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EmoSex: Emotion Prevails Over Sex in Implicit Judgments of Faces and Voices

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Appraisals can be influenced by cultural beliefs and stereotypes. In line with this, past research has shown that judgments about the emotional expression of a face are influenced by the face's sex, and vice versa that judgments about the sex of a person somewhat depend on the person's facial expression. For example, participants associate anger with male faces, and female faces with happiness or sadness. However, the strength and the bidirectionality of these effects remain debated. Moreover, the interplay of a stimulus' emotion and sex remains mostly unknown in the auditory domain. To investigate these questions, we created a novel stimulus set of 121 avatar faces and 121 human voices (available at https://bit.ly/2JkXrpy) with matched, fine-scale changes along the emotional (happy to angry) and sexual (male to female) dimensions. In a first experiment ($N = 76$), we found clear evidence for the mutual influence of facial emotion and sex cues on ratings, and moreover for larger implicit (task-irrelevant) effects of stimulus' emotion than of sex. These findings were replicated and extended in two preregistered studies—one laboratory categorization study using the same face stimuli ($N = 108$; https://osf.io/ve9an), and one online study with vocalizations ($N = 72$; https://osf.io/vhc9g). Overall, results show that the associations of maleness-anger and femaleness-happiness exist across sensory modalities, and suggest that emotions expressed in the face and voice cannot be entirely disregarded, even when attention is mainly focused on determining stimulus' sex. We discuss the relevance of these findings for cognitive and neural models of face and voice processing.

Keywords: facial expression, vocalization, emotion, sex, implicit vs. explicit

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Humans are experts in perceiving and recognizing faces and voices, from which they rapidly infer information such as a person's identity, age, sex, and mood.[1] For example, 100 ms, that is, the blink of an eye, suffice to form first impressions from a face, and extract information that is used to judge a person's attractiveness, likeability, trustworthiness, and competence (Willis & Todorov, 2006). The same inferences are also rapidly made when hearing a person's voice (Schirmer & Kotz, 2006; Schweinberger et al., 2014), based on acoustic cues, such as pitch, amplitude, speech rate, and prosody (Banse & Scherer, 1996). However, the precise mechanisms by which variant (e.g., emotion) and invariant (e.g., sex) stimulus features are rapidly extracted and recognized in faces and voices remain unknown. We also lack a clear understanding about the features that weigh more when forming both explicit (task-relevant) and implicit (task-irrelevant) social impressions, as these are often investigated independently of each other.

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[1] In English, sex commonly refers to a person's biological characteristics, such as the nature of reproductive cells (female ova and male spermatozoids). Gender, on the other hand, is increasingly considered a more flexible sociocultural construct. Sex and gender are sometimes used synonymously.

Processing Variant and Invariant Stimulus Properties

Classic models of face processing propose that invariant face properties, like identity or sex (male, female), and variant face properties like emotional expression (angry, happy), are processed in separate cognitive steps and brain regions (Bruce & Young, 1986; Haxby et al., 2000). These models are based on several lines of evidence, including studies with neurological patients, brain imaging, and single cell recordings in nonhuman primates (George et al., 1993; Hasselmo et al., 1989; Humphreys et al., 1993; Striemer et al., 2019; Tranel et al., 1995; Winston et al., 2004).

An analogous separation, both at the cognitive and neural level, is also believed to underlie the processing of variant and invariant features in the human voice. The parallels in face and voice perception have brought some scholars to liken the voice to an 'auditory face' (Belin, 2017; Belin et al., 2004; Young et al., 2020; but see Schirmer, 2018). A striking example of these parallels is given by the conceptual correspondence between prosopagnosia, the impaired recognition of facial identity (with mostly intact emotion recognition), and phonagnosia, that is, the impaired recognition of familiar voices (Neuner & Schweinberger, 2000; Van Lancker et al., 1988).

Other evidence, however, suggests that the separation of variant and invariant features is less strict. Indeed, different aspects of faces are processed in parallel, and the emerging representations can compete with or influence each other (Vuilleumier & Pourtois, 2007). Faces elicit automatic and simultaneous activation of multiple competing representations of social categories (Freeman et al., 2008), which in turn may activate stereotypes, which can affect social perception in a top–down manner (Freeman & Ambady, 2010). Stereotypes can be shared by two or more social categories, resulting in the activation of one category (e.g., Black American) by the facial features associated with another category (e.g., angry; Hugenberg & Bodenhausen, 2003). Therefore, activation of one social category can influence the perception of another, and this has profound consequences. Indeed, these mechanisms may explain why the interpretation of a face can dramatically change depending on its context (e.g., body posture: Aviezer et al., 2008; religious symbols: Korb et al., 2021; or physical scenery: Righart & De Gelder, 2008)—a possibly automatic process (Aviezer et al., 2008, 2011).

Emotion-Sex Associations

The recognition of emotional valence is also not impermeable to other, emotion-unspecific and invariant aspects, such as a person's sex. Indeed, an extensive literature suggests that emotional expressions and sexual features are not perceived independently in a face. For example, Becker et al. (2007) reported that people (a) spontaneously think of angry male and happy female faces when asked to imagine an angry and a happy face, (b) are both faster and more accurate to categorize the emotion of angry male and happy female faces (be these pictures of avatars or real people) compared with happy male and angry female faces, and similarly that (c) they are faster and more accurate to categorize the sex of angry male and happy female faces. Faster categorization of happy female and angry male faces was also reported in a speeded categorization task by Aguado et al. (2009). Similarly, participants perceived neutral male faces as more angry than neutral female faces in a study that used morphing software to gradually change emotional expression (happy to angry) in male and female faces (Harris et al., 2016). Moreover, participants rated an androgynous avatar face as more female-like when it displayed happiness or fear, compared with anger, and were slower to categorize the sex of angry female compared with happy or fearful female faces (Hess et al., 2009). This and other research has convincingly shown that social categories such as biological sex and race can influence facial emotion recognition in line with stereotypes and prejudices (Hehman et al., 2014; Zebrowitz, 2017). Auditory emotion perception is also influenced by speaker's sex in as little as 200 ms (Paulmann et al., 2008), often in ways consistent with gender stereotypes (Bonebright et al., 1996), and judgments about the emotional valence of voices are influenced by auditory context (Liuni et al., 2020). Generally, however, much less is known about the interaction of emotion and sex (or other invariant features) in the vocal (voice) compared with the visual (face) domain.

