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Research Report

Smile variation leaks personality and increases the accuracy of interpersonal judgments

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Abstract

People ubiquitously smile during brief interactions and first encounters, and when posing for photos used for virtual dating, social networking, and professional profiles. Yet not all smiles are the same: subtle individual differences emerge in how people display this nonverbal facial expression. We hypothesized that idiosyncrasies in people's smiles can reveal aspects of their personality and guide the personality judgments made by observers, thus enabling a smiling face to serve as a valuable tool in making more precise inferences about an individual's personality. Study 1 ($N = 303$) supported the hypothesis that smile variation reveals personality, and identified the facial-muscle activations responsible for this leakage. Study 2 ($N = 987$) found that observers use the subtle distinctions in smiles to guide their personality judgments, consequently forming slightly more accurate judgments of smiling faces than neutral ones. Smiles thus encode traces of personality traits, which perceivers utilize as valid cues of those traits.

Significance statement

The present studies demonstrate that variations in smiles leak diagnostic information about a smiler's personality: namely, aggression, communion, conscientiousness, hubristic pride, and trustworthiness. Furthermore, observers properly utilize variation in smiles to judge each of these traits from smiling faces, consequently forming slightly more accurate judgments of smiling than neutral faces. Taken together, these results suggest that smiling faces leak personality and facilitate slightly more accurate personality judgments. Research examining interpersonal accuracy from neutral faces might therefore paint a somewhat conservative portrait of observers' ability to judge personality from the face. Furthermore, profile pictures posted on professional, social networking, and dating websites (which are often publicly available) may reveal more about the person photographed than they might expect.

Introduction

As people navigate the world, they use others' faces to form interpersonal judgments. These judgments guide social behavior, telling observers whom to approach, befriend, and follow. Forming reliable judgments of others is therefore paramount to surviving and thriving in a social world. People can form modestly accurate inferences about a variety of attributes from images of others' neutral (i.e. unexpressive) faces (e.g. 1–3,). Rather than maintain a neutral expression, however, people frequently smile to manage impressions during face-to-face meetings (e.g. greetings, first encounters, and brief interactions) and in photographs, such as those used for virtual dating, social networking, and professional profiles. Although studies have shown that the presence of a smile influences perceptions of a wide variety of traits when compared to neutral faces (e.g. 4–6), little work has examined how and whether individual differences in posed smiles influence observers' perceptions of a smiler's personality. Moreover, almost no studies have tested whether individual differences in smiles relate to stable person-specific information, such as one's characteristic personality traits.

Nonverbal displays leak personality information

Past research suggests that distinctive information about an individual can "leak" through their nonverbal displays (7, 8). For example, individuals unintentionally communicate their actual feelings (e.g. sadness) when attempting to express a contrasting emotion (e.g. happiness 9). Although research on nonverbal leakage has focused largely on transient states, nonverbal expressions can also leak information about stable characteristics. For example, emotion expressions have been found to contain culturally

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variable "accents" that reveal a person's nationality or ethnicity (10, 11). In the same way that verbal language contains accents that yield cultural differences in how a word sounds, nonverbal behavior can contain accents that yield cultural differences in how expressions look (10, 11).

We propose that such subtle differences in posed facial expressions might also reveal individuals' personality traits. For example, the scowls of aggressive people might differ from those of submissive people because aggressive people have greater experience scowling, and thus convey the display in a manner that appears more natural or genuine (12). Analogously, warm and prosocial people's smiles—a display shown both spontaneously and posed to invite conversation and signal warmth—might differ from cold and antisocial people's smiles. Although a wide variety of posed facial expressions might reveal personality, we focus here on posed smiles—the most normative nonverbal expression regularly posed in Western culture (13, 14). People frequently pose smiles when interacting with strangers and acquaintances, and for photos posted to the internet, including on personal, romantic, and professional social-media platforms. Other emotion expressions, in contrast, are posed fairly infrequently (e.g. 15). Smiles thus provide a natural, common, important, and ecologically valid behavior within which to examine whether and how posed facial-muscle activations reveal personality dispositions.

Variability in smiles

Several studies have explored smiling variability, finding that individuals who display more intense smiles in posed photographs tend to be more extraverted, affiliative, satisfied with life, and likely to attain positive life outcomes (15–19). Although these studies support our hypothesis that smile variability relates to personality, they do not test whether perceivers use this variability to form more accurate personality judgments of a smiler. Furthermore, all of these studies address individual differences in smiling intensity only, and people's smiles differ in ways beyond intensity, such as relying on different configurations of facial muscles to form a posed smile.

All smiles include activation of the zygomaticus major muscle (Action Unit 12 in the Facial Action Coding System FACS; 20), which raises the lip corners obliquely and often pairs with parting of the lips (AU25), revealing the teeth. Smiles commonly differ, however, in whether they include the simultaneous activation of the orbicularis oculi (AU6), a circular muscle surrounding the eye responsible for horizontal wrinkling at the lateral canthi (i.e. "crow's feet wrinkles"; Ekman & Friesen (20)). Smiles that activate AU6 and AU12, and often include AU25, are called "Duchenne smiles," and were traditionally believed to signal onsets of genuinely experienced positive emotion (21).[a] Critically, Duchenne smiles do not necessarily indicate that a positive emotional experience is actively occurring; they can be deliberately posed, including in the absence of felt emotion (e.g. 22, 23). For example, Harker and Keltner (15) found that approximately 45% of women in a college yearbook posed Duchenne smiles, even though being photographed typically impedes positive emotional experiences (e.g. 24). In contrast, non-Duchenne "polite" smiles—hallmarks of cordial greetings—include AU12 activation but not AU6 (25, 26). A large literature has explored distinctions between Duchenne and polite smiles, with one meta-analysis concluding that Duchenne smiles are perceived as more positive (e.g. attractive, authentic, trustworthy) even when deliberately posed (27).

Smiles also vary in ways beyond the Duchenne versus non-Duchenne distinction. For example, dominance smiles (AUs 5, 6, 9, 10, 12), reward smiles (AUs 1, 2, 12, 13, 14), and affiliation smiles (AUs 12, 14, 24), each of which include AU12 alongside a distinct set of companion AUs, serve distinct adaptive functions in specific situations: negotiating hierarchies, rewarding others, and signaling appeasement, respectively (28, 29). These smiles thus supply flexible tools that smilers wield in response to specific contexts, leaving unclear whether they might also leak stable trait-like personality information. Although the present research did not intend to address that question, we do test whether these distinct smiles occur when people pose smiles.

The prior literature on smiling thus indicates that smiles provide rich and variable sources of information that might convey personality. Yet it remains unknown (i) whether and how individual differences in smiling reveal individual differences in personality, (ii) which traits posed smiles might leak, and (iii) whether observers use individual variations in smiles to accurately judge others' personality from their smiling faces.

Accurate personality judgments from smiles

If smiles leak diagnostic information about a smiler's personality, observers may use this information to judge the smiler's personality, consequently forming more accurate personality judgments when observing smiles. In other words, although neutral faces enable modestly accurate trait judgments (e.g. 3), individual differences in the muscle activations that occur during a smile (even one that is posed) might add information that enhances interpersonal accuracy.

To test how and whether smiles provide information that enhances the accuracy of personality judgments, we adopted Brunswik's Lens Model (30, 31). This model allows us to decompose an accurate perception (the correspondence between a target's personality and observers' judgments of that target's personality) into cue validity (i.e. the extent to which particular behavioral cues correspond to the target's actual attributes) and cue utilization (i.e. the extent to which perceivers utilize each valid cue to guide their judgments; see Figure 1). In other words, a personality trait might "leak" via nonverbal cues that validly correspond to the target's actual personality, and that are utilized by observers to infer the target's personality. If observers' judgments are guided by the specific individual differences in facial movements shown by targets posing smiles, and these differences correspond to valid individual differences in targets' personalities, then observers should accurately judge targets' personalities from information leaked by their smiles. We apply a Lens Model to five different traits to test this hypothesis and, in doing so, address several research questions (RQs):

- RQ1 (Study 1): Do differences in targets' smiles leak information about their personality?
- RQ2 (Study 1): If so, which muscle activations expose personality?
- RQ3 (Study 2): Do observers utilize smile variation to judge targets' personality?
- RQ4 (Study 2): Do observers accurately judge targets' personality from their smiles?
- RQ5 (Study 2): Do observers form more accurate judgments about personality when viewing smiling expressions compared to neutral expressions?

