific questions are asked, nonverbal behaviors including DS are likely directing interaction without regard for the boundaries of mental constructs that are so dear to psychologists.

Conclusion

While there is no question that smiles are biological in origin (Darwin, 1872/2009), it is important not to get stuck interpreting 'expressive behavior' (whether DS or other types of smiles) exclusively in an affective framework focused on the individual. Instead, we need to appreciate the complex ecological reality in which expressions occur. As adaptive signals, they

synchronize and reinforce each other in social transaction (Kappas & Descôteaux, 2003). They are part of bidirectional intra- and interpersonal processes (Kappas, 2013), with the ultimate goal to connect with the social environment and secure survival (Baumeister & Leary, 1995). In other words, facial displays have evolved in interaction and are rich and multifaceted in their meaning, fulfilling a variety of functions (e.g., affective states, social motives, cognitive appraisals, action tendencies).

It is because of this that we hold a functional view that focuses on what facial actions, and here specifically DS, *do* rather than what they express. In different contexts DS might correlate with happiness (affective state), with being flirtatious (social motive), while perceiving something intrinsically pleasant (cognitive appraisal), or before engaging in an approach behavior (action tendency). In all these cases, the DS has the potential, and often does, change the physical or social relation between interaction partners in the short and medium term. There is a clear ontogenetic trajectory in developing the tendency to show expressions in certain contexts and reacting to them in a particular way (Abe & Izard, 1999). These tendencies are reinforced and stabilized via social processes according to cultural and local rules.

In such a logic, the question of whether expressions are felt or false is simply not fruitful, because in interaction a DS can be meaningful to the interactants regardless of whether it is accompanied by a highly specific affective state or not. For example, it might be employed to further trust and cooperate, and it does, as empirical evidence has shown, change liking (Frank et al., 1993; Harker, & Keltner, 2001; Johnston, Miles, & Macrae, 2009). It is the complexity of this tapestry of entwined processes that are fundamental to facial expressions (Kappas, 2003). The idea of taking a random photo and saying with certainty whether the person is happy or not may

seem a desirable goal. However, it runs the risk of oversimplification by implying that a single facial characteristic can signal in a diagnostic/lawful manner a discrete emotional state or trait.

Based on the available empirical evidence, there exists no one-to-one association between specific emotions and their facial expressions (Barrett Adolphs, Marsella, Martinez & Pollak, 2019; Durán, Reisenzein, & Fernández-Dols, 2017; Fernández-Dols & Crivelli, 2013). That is, facial activity cannot be assumed to directly reflect a person's emotional experience (Crivelli & Fridlund, 2018). When studying emotions, particularly emotions in the face, it will be crucial for future research to acknowledge that such co-occurrences may only appear to us that way, but may not actually depict a representation of reality. The common interpretation of DS is not an error, nor is it irrelevant. It is simply not sufficient to use such beliefs as evidence for a 'readout view' of emotions based on any expressive behavior.

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Table 1. *Re-examination of the literature cited in support of hypotheses 1-3 by Sheldon et al. (2021).*

Article	HYPOTHESIS 1: Counter-arguments	Classification
Ekman, Davidson, & Friesen (1990)	• The emotion-arousing films shown to the subjects were designed to be amusing (not pleasurable) • A one-tailed t-test was used to show that DS occurred more often during the positive than the negative film ($p = .005$) A two-tailed t-test was used to show that this difference was not significant for NDS ($p = .15$). The amount of DS and NDS was not directly compared in each condition • DS were also negatively correlated with self-reports of anger and sadness (implying intrapersonal regulation) • The difference between DS and NDS in predicting which of the two films was more positive was significant for happiness ratings ($p < .05$, one-tailed) but failed to reach significance for amusement ratings ($p > .06$)	• inconclusive • misread
Frank & Ekman (1993)	• No empirical data are reported (literature review only)	
Soussignan (2002)	• Only female participants tested • DS were not expressed spontaneously, but 'intentionally adopted' and made in response to the experimenter's instruction to hold a pen in their mouth (so that AU6+12 would be activated) • The study authors were interested in the role of facial feedback on subjective responses • Participants were aware of being video-recorded (implicit social presence) and that the pen-holding procedure may affect their perception and feelings	• misread
Johnson, Waugh, & Fredrickson (2010)	• In both studies, the frequencies of DS and NDS during (positive, neutral, and negative) emotion induction did not significantly differ from each other • In Study 2, DS occurred at similar rates across the positive, neutral, and negative emotion induction • Both DS and NDS were strongly correlated with self-reports of positive emotion (i.e., amusement, happiness, joy) during emotion induction • Higher frequencies of DS were correlated with higher levels of extraversion and openness	• incomplete