Several factors can explain these effects. First, gender evaluation and gender stereotyping can influence emotion perception in a top–down manner (Amodio & Devine, 2006). In line with this, women are evaluated more positively than men (Eagly & Mladinic, 1989), men are stereotyped as more aggressive and women as more docile, and men with stronger stereotypic beliefs about emotional expression interpret an infant's facial expression as angry if they believe the infant is male, and as sad if they believe it is female (Plant et al., 2000). Many traditional gender stereotypes seem to persist today, despite recent changes in many societies' gender roles (Heilman, 2012). Second, associating certain emotions with a specific sex may have had increased survival chances in hunter-gatherer societies, as males are generally more aggressive, and because an aggressive (angry) male may pose a greater imminent threat than an aggressive female (Archer, 2004; Wilson & Daly, 1985). Third, male and female faces differ morphologically, and a lower brow ridge (typical in males), or a rounder jaw (typical in females), can contribute to judgments about emotional expression and personality traits (Becker et al., 2007; Said et al., 2009; Zebrowitz et al., 2010). Finally, the degree to which sex and other features influence emotion recognition may also vary depending on the experimental task (e.g., whether verbal labeling of the categories is required, or instead fast and intuitive responses are encouraged), the main dependent variable of interest (ratings, categorization choices, and response times), and whether variations in several stimulus features are presented together or in separate blocks (as in the Garner paradigm, e.g., see Atkinson et al., 2005).

Open Questions

Irrespective of what causes emotion recognition to be influenced by other face features, extant research suggests that the two social categories of emotion and sex, and/or their associated stereotypes, are intertwined, and that they can affect stimulus processing in combination. However, important questions remain about the bidirectionality and symmetry of these effects.

The bidirectionality of these effects was seldom investigated directly—with the eventual exception of studies using the Garner task, which present stimuli in blocks of trials with variations on either one dimension only or two dimensions at the same time, focus on average reaction time (RT) by condition, and typically do not find the preferential association between specific emotional expressions (anger, happiness) and sexes (male, female) described above (Atkinson et al., 2005; Schweinberger et al., 1999). Instead, experiments have typically held one category constant (e.g., emotion), while varying the other (e.g., sex). In a now classic study this was done through priming. Condry and Condry (1976) found that infants' ambiguous emotional responses were rated more often as angry when the infant was labeled as a boy, and as fearful when it was labeled as a girl. Similarly, androgynous adult faces with ambiguous emotional expression were rated angrier if they were associated with typically male clothing and hairstyle, and sadder if they were associated with a typically female style of clothing and hair (Plant et al., 2004). Others have used morphing software to create several degrees of emotional expression in males and females, however, without generating comparable levels on the sex dimension (Harris & Ciaramitaro, 2016; Harris et al., 2016; Hess et al., 1997). More research is needed, to better understand how emotion and sex interact and influence each other during face perception, and to extend the investigation of these phenomena into the auditory domain.

The precise amount by which emotion and sex influence each other, and their symmetry, also remains debated. In other words, it is unclear if judgments about a face's emotion are influenced by its sex as much as the other way around. Both dimensions are processed rapidly and automatically based on facial features, and likely activate conceptual categories and associated stereotypes, which are intertwined (e.g., the categories of anger and maleness share the stereotype "aggression"). Specific categories of emotion and sex may also overlap at the physical level, as suggested by computational models (Said et al., 2009; Zebrowitz et al., 2010). Nevertheless, mutual effects of a face's emotion and sex may well be asymmetrical, based on neurological findings and evolutionary considerations. First, responses to emotional expressions can occur even in the absence of a functioning visual cortex (Tamietto & De Gelder, 2010; Tamietto et al., 2009), suggesting that perception of a face's emotion is a crucial cognitive function that occurs, at least partly, in subcortical brain areas encompassing the amygdala. Second, the information conveyed by the emotional expression of a face may be more relevant for survival and for attainment of one's goals than the information carried by the sex of a face. In evolutionary terms, it likely is more relevant (at least outside of a mating context) to quickly detect and accurately recognize if somebody is approaching with a threatening (angry) face, than to determine if that person is male or female. This is implied by the idea that immediate survival goals have priority over reproductive goals (Kenrick et al., 2010). Based on the assumption that fast emotion recognition is more relevant for the organism than sex discrimination, it can be hypothesized that the emotion of a face will influence judgments about its sex more than the sex of a face will influence judgments about its emotional expression.

However, because fleeting social cues like facial expressions can also be produced voluntarily, and can be used in strategic communication to deceive others, researchers have postulated that perceivers tend to rely on cues that are relatively invariant, or cues that cannot be easily manipulated at will (Brown et al., 2003; Mehu et al., 2012). The latter category includes sexually dimorphic cues. Therefore, the reverse hypothesis also seems plausible, and the categories male/female activated by specific facial features can be expected to have a greater effect on judgments about the face's emotional expression, than vice versa. In line with this, studies focusing on RT during speeded categorization tasks, in response to stimuli presented in specific blocks with variations on either one or two dimensions (Garner paradigm), have often found that the RT during emotion categorization of faces is influenced by the task-irrelevant sex of the face, and not vice versa (Atkinson et al., 2005; Schweinberger et al., 1999; but see Le Gal & Bruce, 2002; Lipp et al., 2015).