Study 1

We first examined whether and how individual differences in personality traits relate to the specific facial muscles that individuals

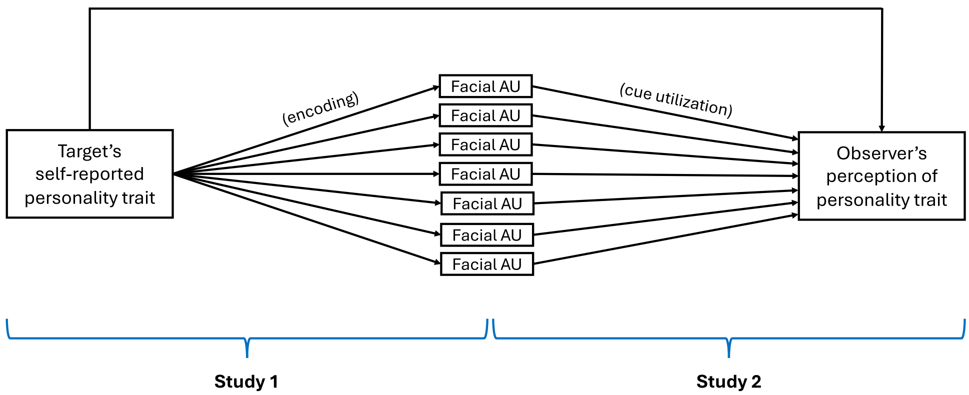

Fig. 1. Conceptual Lens model tested in Studies 1 and 2. This model allows us to decompose an accurate perception (the total correspondence between a target's personality and observers' judgments of that target's personality) into cue encoding (the extent to which specific behavioral cues validly indicate a target's self-reported attribute) and cue utilization (the extent to which perceivers use each valid cue to make their judgments).

Table 1. Descriptive statistics for study 1 measures.

Measure	Cronbach's α	M	SD	Mdn	Skew
Agency	0.72	4.66	1.01	4.75	−0.10
"Angry"	—	1.73	0.84	2.00	1.09
Aggression	0.88	2.34	0.52	2.28	0.23
Agreeableness	0.12	5.03	1.00	5.00	−0.04
Anxiety	—	5.20	1.30	5.00	0.53
"Attractive"	—	4.28	1.28	4.00	−0.27
Authentic Pride	0.89	3.12	0.79	3.17	−0.31
Communion	0.70	5.42	0.88	5.50	−0.37
Conscientiousness	0.57	5.19	1.33	5.50	−0.63
Depression	—	3.06	1.07	3.00	0.62
"Disgusted"	—	1.42	0.69	1.00	1.63
Dominance (full scale)	0.84	2.80	1.28	2.75	0.51
"Dominant"	—	3.96	1.35	4.00	−0.12
Extraversion	0.70	4.08	1.49	4.00	−0.03
"Fearful"	—	2.22	1.04	200	0.59
"Happy"	—	3.56	0.92	4.00	−0.06
Hubristic Pride	0.89	1.60	0.64	1.43	1.09
Life Satisfaction	0.94	3.17	0.76	3.17	0.01
Neuroticism	0.64	4.18	1.41	4.00	−0.12
Openness	0.43	5.05	1.15	5.00	−0.35
Prestige	0.81	4.44	1.20	4.50	−0.37
"Sad"	—	2.22	1.01	2.00	0.57
Satisfaction With Life	0.88	4.64	1.31	4.80	−0.29
Self-Esteem (Rosenberg)	0.90	2.91	0.57	2.90	−0.18
"Self-Esteem (SISE)"	—	4.38	1.48	5.00	−0.33
"Surprise"	—	2.11	1.08	2.00	0.57
"Threatening"	—	1.91	1.02	2.00	1.19
"Trustworthiness"	—	5.98	0.92	6.00	−1.24
"Youthful"	—	4.95	1.25	5.00	−0.45

Note. Cronbach's *α* not applicable to single-item measures.
Items in quotations measured with the quoted word; all other variables measured with multiitem scales, as reported in the Measures section.

activate when they pose a smile. Although we hypothesized that individuals scoring higher on warm and prosocial traits would more frequently display Duchenne smiles, we used a bottom-up, data-driven approach to explore how a wide variety of muscle activations potentially present in the smile might associate with a wide variety of personality traits.

Method

Study 1 was approved by a research ethics review board at the University of British Columbia (Approval # H17-01947). Informed consent was obtained from all participants.

Participants

We recruited 331 individuals from the undergraduate psychology participant pool of a diverse Canadian university. Participants completed a battery of self-report measures (Table 1) before being individually photographed. We excluded 28 participants' data because of poor image quality, photography issues (e.g. blurry images, closed eyes), or experimenter or computer error (e.g. broken links between data and images, response recording failure, issues identifying facial landmarks) for a final sample of 303 participants (79% female, 21% male, <1% other; $M_{age} = 20.30$ years, SD = 2.80, Range = 17–44, Median = 20; 55% East Asian, 22% White, 17% Other, 3% Middle Eastern, 2% Hispanic/Latino). This sample size allowed us to estimate stable correlation coefficients (32).

Research assistants used a Nikon Coolpix B500HD camera mounted on a tripod to photograph participants, all in the same room under the same lighting conditions. The camera's height was aligned with each participant's eye-level, and participants were instructed to sit up straight with their back against the back of a chair before the research assistant took two photos. For the first photo, participants were instructed to completely relax their face while looking directly into the camera, yielding a neutral expression. For the second photo, participants were instructed to smile the way they normally would when having their photo taken, yielding a smiling photo. The goal was to capture ecologically valid posed smiles so that we could test whether personality leaks via expressions that occur when people naturally present themselves in photographs. For both conditions, we took three photos in rapid succession to ensure that we obtained at least one with open eyes (notably, we were able to use the first smiling photo for nearly all participants).

Measures and materials

Demographics

Participants reported their age, gender identity, and ethnicity.

Agency and communion

Agency and communion were assessed using a scale comprised of items from The Interpersonal Circumplex (33, 34) and researcher-generated items. Specifically, the items "assertive," "persistent," "competent," and "confident" were included to assess agency, and "tender," "cold-hearted" (reverse-coded), "warm," and "sincere" to assess communion. Participants responded to all items using a scale ranging from 1 (*not at all*) to 7 (*very much*).

Aggression

Trait aggression was measured using the Buss Perry Aggression Questionnaire (35), which consists of 29 items (two reverse-coded) rated using a scale ranging from 1 (*disagree strongly*) to 7 (*agree strongly*).

Big Five personality traits

Agreeableness, conscientiousness, extraversion, neuroticism, and openness were measured using the Ten Item Personality Inventory (TIPI; 36), which assesses each trait with two items (one reverse-coded item per scale) using a scale ranging from 1 (*Disagree strongly*) to 7 (*Agree strongly*).

Anxiety and depression

Anxiety and depression were measured separately using two single-item measures. To measure anxiety, participants responded to the item "In general, how often do you feel anxious and worried," and, to measure depression, participants responded to the item "In general, how often do you feel depressed or down?" Participants responded to each using a scale ranging from 1 (*never*) to 6 (*almost always*).

Single-item measures: dominance, threat, trustworthiness, and youthfulness

Dominance, threat, trustworthiness, and youthfulness were each included as single items rated using scales ranging from 1 (*not at all*) to 7 (*very much*). We included these items because they are central to face perception (e.g. 37). Participants did not receive definitions for these items.[b]

Authentic and hubristic pride

Authentic and hubristic pride were measured with The Trait Authentic and Hubristic Pride Scale (38) consisting of 14 items (7 for authentic pride, 7 for hubristic pride) rated using a scale ranging from 1 (*not at all*) to 5 (*extremely*).

Trait basic emotions

Participants' trait-like tendency to experience distinct basic emotions was measured with the items "angry," "disgusted," "fearful," "happy," "sad," and "surprise." Participants responded using scales ranging from 1 (*not at all*) to 5 (*extremely*). Trait-like basic emotion items were intermixed with trait authentic pride and trait hubristic pride items.