Table 1. *(continued)*

Article	HYPOTHESIS 1: Counter-arguments	Classification
Zaalberg, Manstead, & Fischer (2004)	• Social interaction paradigm: a confederate told participants a joke that was either funny or not • Joke type had a marginal significant effect ($p = .06$, one-tailed) on DS • When social motives (i.e., sharing of positive affect) were considered as a covariate, this effect was no longer significant • The motivation to share positive affect mediated the relationship between rated funniness of the joke and smile intensity and duration of DS	• incomplete • misread
Gonzaga, Keltner, Londahl, & Smith (2001)	• Social interaction paradigm: romantic partners discussed various topics that were prompted by the experimenter over intercom • Affiliation cues (including DS) did not predict self-reports of happiness after controlling for love • Partners' own DS significantly predicted how much love they thought the other partner would feel • Couples who displayed more affiliation cues during the positive disclosure reported to engage more in shared activities, have greater mutual influence on collective life goals, and feel more trust toward their partner	• misread
Clé et al. (2019)	• Out of the 108 DS, 103 were shown by patients with REM sleep behavior disorder (RBD), 2 were shown by non-parasomnia patients, and 3 by sleep-walking patients • Patients with RBD were older than those from the other two groups • The difference in DS between non-parasomnia and sleep-walking patients was not significant • The presence of happy emotional faces (including DS) during sleep was not significantly associated with more pleasant dream recall scenarios compared with their absence	• incomplete

Table 1. *(continued)*

Article	HYPOTHESIS 2: Counter-arguments	Classification
Frank, Ekman, & Friesen (1993)	• Two different stimulus sets: solitary smiles (taken from Davidson et al., 1990) and social interaction smiles (taken from Ekman & Friesen, 1974) • Stimuli were highly selected to make up an equal number of DS and NDS • Social interaction smiles probably involved a deceptive component since subjects believed that they had to be convincingly truthful • DS and NDS did not significantly differ in their mean duration • Offset durations of DS and NDS were of similar consistency	• inconclusive • incomplete
Hess, Banse, & Kappas (1995)	• The study authors concluded that the intensity of expressive displays cannot be satisfactorily predicted by either of these factors alone but is influenced by all three • More intense DS when another person was believed to simultaneously perform the same (vs different) task (implicit social presence) • Most intense DS when two participants watched the film together (social interaction)	• misread
Gunnery & Ruben (2016)	• Evidence relates to decoding (not production) of emotional states • The intensity of DS was an indicator of the intensity of perceived (not expressed) emotional state • The paper authors concluded that smile intensity depicts a potential confound in the relationship between the Duchenne marker and smile perception	• irrelevant • incomplete
Gunnery & Hall (2015)	• No empirical data are reported (literature review only) • Intense smiles typically involve the Duchenne marker due to co-activation • The paper authors concluded that numerous studies in the Duchenne literature are potentially compromised by the possible presence of DS that confound AU12 intensity with AU6 activation	• misread
Krumhuber & Manstead (2009)	• Evidence relates to decoding (not production) of emotional states • Orbicularis oculi (AU6) intensity was not measured • Pronounced (more) and moderate (less) activation relates to AU12 (smile) intensity	• irrelevant • incomplete

Table 1. *(continued)*

Article	HYPOTHESIS 2: Counter-arguments	Classification
Dapelo et al. (2015)	• Elevated levels of comorbid depression occur in eating disorders such as anorexia nervosa (AN) and bulimia nervosa (BN) (O'Brien & Vincent (2003) – implying that both should be low in CPM • People with AN showed DS with shorter duration and less intensity compared to the healthy control group <u>and</u> the BN group. BN participants did not differ from healthy controls on DS intensity and duration (as predicted by the study authors). • The reduced expression of DS in the AN group was interpreted by the study authors as a sign of social-signalling difficulties, diminished social connectedness, and lower reward sensitivity specific to AN (but not BN) disorder	• incomplete • misread
Zlochower (2002)	• Unpublished doctoral dissertation • Deliberate and spontaneous smiles did not differ in the presence/absence of DS (AU6) • Eye narrowing could also be due to lid tightening (AU7)	• inconclusive • incomplete
Krumhuber & Kappas (2005)	• Evidence relates to decoding (not production) of emotional states • Smiles were synthesised in artificial faces • All expressions were DS	• irrelevant
Fairbairn (2015)	• Unpublished doctoral dissertation. The data seem to be reported in Fairbairn et al. (2015) • Social interaction paradigm: participants consumed an alcoholic beverage in groups of three • A person's own mean duration of DS did not explain alcohol reward-sensitivity among extraverted individuals ('actor effect'). Instead, participants high in extraversion derived greater reward from the DS displayed by their groupmates ('partner' effect) • The study authors argued that social processes fully and uniquely accounted for increases in self-reported reward (i.e., mood, social bonding)	• incomplete • misread