In summary, judgments of facial emotion and sex were rarely compared directly in past research, and past stimuli often included only discrete levels of both emotion and sex dimensions (i.e., happy and angry male and female faces, see Becker et al., 2007), or included more fine-grained changes of emotion but not of the sex dimension (Harris et al., 2016; Hess et al., 1997; Korb & Massaccesi, 2020). Direct comparisons of judgments of emotion and sex are even more rare in the auditory domain. To fill these gaps in the literature, research needs to assess and compare the size of the implicit effects of emotion and sex in the perception of controlled stimulus sets—both in the visual (face) and auditory (voice) domain.

The Present Study

To further investigate the mechanisms leading us to perceive male (female) faces as more angry (happy), and angry (happy) faces as more (less) masculine, and to extend this research into the auditory domain, we carried out a direct comparison of both types of effects using a controlled stimulus set of faces and voices. A novel stimulus set was created that comprises avatar faces and human vocalizations with gradual and simultaneous changes in two dimensions: emotion (happy to angry) and sex (female to male). Face contours were not, as in much of previous research (Atkinson et al., 2005; Harris & Ciaramitaro, 2016; Harris et al., 2016; Ng et al., 2006), hidden through the overlaying of an oval mask used to remove hair and background. Important sexually dimorphic facial features, such as the facial width-to-height ratio (Geniole et al., 2015), or the more squared jaw in males and the higher cheekbones in females, which are known to influence emotion perception and social judgments (Costa et al., 2017), remained entirely visible. Low-level visual features, such as symmetry and luminance of the images, were controlled for.

Comparing the size of the two effects (emotion on sex and sex on emotion) contributes to clarifying their relative importance. In addition, by using stimuli with several degrees of emotional and sexually dimorphic features, it is possible to investigate if the effect of one dimension on judgment of the other dimension manifests prevalently for stimuli with ambiguous (less stereotypical) features. Indeed, the tendency to categorize male faces or voices as angry, and female faces or voices as happy, can be expected to be greater for those faces or voices that express a blended and ambiguous emotional expression, as these stimuli will elicit greater conceptual and neural competition between the social categories "happy" and "angry" (Freeman et al., 2011; Stolier & Freeman, 2016, 2017). Conversely, the categorization of a face or voice as male or female is expected to be influenced by its emotional expression, especially for androgynous faces or voices with ambiguous sexual features.

The face stimulus set was used in two separate experiments, of which the second was preregistered. By measuring ratings (Experiment 1, $N = 76$), and categorization choice and speed (Experiment

2, $N = 108$) for face emotion and sex in different tasks, we were able to directly compare the explicit and implicit effects of both facial dimensions on various dependent variables. Furthermore, to extend this research to the vocal domain, we investigated if similar emotion-sex associations also occur in the auditory modality (Experiment 3, $N = 72$), by collecting ratings of emotion and sex for vocalizations varying between a man and woman, as well as between happiness and anger.

Experiment 1: Rating of Faces

Participants were randomly assigned to one of two groups to rate, once for each stimulus, either the emotion or the sex of 121 faces varying in their degree of emotional (happy, angry) and sex (male, female) characteristics. The following hypotheses were formulated. Hypothesis 1 (H1): Based on a considerable literature reporting effects of facial emotion on sex, and vice versa, we expected changes in the physical features of the implicit stimulus dimension (the task-irrelevant dimension, which participants were not instructed to rate) to influence explicit ratings. For example, explicit rating of a face's sex will be influenced by the implicitly processed emotional expression of the face. Conversely, when participants are explicitly instructed to rate the emotional expression of a face, they will be influenced by its sex. These effects were expected to reflect the reported association between happiness and femininity on the one hand, and between anger and maleness on the other hand. Hypothesis 2 (H2): effects of the implicit stimulus dimension on explicit ratings will be greater for faces that are ambiguous on the explicit dimension, as these induce greater competition between mental categories. Concretely, the sex of a face will influence emotion ratings more for faces that have an ambiguous emotional expression (mixed between happiness and anger), than for faces that are prototypically happy or angry. Similarly, the emotion of a face will influence sex ratings more for androgynous faces, than for faces that are clearly male or female. Hypothesis 3 (H3): Participants' responses are expected to be influenced by both explicitly and implicitly processed dimensions, but greater effects are expected for explicit processing (Habel et al., 2007)—essentially showing that participants can focus on a particular dimension as instructed.

A major interest of Experiment 1 was to quantify the mutual influence of emotion and sex. However, both an emotion-over-sex, and a sex-over-emotion hierarchy of effects seem plausible based on the literature and on a-priori reflection. We formulated two competing hypotheses regarding this point. According to Hypothesis 4 (H4), the implicit effect of emotion prevails over the implicit effect of sex. Hypothesis 5 (H5), on the other hand, expects the opposite effect, that is, that the implicit effect of sex will be stronger than the implicit effect of emotion.

Method

Participants

Participants ($N = 76$, 49 females, age range 21 to 56 years, $M_{age} = 35.7$, $SD = 10.0$) were recruited through announcements on social media, and were randomly assigned to one of two tasks (EmoRate, in which participants explicitly rated the emotion shown by the face, and SexRate, requiring explicit rating of the sex of the face). Sample sizes were 35 for EmoRate (23 females), and 41 for SexRate (26 females)—the difference in numbers is due to random assignment by the online platform. No power analysis was carried out to determine sample size, but our initial goal was to collect data of at least 30 participants per task. This sample size was deemed to provide sufficient power to detect a small to medium effect in such a simple task. Previous studies investigating the interaction of emotion and sex in faces have used similar or smaller sample sizes (Becker et al., 2007). Data collection was stopped after 3 months, as this minimum sample size had been achieved, and because it was the end of term. Data collection was not continued after data analysis. The study was approved by the Institutional Review Board (IRB) of Webster University.