Dominance and prestige

Dominance (the tendency to use aggression and intimidation to obtain power) and prestige (the tendency to obtain power by garnering respect through demonstrated knowledge and expertise) were measured with the Dominance-Prestige scales (39) consisting of 17 items (8 for dominance, 2 reverse-coded; 9 for prestige, 3 reverse-coded) rated using a scale ranging from 1 (*not at all*) to 7 (*very much*).

Life satisfaction

Life satisfaction was measured using The Riverside Life Satisfaction Scale (40) consisting of 23 items (14 reverse-coded) rated using a scale from 1 (*extremely uncharacteristic of me*) to 5 (*extremely characteristic of me*), and the Satisfaction with Life Scale (41) consisting of five items rated from 1 (*strongly disagree*) to 7 (*strongly agree*).

Self-esteem

Self-esteem was measured using the Rosenberg Self-Esteem Scale (42) consisting of 10 items (5 reverse-coded) rated using a scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*), and also the Single-Item Self-Esteem Scale (SISE; 43) in which participants respond to the item "I have high self-esteem" using a scale ranging from 1 (*not very true of me*) to 7 (*very true of me*).

AU coding

We used the open-source computer-based facial behavior analysis toolkit OpenFace (44) to code all photos based on the FACS. Specifically, we used the Multi-Task Convolutional Neural Network and Convolutional Experts Constrained Local Model algorithms to detect faces and facial landmarks. Scores represented the intensity of the AU activation from 0 (no intensity) to 5 (maximal intensity). Although OpenFace also provides separate (dichotomous) scores representing muscle activation occurrence, we elected to use continuous muscle activation intensity because naturally occurring muscle activations can differ in intensity to communicate different messages (e.g. 45) and such differences might be relevant to personality leakage.

OpenFace provided the muscle activation intensity for a total of 15 different AUs. However, because our analytic approach involved analyzing each AU as both a criterion (of a target's self-reported personality, RQ2) and predictor (of observers' perceptions, RQ3), per Brunswik's Lens Model, we reduced the total number of AUs to limit the possibility of inflating Type-I error and overfitting. Given that not all AUs are relevant to forming smiles, many were expressed at extremely low intensity and did not meaningfully vary across targets. We therefore focused the analyses on facial muscles activated with an average intensity of at least 0.5 on the 5-point scale. This low but nonzero value avoided misclassifying noise or measurement error as evidence of meaningful AU activation while remaining sensitive to slight activations, and left us with a total of seven at least slightly activated AUs: 6, 7, 10, 12, 14, 20, and 25. We refer to these as "core" features of the smile below (see Table 2).

Analytic strategy

We planned to limit the primary analyses to five personality traits in Study 1, instead of analyzing data for all 28 traits, to be consistent with Study 2's plan of testing the second half of the Lens Model, which examines observers' accuracy in reading each measured personality trait from the face. In Study 2, we opted to collect perception data for five traits only, to ease participant burden. To determine which traits to include, we first analyzed the behaviors coded from smiling photographs to identify the five traits most readily leaked via a smile—that is, the traits with variance best captured by the core muscle activations in participants' smiles. After identifying the five traits most strongly associated (positively or negatively) with smiles, we constructed a series of structural equation models (SEMs) with one of the five personality traits as the focal predictor and the intensity of all seven core AUs as the outcome (i.e. building an SEM for each of the five most-leaked personality traits). Together, these models addressed the first part of a Brunswik's Lens Model (i.e. cue validity) for five different traits; in other words, does personality relate to how people pose their smile (RQ1) and, if so, which facial-muscle activations reveal personality from posed smiles (RQ2)? We

Table 2. Core AU descriptions and related appearance changes critical to smiling.

AU	Descriptive Label	Corresponding Muscles	Typical Appearance Changes
AU6	Cheek raiser	Orbicularis Oculi, Pars Orbitalis	Lifts cheeks upwards, often causing crows-feet wrinkling around the lateral canthi of the eyes
AU7	Lid tightener	Orbicularis Oculi, Pars Palebralis	Tightens the eyelids and narrows the eye aperture
AU10	Upper lip raiser	Levator Labii Superioris, Caput Infraorbitalis	Raises the medial upper lip and deepens the nasolabial furrow
AU12	Lip corner puller	Zygomaticus Major	Pulls the lateral corners of the lips obliquely
AU14	Dimpler	Buccinator	Tightens the canthi of the lips, pulling them inwards
AU20	Lip stretcher	Risorius	Pulls lips back laterally, stretching and flattening the lips while elongating the mouth
AU25	Lips part	Depressor Labii, Mentalis, Orbicularis Oris	Parts lips to produce a visible gap

Note. AU codes, descriptive labels, and appearance cues taken from the FACS (20).

addressed the second part of Brunswik's Lens model (i.e. cue utilization and accuracy—RQs 3, 4, and 5) in Study 2.

Note that the assessment of interpersonal accuracy in Study 2 does not incorporate or statistically depend on the association between self-reported personality and individual facial AU activations uncovered in Study 1 (reported in Table 3). Interpersonal accuracy can occur (or not occur) regardless of whether any of the measured facial AUs correspond to self-reported personality; accuracy is based on whether Study 2 perceivers' judgements of a target's personality correlate with the target's self-reported personality, regardless of AU activations. Nonetheless, we examine the association between self-reported personality and AU activation in Study 1 to establish which facial AUs might serve as potential mechanisms through which observers form accurate judgments in Study 2.

Results

RQ1: do targets' smiles leak information about their personality?

If personality leaks via facial muscles activated during smiling, then the AU intensities in smiling targets' faces should account for variance in their self-reported personality traits. We thus examined the proportion of variance in each personality trait explained by AU activation in participants' smiles (i.e. using photos from the smiling condition only). We constructed separate linear models for each trait, treating the intensity of all core AUs as simultaneous predictors. Variation in these core AUs best accounted for hubristic pride ($R^2 = 0.07$, $R^2_{adj} = 0.04$), conscientiousness ($R^2 = 0.06$, $R^2_{adj} = 0.04$), trustworthiness ($R^2 = 0.06$, $R^2_{adj} = 0.04$), aggression ($R^2 = 0.05$, $R^2_{adj} = 0.03$), and communion ($R^2 = 0.05$, $R^2_{adj} = 0.03$; Figure 2).[c] We therefore focused on these five traits in the remaining analyses because they exhibit the greatest potential for leakage through smiles' core facial-muscle activations.

RQ2: which muscle activations expose personality?

To identify the AUs in a smile that systematically vary with personality, we constructed separate SEMs predicting all core AUs in a smile (AU6, AU7, AU10, AU12, AU14, AU20, and AU25) for each of the five traits identified above, paralleling the traditional cue-validity analysis in Brunswik's Lens Model. All AUs were allowed to freely correlate with each other, which produced fully saturated models that therefore perfectly fit the data (CFIs = 1.00, TLIs = 1.00, RMSEAs = 0.00).[d]

All five traits were associated with AU6, AU12, and AU25 activation, and all traits except conscientiousness were associated with AU10 (Table 3).[e] In contrast, AU7, AU14, and AU20 did not consistently relate to any of the five traits. For all significant associations, warm and prosocial traits—communion, conscientiousness, and trustworthiness—related to *increased* activation intensity, whereas cold and antisocial traits—aggression and hubristic pride—related to *decreased* activation intensity.

Given that AUs 6, 12, and 25 (which characterize the Duchenne smile) all showed independent relations with each personality trait, we next tested how their simultaneous activation related to the traits. We computed a dichotomous "Duchenne smile" variable by categorizing targets who simultaneously activated these three AUs (which co-occur during a Duchenne smile) at a level greater than 1 on the 0–5 rating scale[f] as displaying *comprehensive* Duchenne smiles (51% of all targets). We regressed this Duchenne smile variable (1 = present, 0 = absent) on each trait in five separate logistic regression models; each returned significant results: aggression, $b = -0.62$, $z = 2.72$, $P = 0.007$, OR = 0.54, communion, $b = 0.35$, $z = 2.61$, $P = 0.009$, OR = 1.42, conscientiousness, $b = 0.31$, $z = 3.32$, $P < 0.001$, OR = 1.36, hubristic pride, $b = -0.55$, $z = -2.88$, $P = 0.004$, OR = 0.58, and trustworthiness, $b = 0.55$, $z = 3.80$, $P < 0.001$, OR = 1.73.[g] Each trait thus related to the presence of a Duchenne smile.[h,i]

Although we planned to conduct follow-up analyses examining whether comprehensive affiliation (Aus 12 + 14 + 24), dominance (Aus 5 + 6 + 9 + 10 + 12), and reward smiles (Aus 1 + 2 + 12 + 14) related to self-reported personality, no participants (i.e. 0 of 303) posed any of these three smiles (for additional information about follow-up exploratory analyses, see Supplementary Material).