Table 1. *(continued)*

Article	HYPOTHESIS 3: Counter-arguments	Classification
Auerbach (2017)	• Group allocation not based on statistical criteria (e.g., median-split). Instead, 10 patients with the lowest/highest scores allocated to the low/high trait cheerful group, respectively • Social interaction paradigm: always two patients participated in each trial. The clown visit also involved a clown pair (male and female clown) • Despite a non-significant interaction between smile type (DS, NDS) and trait cheerfulness ($p = .11$), t-tests were conducted to decompose the interaction	• inconclusive
Abe & Izard (1999)	• No empirical data are reported (literature review only) • The term 'Duchenne smile' is not mentioned in the paper • The paper authors refer to the intrinsic social value of smiles: "the infants' social smile [shown in response to another person] communicates well-being, elicits approach and promotes necessary interaction (pp. 528-529). "Smiles of joy foster social interaction (…) and the formation and strengthening of social bonds and attachment" (p. 527)	• incomplete • misread
Hall, Gunnery, Letzring, Carney, & Colvin (2017)	• Evidence relates to decoding (not production) of emotional states • Social interaction paradigm: targets participated in groups of two and took turns telling their affect narratives • No DS classification: Video-recordings were not analyzed in terms of facial expressions • The ability to judge a target's level of extraversion and positive affect was only correlated in one out of the two studies • Targets' self-rated extraversion was marginally related with self-ratings of happiness ($p < .06$) in the happy narrative condition of Study 1, and in Study 2 not significantly related ($p < .31$) to their positive affect when they could talk about whatever they liked	• inconclusive • irrelevant
Dapelo et al. (2015)	• O'Brien & Vincent (2003) report elevated levels of comorbid depression in eating disorders such as anorexia nervosa (AN) and bulimia nervosa (BN) – implying that both should be low in CPM • People with AN showed DS with shorter duration and less intensity compared to the healthy control group <u>and</u> the BN group. BN participants did not differ from healthy controls on DS intensity and duration (as predicted by the study authors) • The reduced expression of DS in the AN group was interpreted by the study authors as a sign of social-signalling difficulties, diminished social connectedness, and lower reward sensitivity specific to AN (but not BN) disorder	• incomplete • misread

Table 1. *(continued)*

Article	HYPOTHESIS 3: Counter-arguments	Classification
Keltner & Bonanno (1987)	• Social interaction paradigm: Bereavement interview involving two persons • While talking about their deceased spouse, Duchenne laughers and nonlaughers did not significantly ($ps \geq$ .10) differ in their self-reports of positive emotion (i.e., interest, enjoyment), despite scoring similarly high on personality traits (including extraversion) • Increases in Duchenne laughter were associated with greater enjoyment <u>and</u> reduced anger/distress (implying intrapersonal regulation). Duchenne laughers also remembered relationships with their deceased spouse as characterised by higher overall adjustment, consensus, and cohesiveness • The benefits of laughter were interpreted by the study authors in terms of the intrapersonal (physiological and behavioral adjustment to stressful events) and interpersonal function of laughter (enhancing social relations)	• incomplete • misread
Bonnano et al. (2007)	• Social interaction paradigm: participants were asked to speak about distressing events during an interview • For childhood sexual abuse survivors (CSA) Duchenne laughter during the interview predicted less social problems and withdrawal 2 years later when they described an event that was unrelated to the previous abuse experience (e.g., death of a loved one or a natural disaster). The opposite was true for CSAs who described during the interview a past abuse experience, with Duchenne laughter resulting in higher social problems and increased social withdrawal at time 2. • For non-abused (non-CSA) participants, there was no significant (ps > .06) correlation between DS and Duchenne laugher and social adjustment measures • As argued by the study authors, the adaptive value of the Duchenne laughter for CSA seems to be context-specific Only in situations that are free of stigma and possible misattributions of culpability, Duchenne laughter can serve socially adaptive functions by encouraging social affiliation	• incomplete • misread

Table 1. *(continued)*

Article	HYPOTHESIS 3: Counter-arguments	Classification
Harker & Keltner (2001)	• Only female participants tested • DS were unrelated to self-reported positive emotionality (e.g., experiencing positive affect) at age 21, 27, 43, and 52. Instead, DS were negatively related to self-reported negative emotionality at these time (implying intrapersonal regulation) • DS correlated positively with self-reported affiliation (which closely resembles the Big-Five dimension of agreeableness, p. 115). Women with more intense DS described themselves as nurturing, caring and sociable. They had more satisfying marriages at age 52, and less marital tensions at ages 27 and 52, besides reporting greater well-being • The study authors proposed a social-functional view in which DS help deal with negative emotions and build/strengthen social bonds by inviting others to approach/cooperate	• incomplete • misread