Stimuli

The stimulus set included 121 unique avatar faces, each with a different degree of emotional expression and gender morphing (e.g., see Figure 1; the full stimulus set is available online: https://bit.ly/2JkXrpy). A male and a female avatar face with neutral expression were created with FaceGen Modeler 3.5.3 (Singular Inversions Inc.), sampling from a face space created based on high-resolution three-dimension (3D) face scans of 273 real faces. Emotional facial expressions of happiness and anger, and gradual transitions between them, were generated with FacsGen (Krumhuber et al., 2012) based on the Facial Action Coding System (Ekman et al., 2002; coauthor Marc Mehu is a certified FACS coder). Morphing between male and female faces at each level of emotion was achieved with Psychomorph (Tiddeman et al., 2001). All images were in grayscale with equalized luminance. See online supplemental materials for more details on stimulus creation.

Procedure

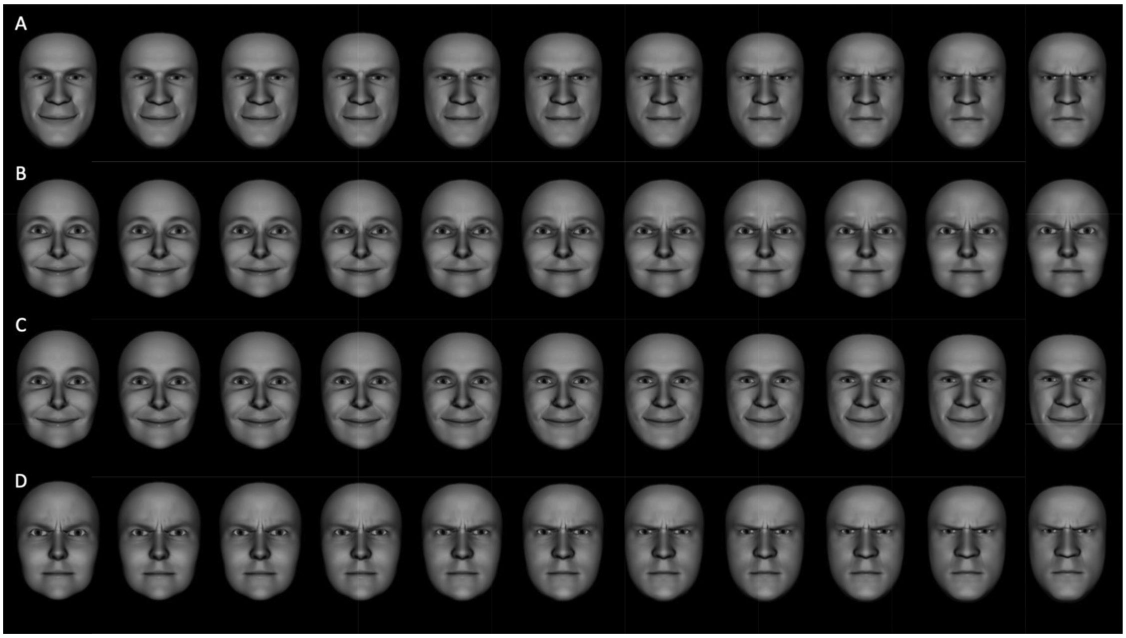
Ratings were collected through an online platform (www.soscisurvey.de). Faces were shown individually, with a rating scale below. Participants rated each face by moving a cursor on a scale using the computer mouse, and clicked on a button to move to the next trial. The task did not advance, if no rating was given. In a between-subjects design, participants were instructed either to judge the emotional expression of faces by moving a cursor on a visual analogue scale with the left and right ends, respectively, labeled "happy" and "angry" (EmoRate), or to judge the biological sex of faces by moving the cursor on a scale with the labels "male" and "female," respectively, on the left and right ends of the scale (SexRate). Every participant judged 121 pictures of faces, without repetitions, varying across 11 levels on both the emotion and the sex dimension, and presented in random order.

Analyses

All measures, manipulations, and exclusion procedures in the study are disclosed. The data and analysis scripts are available online (https://bit.ly/2JkXrpy).

Ratings for each face were saved as numbers between 1 (cursor placed farthest on the left, i.e., 100% happy or male) and 101 (cursor placed farthest on the right, i.e., 100% angry or female). To investigate if ratings were influenced by stimulus' emotion and/or sex, we fitted a separate linear mixed model (LMM) for each task version using the *lmer* function of the *lme4* package in R (Bates et al., 2014; R Core Team, 2020). Each model included the continuous fixed effects Emotion (11 levels, centered), Sex (11 levels, centered), and their interaction, and as random effects by-subject

Figure 1
Selection of 44 of the 121 Stimuli Used in Experiments 1 and 2



Note. (A) Happy male to angry male; (B) happy female to angry female; (C) happy female to happy male; and (D) angry female to angry male.

intercepts and slopes for Emotion, Sex, and their interaction.[2] Main and interaction effects of participants' gender were included in separate models, to control for potential gender differences.

To investigate the hypothesis that the effect of the implicit stimulus dimension is greater for ambiguous levels of the explicit dimension (e.g., the effect of Sex on ratings of Emotion is greater for stimuli that are closer to the center of the emotion dimension, i.e., further away from the full-blown expressions of anger and happiness), an additional model was fitted that included as predictor the ambiguity of the explicit dimension (varying from 0 at the extremes of the continua, to 1 at the center), and its interaction with the task-irrelevant dimension (e.g., Sex in the EmoRate task). The Emotion × Sex interaction term was removed from this model, due to its redundancy.

To directly compare the explicit (i.e., task-relevant) and implicit (i.e., task-irrelevant) effects of stimulus' emotion and sex on ratings, we fitted an LMM with the fixed effects task (EmoRate, SexRate), Explicit (Emotion, Sex), and Implicit (Emotion, Sex), as well as their interactions.

Type-III *F*-tests were computed with the Satterthwaite degrees of freedom approximation. Regression coefficients and their 95% confidence intervals (CIs; computed with the Wald method using the function *confint.merMod*) are also provided. The *emtrends* function in the *emmeans* package served for post hoc comparisons. Complete model tables, made with the *tab_model* function of the *sjPlot* package, are available in the online supplemental materials.