Discussion

Posed smiles systematically relate to individual differences in the posers' personality traits: Prosocial and warm traits (communion, conscientiousness, trustworthiness) predict a higher likelihood of Duchenne smiling whereas colder and antisocial traits (aggression, hubristic pride) predict a lower likelihood of Duchenne smile characteristics. These associations emerged when analyzing each distinct muscle activation in the Duchenne smile separately, as well as when measuring concurrent activation of all three muscles. Answering our first two RQs, then, we found that the intensity of activation of the muscles constituting the Duchenne smile (AUs 6, 12, and 25) leak relevant personality traits.

Notably, AU6, AU12, and AU25 no longer significantly related to all five traits after a conservative Bonferroni correction for 35 distinct comparisons ($\alpha = 0.05/35 = 0.0014$). Instead, AU12 still significantly related to all five traits, AU25 related to three of the five traits, and AU6 significantly related to two of the five traits. Given

Table 3. Standardized regression coefficients from SEMs modeling the associations between personality traits and AU activations.

Trait	AU6	AU7	AU10	AU12	AU14	AU20	AU25
Aggression	**−0.18*****	−0.10†	−0.14*	**−0.22*****	−0.09	−0.01	**−0.18*****
Communion	0.15**	0.05	**0.21*****	**0.18*****	0.07	−0.11†	0.16***
Conscientiousness	0.13*	−0.03	0.11†	**0.21*****	0.08	−0.04	**0.19*****
Hubristic Pride	**−0.23*****	−0.07	−0.18**	**−0.22*****	−0.11†	0.07	**−0.20*****
Trustworthiness	0.15**	−0.01	0.16**	**0.20*****	0.01	−0.11†	0.18***

Note. Uncorrected †*p* < .10, **p* < .05, ***p* < .01, ****p* < .001. Correlations significant following a conservative Bonferroni correction for 35 comparisons ($\alpha = 0.05/35 = 0.00143$) presented in boldface.

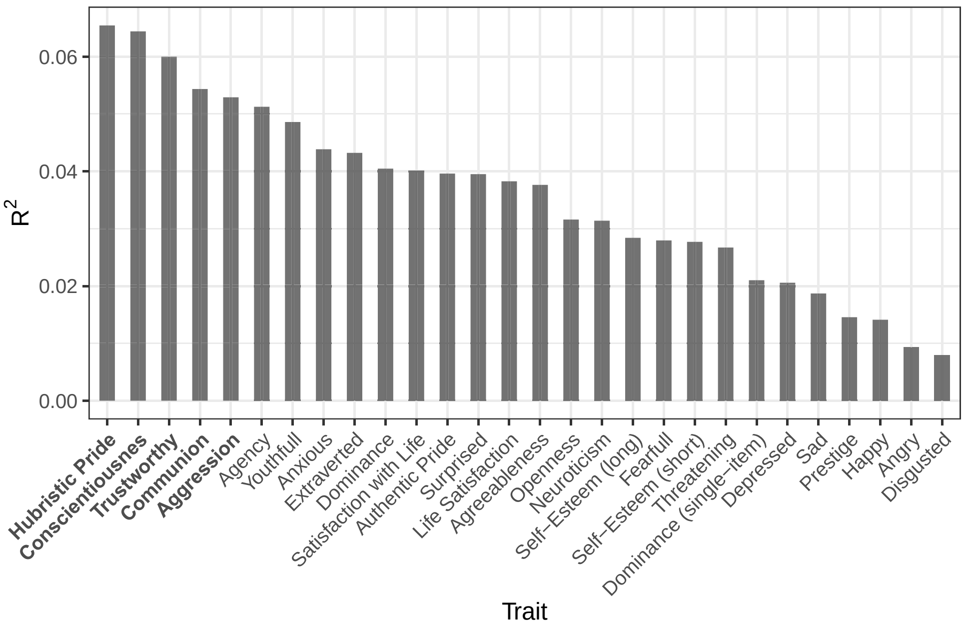

Fig. 2. R^2 effect sizes from individual linear models of core AUs predicting all personality traits included in Study 1.

the conservative correction used here, these remaining effects (presented in boldface in Table 3) are likely not Type-I errors, though we urge readers to interpret the specific associations between individual AUs and traits that did not survive this conservative Bonferroni correction with great caution. Furthermore, although AU6 did not significantly relate to conscientiousness after a conservative Bonferroni correction for 35 comparisons, results from a direct replication using an independent sample also found that people reporting higher conscientiousness were more likely to display a Duchenne smile (see Supplementary Material). In addition, simulations demonstrate that the total number of significant effects uncovered (reported in Table 3), and the systematic pattern of multiple AUs relating to all five traits, would be exceedingly unlikely to occur due to Type-I error; see Supplementary Material.

Study 2

Study 1 established that individual differences in posed smiles correlate with self-reported personality traits. Study 2 addressed the other side of the Lens Model by testing whether observers reliably utilize these differences to judge targets' personality, and if doing so improves the accuracy of their judgments (all data, and the preregistration for Study 2, publicly accessible at: https://osf.io/45gkw/?view_only=c3b2310b0eec4a778e44021081e30d29).

Method

Study 2 was approved by a research ethics board at the University of Toronto (Approval # 31944). Informed consent was obtained from all participants.

Participants

We recruited 1,231 American Mechanical Turk Workers. We excluded 244 individuals who failed an attention-check question (20%; 48, 49), leaving 987 participants (57% female, 43% male, <1% other; 74% White/Caucasian, 11% Black, 6% other, 5% Middle Eastern, 4% East Asian; $M_{age} = 43.47$ years, SD = 13.25, Range = 20–80, Median = 41).

Stimuli

We used the smiling and neutral photos from Study 1, cropping them around the head to remove the background. The photos were otherwise unedited.

Procedure

Participants were assigned to view 100 randomly selected targets exhibiting either a smiling ($n = 499$) or neutral ($n = 488$) pose. They rated each image on the five traits that best related to the AUs in Study 1, which we thus expected to be most diagnostically leaked via smiles (i.e. aggression, communion, conscientiousness, hubristic pride, and trustworthiness). After making their judgments, participants completed a brief exploratory measure assessing their beliefs about social perception (not analyzed here) and a brief demographics survey before debriefing. All exploratory trials followed the main experiment and therefore could not have altered the current results.

Measures

Given that participants rated 100 unique targets, we used single-item measures for each trait to minimize fatigue. All measures were adapted from the self-report scales used to measure the targets' actual personalities in Study 1.

Perceived aggression

To measure perceptions of aggression, participants rated whether "This person is aggressive, hostile, and threatening," from 1 (*strongly disagree*) to 5 (*strongly agree*). This researcher-generated item was designed to broadly capture the multiple dimensions of Buss and Perry's (50) Trait Aggression Questionnaire (i.e. physical aggression, verbal aggression, anger, and hostility).

Perceived communion

Combining four items that measure communion from the interpersonal circumplex (33, ; see also 34, 49, 51), participants rated "This person is kind, gentle-hearted, tender, and accommodating" from 1 (*strongly disagree*) to 5 (*strongly agree*) for each target.

Perceived conscientiousness

Perceptions of conscientiousness were measured with the item "This person is conscientious, organized, dependable, and self-disciplined" from 1 (*strongly disagree*) to 5 (*strongly agree*) based on the two items measuring conscientiousness in the TIPI (36) used in Study 1 (substituting the original reverse-coded items "disorganized" and "careless" with "organized" and "self-disciplined" to facilitate the single-item measure).