Results

As expected, ratings of emotional expression in the EmoRate task (model: Rating ∼ Emotion * Sex + [Emotion * Sex | Participant]) were significantly predicted by stimulus' Emotion (b = 7.43, 95% CI [6.85, 8.02], $F(1, 34) = 616.46$, $p < .001$), confirming that participants carried out instructions and were able to distinguish happy from angry faces. However, emotion ratings were also influenced by the task-irrelevant dimension of stimulus' sex, as shown by a main effect of Sex (b = 1.30, 95% CI [1.00, 1.59], $F(1, 34) = 73.48$, $p < .001$), with higher ratings of anger for male than female faces. Inclusion of the predictor Participant Sex (model: Rating ∼ Emotion * Sex * Participant Sex + [Emotion * Sex | Participant]) resulted in the same main effects of Emotion and Sex, as well as in an Emotion × Participant Sex interaction (b = 1.27, 95% CI [.08, 2.44], $F(1, 33) = 4.42$, $p = .04$). The latter reflected a steeper slope of ratings of emotion in female (b = 7.87) compared with male participants (b = 6.61, p = .03 for the difference in slopes), indicating that female participants were slightly more sensitive than male participants to subtle changes in facial expression. Note, however, that effects of stimulus sex on ratings did not differ between male and female participants, as both the two-way Sex × Participant Sex and the three-way Emotion × Sex × Participant Sex interactions were not significant.

Moreover, when Ambiguity was included in the model (Rating ∼ Emotion + Sex + Ambiguity + Sex: Ambiguity + [Emotion + Sex + Ambiguity + Sex: Ambiguity | Participant]), a significant Sex × Ambiguity interaction (b = 1.39, 95% CI [.79, 1.98], $F(1, 34) = 21.16$, $p < .001$) confirmed the assumption that ratings of

[2] The model for both tasks was: Rating ∼ Emotion * Sex + (Emotion * Sex | Participant), with the difference being the DV (ratings of emotion in the EmoRate task; ratings of sex in the SexRate task). If a model did not converge or resulted in singular fits, the random effects structure was gradually simplified (e.g., removing the slope for the interaction). For model details see Results section here below, and the tables in online supplemental materials.

emotion are mainly influenced by stimulus' sex when the stimulus' emotion is ambiguous (Figure 2A and 2C and https://plot.ly/~skorb/44).

As expected, ratings of biological sex in the SexRate task (model: Rating ~ Emotion * Sex + [Emotion * Sex | Participant]) were significantly predicted by the relevant target dimension Sex ($b = 7.27$, 95% CI [6.55, 7.98], $F(1, 39) = 395.44$, $p < .001$), confirming that participants could accurately identify the sexual characteristics of the stimuli. However, sex ratings were also influenced by the emotional expressions of the stimuli (see Figure 2B and 2D and https://plot.ly/~skorb/46), as suggested by a significant main effect of Emotion ($b = 3.34$, 95% *CI* [2.97, 3.70], $F(1, 39) = 314.18$, $p < .001$), and a significant Emotion X Sex interaction ($b = -.18$, 95% CI [−.26, −.10], $F(1, 39) = 20.61$, $p < .001$). This implicit effect of emotional expression on ratings of sex occurred mainly for stimuli with ambiguous sexual features, as indicated by a significant Emotion × Ambiguity interaction ($b = 3.53$, 95% CI [2.75, 4.31], $F(1, 39) = 78.36$, $p < .001$), in the model including the predictor Ambiguity. Inclusion of the predictor participant Sex (model: Rating ~ Emotion * Sex * Participant Sex + [Emotion * Sex | Participant]) did not change the pattern of results, and did not result in significant main or interaction effects with participant Sex.

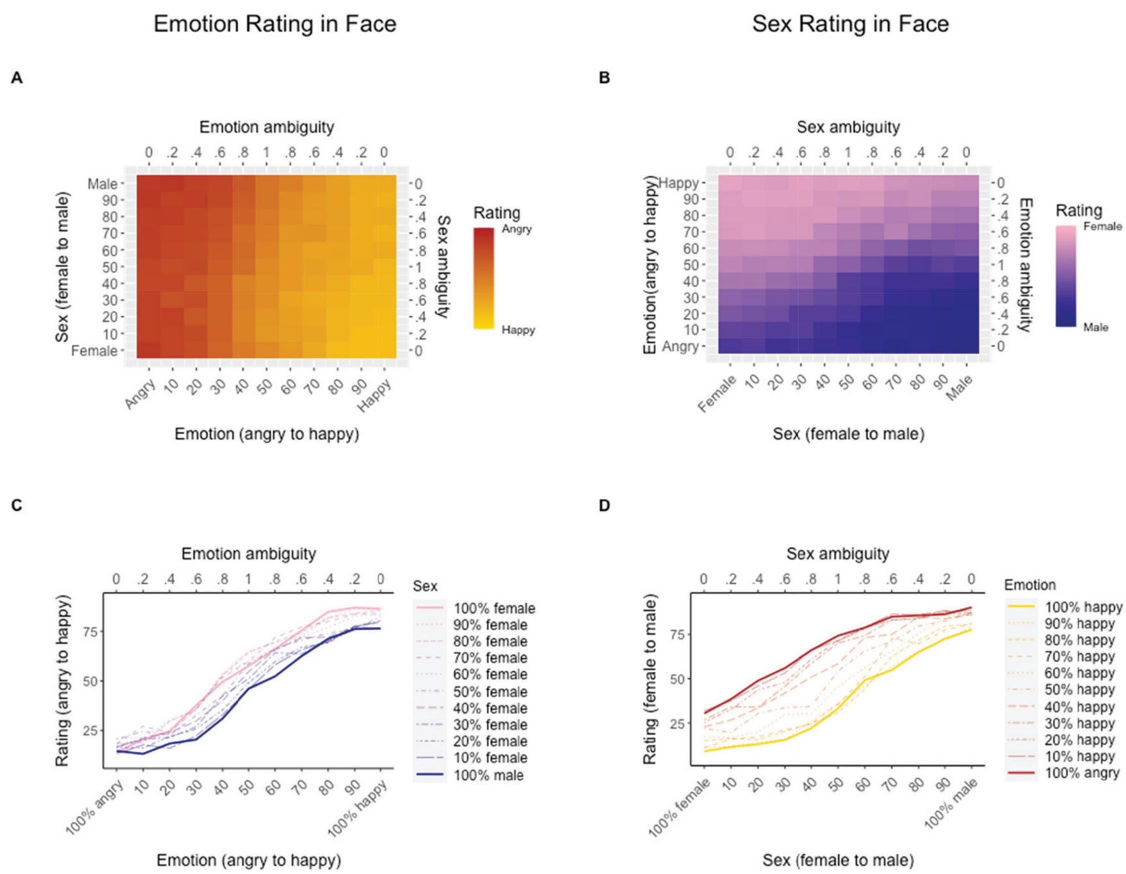
Directly comparing explicit (i.e., task relevant) and implicit (i.e., task irrelevant) effects of stimulus' sex and emotion across tasks (model: Rating ~ Task * Explicit * Implicit + [Explicit * Implicit | Participant]), resulted in all main and interaction effects being significant (all $F > 6.9$, all $p < .01$), with exception of the Task × Explicit interaction ($b = -.06$, 95% CI [−1.33, 1.21], $F(1, 107.17) = .01$, $p = .92$). The significant triple interaction of Task × Explicit × Implicit ($b = 1.24$, 95% CI [.75, 1.73], $F(1, 94.76) = 24.65$, $p < .001$) reflected strong (steep slopes) and near identical effects of both explicit emotion ($b = 23.26$) and sex ($b = 23.14$; Figure 3A), but smaller implicit effects overall, and importantly a greater effect of implicit emotion ($b = 10.6$) than of implicit sex ($b = 4.03$; Figure 3B).