Perceived hubristic pride

Participants rated hubristic pride by responding from 1 (*strongly disagree*) to 5 (*strongly agree*) to the item "This person is arrogant and conceited," which combines two items from the Trait Hubristic Pride scale (38) used in Study 1.

Perceived trustworthiness

Participants responded to the prompt "This person is trustworthy" from 1 (*strongly disagree*) to 5 (*strongly agree*), which we adapted directly from the single-item measure of self-reported trustworthiness used in Study 1.

Analytic strategy

We first tested RQ3—whether individual differences in facial-muscle activations in the smiling condition guide observers' personality judgments (i.e. cue-utilization in Brunswik's Lens Model)—by matching the AU intensity data from Study 1 to the personality-perception data from Study 2. Specifically, we constructed five multilevel models (MLMs; one for each trait)[j] in which the intensity of targets' core facial-muscle activations (i.e. AU6, AU7, AU10, AU12, AU14, AU20, and AU25) in their smiling photos predicted observers' personality ratings, including random intercepts for targets and perceivers.

We then tested RQ4 (whether observers form accurate personality judgments from images of smiling targets) and RQ5 (whether observers form more accurate judgments from images of smiling targets compared to neutral targets) by matching the self-reported personality data from Study 1 to the personality-perception data from Study 2. Operationally, we constructed MLMs that tested whether targets' self-reported personality traits predict observers' judgments about targets' personality, and whether this association is moderated by stimulus type (0 = neutral, 1 = smiling), allowing us to simultaneously test whether observers form accurate judgments and whether their judgments are more accurate for smiling than neutral expressions.

Finally, we proceeded to construct comprehensive Brunswik's Lens Models using photos of smiling targets to test whether the presence versus absence of Duchenne smiles explain accuracy in observers' personality judgments. These models combine the cue-validity elements from Study 1 (i.e. how targets' presence/absence of a Duchenne smile relates to their actual self-reported personality) and the cue utilization elements of Study 2 (i.e. how presence/absence of Duchenne smiles relates to observers' perceptions of targets' personality) to predict observers' accuracy (in the smiling condition) in Study 2. To do so, we averaged observers' ratings in the smiling condition to form consensus scores for each target and trait (i.e. target-level Brunswik Lens Models),[k] and conducted identical mediation models for each trait using lavaan in R (53). In each model, we treated one of the five self-reported traits as the predictor, the comprehensive Duchenne smile (0 = absent, 1 = present) as the ordered categorical mediator, and trait judgments of each target (averaged across observers) as the outcome. This allowed us to calculate a comprehensive Brunswik's Lens Model in a single SEM (i.e. Figure 1).

Results

RQ3: do observers utilize smile variation to judge targets' personality?

We constructed five MLMs (one for each trait) in which the intensity of targets' core facial-muscle activations (i.e. AU6, AU7, AU10, AU12, AU14, AU20, and AU25) in their smiling photos predicted observers' personality ratings, including random intercepts for targets and perceivers. Zygomaticus major (AU12) and buccinator (AU14) activation intensities significantly related to perceptions of all five traits, and lip parting (AU25) related to perceptions of four of the five traits (Table 4).[l] All significant associations uncovered between AU12, AU14, and AU25 activations and trait judgments remained statistically significant and in the same direction when including target gender, target ethnicity, perceiver gender, and perceiver ethnicity as simultaneous covariates in the same model, $|\beta|s \geq 0.08$, $|t|s \geq 3.35$, $Ps < 0.001$ (see Supplementary Material). These three muscle movements therefore guided perceptions of aggression, communion, conscientiousness, hubristic pride, and trustworthiness from smiles. The only other result that reached significance revealed that targets who activated AU20 were perceived as slightly less arrogant. In contrast, AU6, AU7, and AU10 activation intensities during smiling did not uniquely contribute to perceiving any traits (when adjusting for the influence of the other AUs).[m]

Given that two of the three AUs that constitute the Duchenne smile independently related to perceptions of each trait,[n] we next tested whether comprehensive Duchenne smiles affected personality judgments. We constructed the same dichotomous *comprehensive Duchenne smile* variable used in Study 1, wherein targets who simultaneously activated all of AU6, AU12, and AU25 at values greater than 1 on the 0–5 intensity scale were considered as showing a Duchenne smile. In five separate cross-classified MLMs

Table 4. Standardized coefficients from each cross-classified MLM predicting study 2 observers' perceptions of each personality trait from AUs in study 1 targets' smiles.

Trait	Action Unit						
	AU6	AU7	AU10	AU12	AU14	AU20	AU25
Aggression	−0.01	−0.004	0.02	**−0.12*****	−0.06***	−0.01	**−0.07*****
Communion	0.03	0.004	−.02	**0.16*****	0.07***	0.01	**0.10*****
Conscientiousness	−0.03	0.01	0.02	**0.11*****	0.06***	−.01	0.03
Hubristic Pride	−0.05†	0.002	0.01	−0.05*	−0.07***	−0.04*	**−0.09*****
Trustworthiness	0.03	−0.005	−0.007	**0.11*****	0.06***	0.005	**0.08*****

Note. $^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. Separate cross-classified MLMs constructed for each trait. Correlations significant following a conservative Bonferroni correction for 35 comparisons ($\alpha = 0.05/35 = 0.00143$) presented in boldface.

(with random intercepts for targets and observers), we predicted each trait from the Duchenne smile variable, all returning significant results: aggression, $\beta = -0.14$, $t(302.06) = 10.16$, $P < 0.001$, communion, $\beta = 0.22$, $t(301.51) = 13.30$, $P < 0.001$, conscientiousness, $\beta = 0.11$, $t(301.70) = 7.09$, $P < 0.001$, hubristic pride, $\beta = -0.15$, $t(301.73) = 9.89$, $P < 0.001$, and trustworthiness, $\beta = 0.16$, $t(301.84) = 11.27$, $P < 0.001$. Duchenne smiles thus guided perceptions of each trait.

RQ4 and RQ5

Do observers accurately judge targets' personalities from their smiles, and do observers form ***more*** accurate judgments about personality when viewing smiling expressions compared to neutral expressions?

Study 1 showed that facial-muscle activations in smiles leak self-reported personality information. In Study 2, we found that similar muscle activations guide perceptions of personality. Combining these findings, we reasoned that observers might use targets' smiles to form accurate personality judgments about them. Furthermore, given the possibility that additional diagnostic personality information becomes available when targets smile, observers might form *more* accurate personality judgments from smiling compared to neutral expressions.

We therefore tested whether observers form accurate personality judgments of smiling and neutral targets, and then compared those rates of accuracy. To do so, we constructed and replicated the same MLM for each of the five personality traits that observers judged. In each cross-classified multilevel interaction model, we included observers' perceptions of a selected trait as the criterion (i.e. perceived aggression, perceived communion, perceived conscientiousness, perceived hubristic pride, or perceived trustworthiness) and three predictors: (i) the smiling condition, (ii) targets' self-report on the trait being judged, and (iii) the self-reported trait by smiling condition interaction. Each model therefore tests whether the smiling photograph leads to higher perceptions of a trait than the nonsmiling photograph, whether targets' self-reported personality predicts observers' judgments of their personality (i.e. accuracy; when the condition = 0), and whether the stimulus condition (dummy coded; 0 = neutral, 1 = smiling) moderates the association between self-reported personality and perceived personality, including random intercepts for both target and observer. The interaction term tests RQ5; that is, whether interpersonal accuracy—the correspondence between targets' self-reported trait and observers' judgments of that trait—is greater when viewing a smiling versus neutral photograph. For comprehensiveness, we report the interaction term from this model and the simple effects at each level of the smiling condition, calculating degrees of freedom using Satterthwaite (54) approximation (see also 55). All significant interactions reported below remain statistically significant and in the same direction after including target gender, perceiver gender, target ethnicity, and perceiver ethnicity as simultaneous covariates, $\beta s \geq 0.019$, $ts \geq 3.07$, $Ps < 0.002$ (see Supplementary Material).

Aggression

A significant effect of target condition showed that targets appeared less aggressive when smiling than when neutral, $\beta = -0.359$, $t(1{,}749) = -9.83$, $P < 0.001$ ($ICC_{Targets} = 0.09$, $ICC_{Observers} = 0.48$). Showing evidence of accuracy, targets' self-reported aggression related to observers' perceptions of their aggressiveness from their smiling photos, $\beta = 0.029$, $t(1{,}115) = 2.61$, $P = 0.009$, but not their neutral photos, $\beta = 0.014$, $t(1{,}118) = 1.28$, $P = 0.20$. Indeed, a significant interaction emerged, indicating that the correspondence between perceived and self-reported aggression was significantly greater for smiling versus neutral photos, $\beta = 0.015$, $t(96{,}788) = 3.06$, $P = 0.002$. Observers thus formed accurate judgments about targets' aggressiveness from their smiling photos, and judgments were significantly more accurate for smiling than neutral photos (though the difference was much smaller than the average effect size in social psychology; $r = 0.21$; 46).

Communion

A significant effect of target condition showed that targets were perceived as more communal when smiling than when neutral, $\beta = 0.400$, $t(3{,}622) = 9.89$, $P < 0.001$ ($ICC_{Targets} = 0.10$, $ICC_{Observers} = 0.29$). Showing evidence of accuracy, targets' self-reported communion related to observers' perceptions of communion from both their smiling, $\beta = 0.035$, $t(761) = 2.54$, $P = 0.01$, and neutral photos, $\beta = 0.042$, $t(764) = 3.07$, $P = 0.002$. No interaction emerged, $\beta = -0.007$, $t(96{,}797) = -1.45$, $P = 0.14$, indicating that observers accurately judged targets' communion from their smiling (and neutral) photos, and observers were not more accurate when judging smiling versus neutral photos.

Conscientiousness

A significant effect of target condition indicated that targets were perceived as more conscientious when smiling than when neutral, $\beta = 0.232$, $t(1{,}834) = 3.28$, $P = 0.001$ ($ICC_{Targets} = 0.07$, $ICC_{Observers} = 0.29$). Showing evidence of accuracy, targets' self-reported conscientiousness related to observers' perceptions of conscientiousness from smiling photos, $\beta = 0.042$, $t(873) = 3.48$, $P < 0.001$, but not neutral photos, $\beta = 0.016$, $t(875) = 1.32$, $P = 0.19$. A small but significant interaction confirmed that the correspondence between perceived and self-reported conscientiousness was significantly greater for the smiling versus neutral photos, $\beta = 0.026$, $t(96{,}799) = 5.10$, $P < 0.001$. Observers thus formed accurate judgments about targets' conscientiousness from their smiling photos, and were significantly more accurate when judging smiling versus neutral photos (though the difference was much smaller than the average effect size in social psychology; 46).

Hubristic pride

A significant effect of target condition indicated that targets were perceived as less hubristically proud when smiling than when neutral, $\beta = -0.257$, $t(1,256) = 9.56$, $P < 0.001$ ($ICC_{Targets} = 0.10$, $ICC_{Observers} = 0.44$). Showing evidence of accuracy, targets' self-reported hubristic pride related to observers' perceptions of their hubristic pride from smiling photos, $\beta = 0.034$, $t(1,703) = 3.14$, $P = 0.002$, but not neutral photos, $\beta = -0.006$, $t(1,710) = -0.54$, $P = 0.59$. Indeed, a significant interaction confirmed that the correspondence between perceived and self-reported hubristic pride was significantly greater for smiling versus neutral photos, $\beta = 0.039$, $t(96,797) = 7.83$, $P < 0.001$. Observers thus formed accurate judgments about targets' hubristic pride from their smiling photos, and were significantly more accurate when judging smiling versus neutral photos (though the difference was much smaller than the average effect size in social psychology; 46).

Trustworthiness

A significant effect of target condition indicated that targets were perceived as more trustworthy when smiling than when neutral, $\beta = 0.319$, $t(3,339) = 4.27$, $P < 0.001$ ($ICC_{Targets} = 0.07$, $ICC_{Observers} = 0.33$). Showing evidence of accuracy, targets' self-reported trustworthiness related to observers' perceptions of trustworthiness from smiling, $\beta = 0.042$, $t(528) = 3.13$, $P = 002$, but not neutral photos, $\beta = 0.025$, $t(530) = 1.85$, $P = 0.065$. Indeed, a significant interaction confirmed that the correspondence between perceived and self-reported trustworthiness was significantly greater for smiling versus neutral photos, $\beta = 0.017$, $t(96,789) = 3.44$, $P < 0.001$. Observers thus formed accurate judgments about targets' trustworthiness from smiling photos, and were significantly more accurate when judging smiling than neutral photos (though the difference was much smaller than the average effect size in social psychology; 46).[o,p]

Brunswik's Lens model

Duchenne smiling related to targets' self-reported aggression, communion, conscientiousness, hubristic pride, and trustworthiness in Study 1. In Study 2, observers used the muscles involved in Duchenne smiles to guide their perceptions of each of these traits from the Study 1 participants' faces. We therefore constructed Brunswik's Lens Models to test whether Study 1 participants' Duchenne smiles explained Study 2 observers' accurate perceptions of each trait.

The indirect effect of interpersonal accuracy through Duchenne smiles expressed in the smiling photographs was significant for all five traits (see Table 5 and Figure 3).[q] Specifically, each trait predicted targets' demonstration of Duchenne smiles in the smiling condition (the *a* paths), Duchenne smiles guided the average judgment of each trait made by Study 2 observers (the *b* paths), and those observers formed accurate judgments of each trait (the total effects). Finally, the Duchenne smile explained accuracy, as evidenced by the absence of any significant direct effects independent of the indirect effects via the Duchenne smile. All indirect effects were significant after including target gender and ethnicity as covariates that simultaneously guided perceptions of each trait, $\beta s \geq 0.10$, $zs \geq 2.54$, $Ps < 0.007$ (perceiver gender and ethnicity could not be accounted for, given that observations were averaged across all perceivers). No photos taken for the neutral condition portrayed Duchenne smiles, so no further analyses were conducted (i.e. covariance and correlation cannot be computed in the absence of variance).[r]

Table 5. Standardized regression coefficients and significance levels for the mediation models in which comprehensive Duchenne smiles explain accurate trait perception.

Trait	Standardized Mediation Model Coefficients				
	a path	*b* path	Indirect Effect	Direct Effect	Total Effect
Aggression	−0.20**	−0.68***	0.13**	0.02	0.15**
Communion	0.19**	0.77***	0.15**	−0.001	0.14**
Conscientiousness	0.24**	0.44***	0.11**	0.08	0.19**
Hubristic Pride	−0.21**	−0.63***	0.14**	0.02	0.16**
Trustworthiness	−0.29**	0.69***	0.20***	−0.04	0.16**

Note. $^{**}p < .01$, $^{***}p < .001$.
The "*a* path" describes the association between each self-reported trait and the Duchenne smile, and the "*b* path" describes the association between the observed Duchenne smile and perceptions of each trait.

Discussion

Addressing RQ3, targets' smiles guided observers' perceptions of their personality: Duchenne smiles positively related to perceptions of prosocial and warm traits (communion, conscientiousness, trustworthiness) and negatively related to perceptions of colder and antisocial traits (aggression, hubristic pride). The presence of Duchenne smiles also facilitated observers' ability to make *accurate* personality judgments, and enabled more accurate judgments from smiling faces than from neutral ones. More specifically, observers formed modestly accurate judgments of all five traits from targets' smiling faces, and the accuracy of trait perceptions formed from smiling faces exceeded the accuracy of perceptions formed from neutral faces for all traits but communion; these results address RQ4 and RQ5. Finally, Brunswik's Lens Models showed that the combination of facial-muscle activations pertinent to Duchenne smiles explained how observers accurately perceived targets' personality traits from their smiles. In sum, posed smiles provide a reliable and valid window into personality by virtue of the presence versus absence of the muscles involved in a Duchenne smile.