Discussion of Experiment 1

The results of Experiment 1 indicate the following. First, participants could reliably identify the emotional expression and the sex of the avatar faces in the newly created stimulus set, as revealed

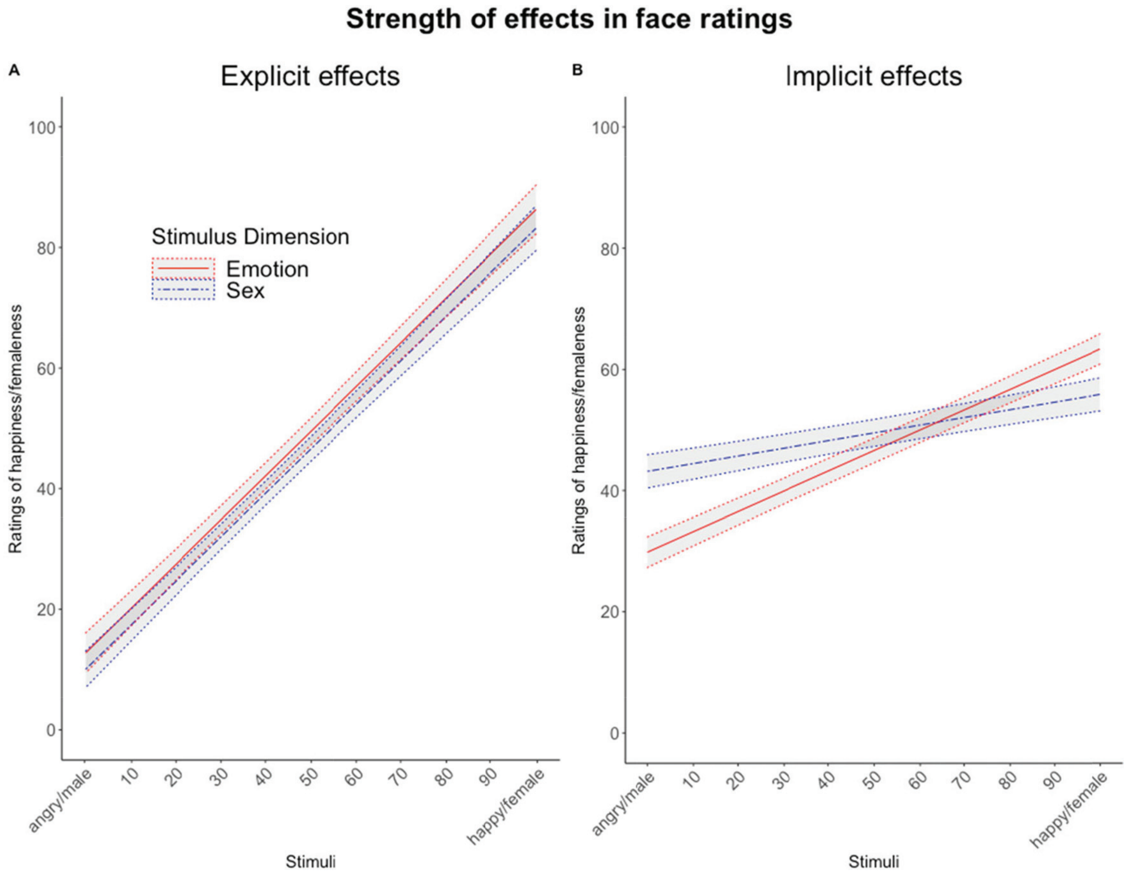
Figure 2

Results of Face Ratings (Experiment 1)



Note. (A) Heat map of all stimuli showing ratings of emotion (happy to angry); (B) heat map showing ratings of sex (male to female)—note the skew in the color gradient for angry compared with happy faces, reflecting the Emotion × Sex interaction; (C) emotion ratings by stimulus' emotion (*x*-axis) and sex (line types); (D) sex ratings by stimulus' sex (*x*-axis) and stimulus' emotion (line types); Graphs C and D also available in three-dimension (3D; https://plot.ly/~skorb/44, https://plot.ly/~skorb/46). See the online article for the color version of this figure.

Figure 3
Comparison of Explicit and Implicit Effects on Face Ratings (Experiment 1)



Note. (A) Explicit effects are large and similar for both stimulus dimensions: happiness ratings increase with the actual happiness of the stimulus (Explicit effect of emotion), just as much (same slope) as femaleness ratings increase with the actual femaleness of the stimulus (Explicit effect of sex). (B) Implicit effects are overall smaller than explicit ones, and they differ between stimulus dimensions: ratings of femaleness increase with the happiness of the stimulus (Implicit effect of emotion), and this effect is bigger (steeper slope) than the amount by which happiness ratings increase with the femaleness of the stimulus (Implicit effect of sex). See the online article for the color version of this figure.

by a linear relationship between happiness in the stimuli and ratings of happiness (Figures 2A, 2C, and 3A), and a linear relationship between the presence of male-like sexual features in the faces, and ratings of maleness (Figures 2B, 2D, and 3A). Second, the ratings of each stimulus dimension were influenced by the, respectively, other dimension (confirming H1), as shown by a main effect of stimulus' sex on ratings of emotion (Figures 2A, 2C, and 3B), and a main effect of stimulus' emotion on ratings of sex (Figures 2B, 2D, and 3B). Third, H2 was confirmed by the finding that effects of stimulus' sex on emotion ratings were largest for faces with ambiguous emotional features, as shown by an emotion by ambiguity interaction effect; similarly, effects of stimulus' emotion on sex ratings were largest for faces with ambiguous sexual features. Fourth, explicit effects of emotion and sex were of comparable size, providing direct evidence that our stimulus set is of comparable difficulty across the two facial features (Figure 3A). Fifth, confirming H3, explicit effects were significantly larger than implicit effects (Figure 3B) for both stimulus' emotion and sex. Although not the focus of this research, we also included participants' sex as statistical predictor. Female participants were found to be more sensitive than male participants to subtle changes in emotional expression—but not to changes in sexual face features. Finally, emotion had a larger implicit effect on ratings of sex, than vice versa (Figure 3B), while explicit effects of emotion and sex were of comparable size (Figure 3A). H4 was confirmed, and the alternative H5, stating that perceivers rely more on invariant than dynamic cues, was not supported.

The results of Experiment 1 are in line with previous research, confirming that the emotional expression and the sex of a face are not processed independently (Becker et al., 2007; Harris et al., 2016; Hess et al., 2009). They also extend previous research, as the emotional and sexual characteristics of a face were varied in a gradual fashion, and their explicit and implicit effects could be assessed and compared.

In Experiment 1, facial features outside of the focus of attention influenced judgments about task-relevant facial features. One possible, although unlikely, explanation of these effects is that, even though not instructed to do so, participants in the

EmoRate task may have taken the time to also analyze the sexual characteristics of the faces, and may have chosen the strategy to take into account the sex dimension when providing emotion ratings. The absence of time restrictions, and also the fact that Experiment 1 was carried out online, that is, outside the controlled environment of an experimental laboratory, provided ample possibilities for both task–relevant and task–irrelevant stimulus dimensions to be consciously analyzed and used.

Experiment 2: Categorization of Faces

We decided to bring participants into the lab for a preregistered second experiment (link of preregistration on Open Science Framework: https://bit.ly/2v8BW7Q), in which the same face stimuli used in Experiment 1 were categorized by sex or emotion, and participants were instructed to answer as quickly and accurately as possible, according to their first impression (see online supplemental materials for task instructions). In addition to providing a more controlled testing environment and to emphasize more the speed of participants' responses, Experiment 2 allowed us to analyze reaction times (RTs) as an additional measure of explicit and implicit effects of stimulus' emotion and sex. In an attempt to rule out the effects of individual differences, we also controlled for participants' self-reported levels of alexithymia, autism spectrum disorders, mood, and gender stereotypes about the experience and expression of anger and happiness, by including them as covariates in the statistical models. We had the same hypotheses as for Experiment 1, but also wondered (not preregistered) if RTs would be slower for happy males and angry females, especially for ambiguous stimuli on the explicit dimension.

Method

Participants

Participants (N = 108, 75 females, age range 18 to 33 years, M_{age} = 21.51, SD = 2.9) were recruited from a research pool of psychology students, signed informed consent, and received study credits for their participation. A minimum sample size of 103 participants was determined with the software G*Power, based on a separate categorization task, which was always completed first, and which was part of a preregistered replication (see Procedure). The study was approved by the ethics committee of the University of Vienna.

Stimuli

The stimuli used in Experiment 2 were identical to those used in Experiment 1.

Procedure

Up to 10 participants were tested simultaneously, each sitting in front of a computer screen in separate cubicles. Following a within-subjects design, participants completed two tasks in randomized order. In the EmoCat task, each trial included a central fixation cross (1 s), followed by one of the 121 faces (1 s), followed by a central question mark (1.5 s). Instructions were to indicate, as quickly and accurately as possible, if the emotion of the face was happy or angry, when the question mark appeared on screen. Perceived emotion was categorized by pressing the right or left arrow button on a standard computer keyboard, using the index and middle (or ring) fingers of the dominant hand. The assignment of the buttons to emotions was counterbalanced across participants, and stimulus presentation order was randomized. The SexCat task was identical, with the difference that faces needed to be categorized as male or female by pressing the left or right arrow button (assignment of keyboard buttons was again counterbalanced across participants).

Experiment 2 was part of a preregistered study (https://bit.ly/2v8BW7Q). It was preceded by an emotion-categorization task with other (real) face stimuli, as used by Harris et al. (2016; results presented in Korb & Massaccesi, 2020), and followed by a series of questionnaires that were filled out online on the same computer (www.soscisurvey.de). All tasks were programmed with PsychoPy2 (Peirce et al., 2019). The entire session lasted between 30 and 45 min.

The required sample size was estimated based on the effect size reported for the first emotion-categorization study (Harris et al., 2016). For the main effect we aimed to replicate in that study (the difference in PSE for male and female faces), Harris et al. (2016) reported an effect size of Cohen's d = .28. Using the software G*Power, a total sample size of 103 participants was estimated to be necessary to replicate the effect with 80% power at alpha .05. To account for eventual technical errors and dropouts we aimed to test up to 110 participants, but had to stop at N = 108 due to organizational reasons. The data was analyzed after the end of data collection, and data collection did not continue after data analysis.