General discussion

From Da Vinci's *Mona Lisa* to Lewis Carroll's *Cheshire Cat*, artists have long known that smiles feature distinct signatures, communicating more than merely the notion of feeling pleased. The present studies are the first to empirically demonstrate that variations in the configuration of muscles people use to pose their smiles leak diagnostic information about personality (namely, aggression, communion, conscientiousness, hubristic pride, and trustworthiness) via specific facial-muscle activations (namely, the cheek-raiser, AU6; upper-lip-raiser, AU10; lip-corner-puller, AU12; and lip-parting, AU25). As expected, people who reported higher levels of communion, conscientiousness, and trustworthiness activated the AUs that constitute the Duchenne smile to a greater extent, whereas those who reported higher levels of aggression and hubristic pride activated the AUs that constitute the Duchenne smile to a lesser extent. Furthermore, observers use variation in AU12 and AU25 (plus AU14), along with comprehensive Duchenne smiles (AUs 6 + 12 + 25), to accurately judge these personality traits from smiling faces.

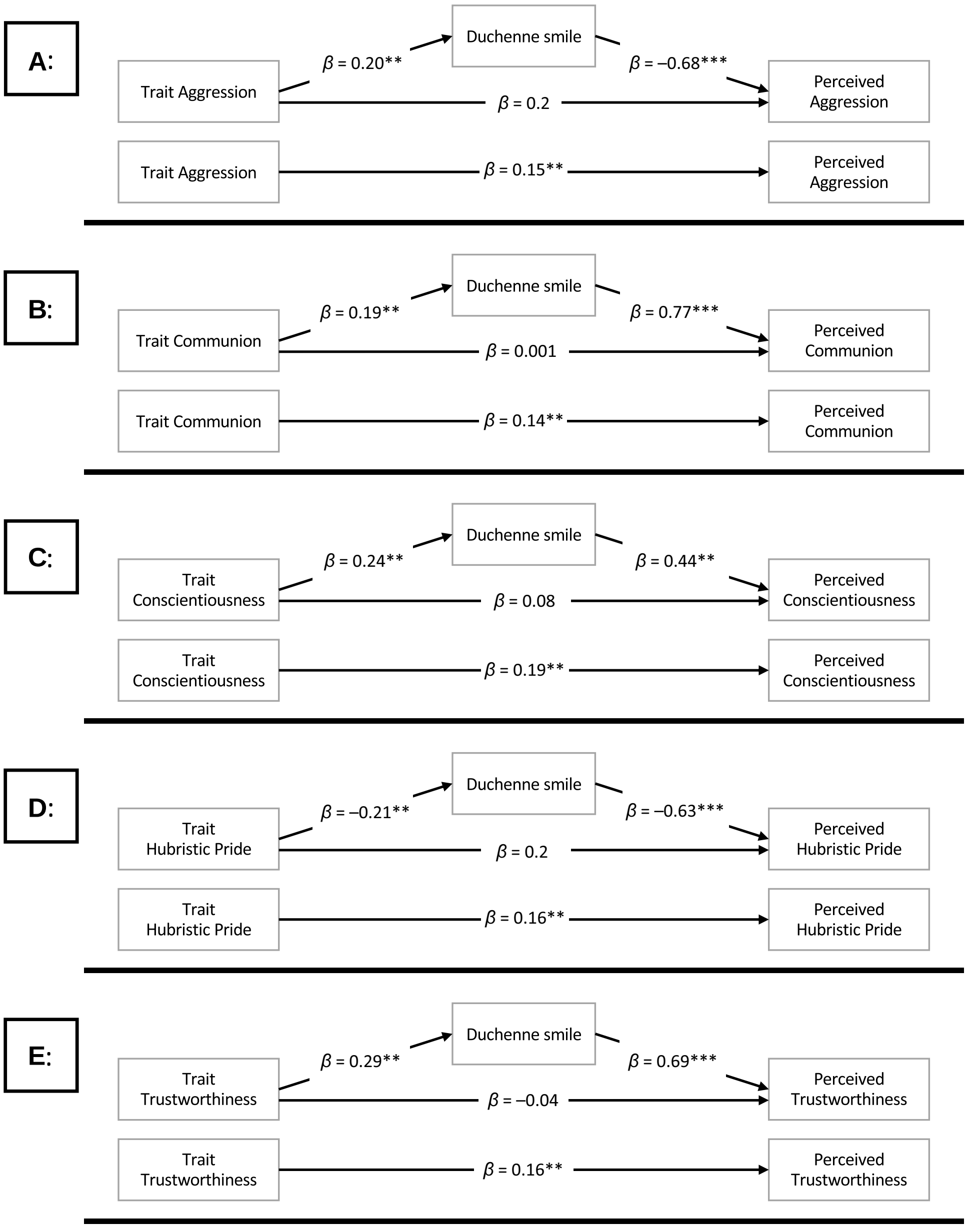

Fig. 3. Mediation models testing whether Duchenne smiles explain accuracy for each trait: aggression (A), communion (B), conscientiousness (C), hubristic pride (D), and trustworthiness (E).

Overall, observers made slightly accurate judgments of smiling individuals' personality, and these judgments were slightly more accurate when targets smiled (vs. when neutral), except for communion, which observers perceived similarly accurately from both smiling and neutral faces. Moreover, Duchenne smiles involving the simultaneous activation of AU6, AU12, and AU25 fully explained observers' accuracy from smiling photos; comprehensive Duchenne smiles are therefore used both to express and to extract reliable personality information. Taken together, these results provide the first evidence that smiling faces, in general, and Duchenne smiles, in particular, facilitate accurate personality judgments, enabling observers to make more accurate judgments from smiling than nonsmiling faces.

Nonetheless, the accuracy of personality judgments made from smiling photographs was far from perfect. Sociodemographic incongruencies between observers and targets might have contributed to the relatively low rates (although accounting for target gender, target ethnicity, perceiver gender, and perceiver ethnicity did not change the interpretation of our primary results). Targets were recruited from a diverse Canadian university with a large proportion identifying as East Asian (55%) and female (79%), whereas the observers in Study 2 were living in the United States, predominantly White (74%), and more gender-balanced (57% female, 43% male). Given prior work demonstrating outgroup disadvantages in emotion recognition (e.g. 10) future research should consider whether group identity also affects personality recognition from smiling faces. More homogeneous samples of targets and perceivers might yield greater accuracy. In addition, future research would benefit from recruiting larger samples of participants from distinct ethnic backgrounds, to empirically test ingroup and outgroup effects.

Although smiles increased the accuracy of interpersonal judgments for nearly all traits measured in Study 2, we would not expect all traits to leak via the smile, or that judgments formed from smiling faces would be more accurate for all traits. Instead, we expect smiles to increase the accuracy of a personality judgment only when variation in those smiles contain valid information about the trait being judged. This is because signal detection (in this case, accurate personality perception) requires a reliable, valid, and observable signal (personality expression). Future research is needed to identify both the totality of traits revealed by smiles and which of those traits observers can accurately judge based on smile variation.

Moreover, smiles vary beyond the Duchenne versus non-Duchenne distinction. For instance, dominance, reward, and affiliation smiles provide flexible tools that individuals wield in specific contexts (28, 29). These smiles' functional basis renders it unlikely that they would leak stable trait-like personality information or that people would display them when posing for a photograph. Indeed, our observation that no participants demonstrated these smiles in Study 1 supports the social-functionalist account of these smiles by underscoring their context-specific nature (28). The current research also builds on past work demonstrating that neutral faces leak personality and dispositions (e.g. 2, 57) and permit modestly accurate judgments of social traits (3, 58). Indeed, personality influences the facial expressions that are repeated over time, shaping neutral facial appearance by strengthening certain facial muscles and causing wrinkling (Dorian Gray effect; 59, 60). Here, we suggest that personality, which may also influence facial expressions repeated over time, shape how people reflexively configure their posed smile such that these smiles enhance the accuracy of observers' personality judgments.

These results also suggest that past research examining interpersonal accuracy from neutral faces might paint a somewhat conservative picture of observers' ability to judge personality from the face. Furthermore, given that people tend to smile for photographs, future research examining interpersonal accuracy from photos might consider using smiling rather than neutral faces for the sake of ecological validity *and* accuracy.

Although we focus on static photographs of posed smiles due to their normativity and prevalence throughout the modern digital world, smiles can also be dynamic sources of information that interact with physical and contextual features in the environment. For example, facial visibility (61), underlying facial morphology (62, 63), and dynamic qualities of smiling behavior and movements not captured by OpenFace (e.g. 64, 65) can influence how smiles are perceived. Future research is needed to address whether, how, and why dynamic smiles posed in different contexts leak personality and increase the accuracy of personality judgments.

Future research might also examine the possible mediating role of emotion experience in personality leakage. For instance, individuals high in communion and low in aggression may feel happier when their photograph is taken, thus presenting Duchenne smiles. Although this would not change the current conclusions (Duchenne smiles would still reveal personality and enable observers to form more accurate personality judgments), future work should simultaneously consider trait-like personality with transient emotion experiences during photographing to allow for a more nuanced understanding of whether and how emotions explain the link between personality and smiles.

It is noteworthy that, although many of the reported effects are modest, cumulatively they carry a great deal of practical significance. For example, if an online dating user (e.g. on Tinder or Bumble) spends 15 seconds observing each dating profile, and just 35 minutes per day using the app, they would be evaluating nearly 1,000 faces each week. Although the increase in personality judgment accuracy produced by any one smiling face may be small, over the course of thousands of trials—the norm for many modern dating apps—these small effects would add up to enable users to evaluate smiling others more accurately over time, potentially finding more desired or compatible partners as a result. Furthermore, people view new faces all of the time, including while scrolling social networking websites, and in person as they navigate the world. Finally, small effects need not be aggregated to be meaningful (e.g. 66) they are the norm in psychology, given that most psychological phenomena are the result of a complex interplay of multiple factors (67).

Conclusion

These results show that personality influences people's posed smiles in ways that divulge their traits to others, and that personality leaks more strongly from smiling than neutral faces. Moreover, specific muscle activations in posed smiles—particularly muscles comprising the Duchenne smile—encode traces of personality, which perceivers use to accurately infer those traits. Smiles thus constitute a nonverbal signature of personality that is sometimes (but not always) correctly read.

Notes

[a] Although some definitions of Duchenne smiles do not require parted lips, a large body of research on the Duchenne smile (including the original work by Duchenne (68)) includes a gap between the lips, also known as AU25.

[b] Participants also responded to the item "attractive." However, given that attractiveness is not a personality trait, results for attractiveness are reported in the Supplementary Material.

[c] Models adjusting for target gender showed slight differences, though the patterns remained largely consistent (see Supplementary Material).

[d] We constructed SEMs with personality predicting smiling behavior based on the postulates of Burnswik's Lens Model. All models were saturated because facial behaviors typically co-occur (Girard et al. (69)), yet we were primarily interested in how muscle activations relate to self-reported and perceived personality rather than how they relate to each other. By allowing all facial-muscle activations to correlate, we could excuse model-fit issues generated by these covariances.

[e] A power analysis conducted using the pwr package in r [pwr.r.test($r = 0.21$, $n = 303$, sig.level = 0.05/35)], which implemented a Bonferroni correction for 35 comparisons and the average effect size in social psychology (46), indicated that we had 69% power to detect each result.

[f] We reasoned that this value requires clear evidence of AU activation, averting misclassification from noise or measurement error.

[g] All of these results remain significant when applying a conservative Bonferroni correction.

[h] Follow-up analyses explored the possibility that incidental facial-muscle activations occurring during neutral expressions leak diagnostic personality information. As expected, (and validating our manipulation), we observed minimal facial-muscle activation (e.g. none of the 303 targets demonstrated comprehensive Duchenne smiles in their neutral expression) and no individual AUs reliably related to all five traits. In fact, very few significant associations emerged at all (see Supplementary Material).

[i] Five post hoc power analyses conducted using pwrss in R (47; $p_0 = 0.51$ $\alpha = 0.05$) indicated an average of 91% power to detect each odds ratio (min = 74%, max = 99%), and an average of 80% power to detect the results after a conservative Bonferroni correction for all five exploratory follow-up tests ($\alpha = 0.01$; min = 48%, max = 99%).

[j] Traditional models with targets as the unit of analysis (i.e. average-perceiver models) yielded the same pattern of results but with substantially larger coefficients: |βs| between 0.002 and 0.44 (see Supplementary Material).

[k] This traditional approach in social perception research (52) notably differs from the MLMs we otherwise used. Although MLMs offer greater statistical power and can account for dependencies between observations made by the same perceiver or for the same target, using target-level linear regression for the encoding path (i.e. "*a*" path; Study 1) but cross-classified MLMs for the decoding path (i.e. "*b*" path; Study 2) limits our ability to calculate intuitive simultaneous indirect effects (i.e. "*ab*" effect) because these methods are not yet established. We therefore constructed several traditional target-level Brunswik Lens Models, allowing us to calculate full mediation models testing the indirect effect of accuracy via the Duchenne smile.

[l] A conservative Bonferroni correction for 35 comparisons ($\alpha = 0.05/35 = 0.00143$), presented in boldface in Table 4, does not drastically shift the interpretation of the results: AU6, AU12, and AU25—the three facial muscles constituting a Duchenne smile—still relate significantly to all traits, except the association between hubristic pride and (reduced) activation of AU12. Thus, Type-I error caused by multiple comparisons does not explain the overall pattern of results.

[m] Follow-up analyses testing whether incidental muscle activations in targets' neutral expressions predict observers' personality judgments (presented in the Supplementary Material) largely match the results reported above: AUs 12, 14, and 25 predicted perceptions of the five traits in the same direction as for the smiling faces, except that AU25 only related to aggression, conscientiousness, and hubristic pride.

[n] AU6 significantly predicts all traits when it is the only predictor in separate cross-classified MLMs with random intercepts for targets and observers: aggression, $\beta = -0.16$, $t(301.90) = -012.15$, $P < 0.001$, communion, $\beta = 0.24$, $t(301.38) = 15.58$, $P < 0.001$, conscientiousness, $\beta = 0.11$, $t(301.44) = 7.60$, $P < 0.001$, hubristic pride, $\beta = -0.16$, $t(301.52) = -010.00$, $P < 0.001$, and trustworthiness, $\beta = 0.18$, $t(301.62) = 12.98$, $P < 0.001$. The null associations between AU6 and each trait (displayed in Table 4) likely occur because AU6 strongly relates to AU12 ($r = 0.80$) and AU25 ($r = 0.70$), which absorb its influence when accounting for the shared variance with these other muscle activations.

[o] All of the significant interactions in the cross-classified MLMs were robust to conservative Bonferroni corrections accounting for the five analyses ($\alpha = 0.01$). Furthermore, they remained statistically significant and in the same direction when including target gender, perceiver gender, target ethnicity, and perceiver ethnicity as simultaneous covariates, βs ≥ 0.019, ts ≥ 3.07, Ps < 0.002 (see Supplementary Material).

[p] Dividing the analyses into two independent studies (one using the AU data to define the traits, and the other correlating the ratings of those traits and the photo) may provide a form of "out-of-sample" validation of the trait selection procedure in Study 1, thus rendering spurious correlations in Study 1 unlikely.

[q] Five post hoc power analyses conducted using MedPower (56; $N = 303$ $\alpha = 0.05$) indicated 96% power on average to detect the observed indirect effects in Table 5 (min = 92%, max = 99%) and 90% power on average (min = 77%, max = 99%) to detect the observed indirect effects following Bonferroni correction ($\alpha = 0.01$) for all five exploratory follow-up tests.

[r] Readers can apply a conservative Bonferroni correction to these results by considering $P \leq 0.01$ as the threshold for statistical significance (i.e. $\alpha = 0.05/5$); doing so does not change interpretation of the results, which remain significant even at this more conservative threshold.

Supplementary Material

Supplementary Material is available at *PNAS Nexus* online.

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Author Contributions

Z.W.: conceptualization, data curation, formal analysis, investigation, visualization, methodology, writing-original draft, project administration, writing-review and editing; L.T.: data curation, methodology, project administration, writing-review and editing; J.T.: conceptualization; supervision, funding acquisition, methodology, writing-review and editing; N.O.R.: conceptualization, supervision, funding acquisition, methodology, writing-original draft, writing-review and editing.

Data Availability

All data, and the preregistration for Study 2, are publicly accessible at: https://osf.io/45gkw/?view_only=c3b2310b0eec4a778e44021081e30d29

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