Questionnaires

Participants filled out a series of questionnaires measuring handedness, alexithymia (TAS-20; Taylor et al., 2003), autism spectrum disorders (AQ; Baron-Cohen et al., 2001), and mood (PANAS; Watson et al., 1988). In addition, two short questionnaires were created based on previous publications (Fabes & Martin, 1991; Plant et al., 2000) to assess participants' cultural stereotypes and personal beliefs about the experience and expression of anger and happiness in men and women (see online supplemental materials). We computed a cultural stereotype (CS) and a personal beliefs (PB) score, by reversing nonstereotypical items (e.g., belief that women express anger; see online supplemental materials), before summing all CS and PB items separately.

Analyses

All measures, manipulations, and exclusions in the study are disclosed. The data and analysis scripts are available online (https://bit.ly/2JkXrpy). Trials without response, and trials with RT below 200 ms (6.8 and 5.9% for the two tasks) were excluded from analyses.

Categorization choices were analyzed, separately for the EmoCat and SexCat tasks, with generalized linear mixed-effects binomial models (GLMM). These models included categorization choice as dependent variable (happy/angry or male/female, depending on the task), stimulus' Emotion and Sex (both continuous) and their interaction as fixed effects, and by-subject random intercepts and random slopes for Emotion, Sex, and their interaction.[3] To investigate the hypothesis that the task-irrelevant dimension influences categorization mostly when the task-relevant dimension is ambiguous, we also included as fixed effects Ambiguity (varying from 0 at the extremes of the continuum, to 1 at the center), and its interaction with Emotion and Sex. To directly compare the explicit and implicit effects of Emotion and Sex on categorization choice, we fitted a GLMM with the fixed effects task (EmoCat, SexCat), Explicit (Emotion, Sex), and Implicit (Emotion, Sex), as well as their interactions.

RTs were analyzed with linear mixed effects models (LMMs), which included the fixed effects Emotion (categorical factor with 11 levels) and Sex (continuous) in the EmoCat task, and Emotion (continuous) and Sex (categorical factor with 11 levels) in the SexCat task. To compare the size of the implicit effects in the RT data, we first extracted, for each level of the implicit dimension, the level of the explicit dimension where RT was the slowest. For example, in the EmoCat task, we obtained per subject 11 values, each corresponding to the level of the explicit dimension emotion, where RT for each level of Sex (implicit dimension) was the slowest. The same was done for the SexCat task, resulting in overall 22 values per subject (11 per task). These values were then fitted with a LMM that contained as fixed effects the task (EmoCat, SexCat), the Implicit dimension (sex in EmoCat, emotion in SexCat), and their interaction. Intercept and slope for the Implicit dimension were allowed to vary randomly by subject. It is important to point out, that this analysis gives us only two values per subject for the explicit effects (namely, the level of the explicit dimension where the RT is the slowest—this is the main effect of Task). We only plot the marginal meals for the implicit effects (Figure 6B).

To control for individual differences, participants' sex and questionnaire scores were included as covariates in separate models. Categorical predictors (e.g., stimulus Emotion) were centered through effect coding (e.g., −1, 1), continuous predictors (i.e., questionnaire scores) were mean-centered and scaled.

The *glmer* and *lmer* functions of the *lme4* package in R were used for, respectively, fitting GLMMs and LMMs. Model tables are provided in the online supplemental materials.

Results

Categorization Choices

Categorization choices in the EmoCat task (model: Choice ~ Emotion * Sex + [Emotion * Sex | Participant], family = binomial) depended on stimulus' Emotion (b = 5.7, 95% CI [5.21, 6.15], z = 23.66, p < .001) and Sex (b = −.1.0, 95% CI [−1.18, -.82], z = −10.71, p = .001), as well as their interaction (b = −.66, 95% CI [−.93, −.39], z = −4.80, p < .001), see Figure 4A (online version https://plot.ly/~skorb/48).

A further model was fitted to investigate our hypothesis that in the EmoCat task sex influences emotion categorizations predominantly when the stimulus' emotion is ambiguous (model: Choice ~ Emotion + Sex + Ambiguity + Emotion: Sex + Emotion: Ambiguity + Sex: Ambiguity + [Emotion + Sex + Ambiguity | Participant], family = binomial). This model resulted in the expected significant Sex × Ambiguity interaction (b = −.28, 95% CI [−.39, −.16], z = −4.68, p < .001), confirming that ambiguity in the emotional expression makes participants' emotion categorization more likely to be influenced by the task-irrelevant stimulus dimension Sex.

Categorization choices in the SexCat task (model: Choice ~ Emotion * Sex + [Emotion * Sex | Participant], family = binomial) depended on the Emotion (b = −1.59, 95% CI [−1.72, −1.45], z = −23.10, p < .001) and Sex (b = 4.28, 95% CI [4.00, 4.55], z = 30.42, p < .001) of the stimulus, as well as on their interaction (b = .29, 95% CI [.13, .45], z = 3.59, p < .001), see Figure 4B (online graph: https://plot.ly/~skorb/50).

The pattern of results for both tasks remained unchanged after inclusion of the covariates participants sex, scores on the AQ and TAS-20 questionnaires, scores on the positive and negative subscales of the PANAS questionnaire, or the cultural stereotypes (CS) and personal beliefs (PB) scores (all models followed the formula: Choice ~ Emotion * Sex + COVARIATE + [Emotion * Sex | Participant]).

Inclusion of the predictor Ambiguity resulted in a significant Emotion × Ambiguity interaction (b = .45, 95% CI [.28, .61], z = 5.31, p < .001), confirming that ambiguity in a face's sexual features make participants' sex categorization more likely to be influence by the task-irrelevant stimulus dimension emotion.

Reaction Times (RT)

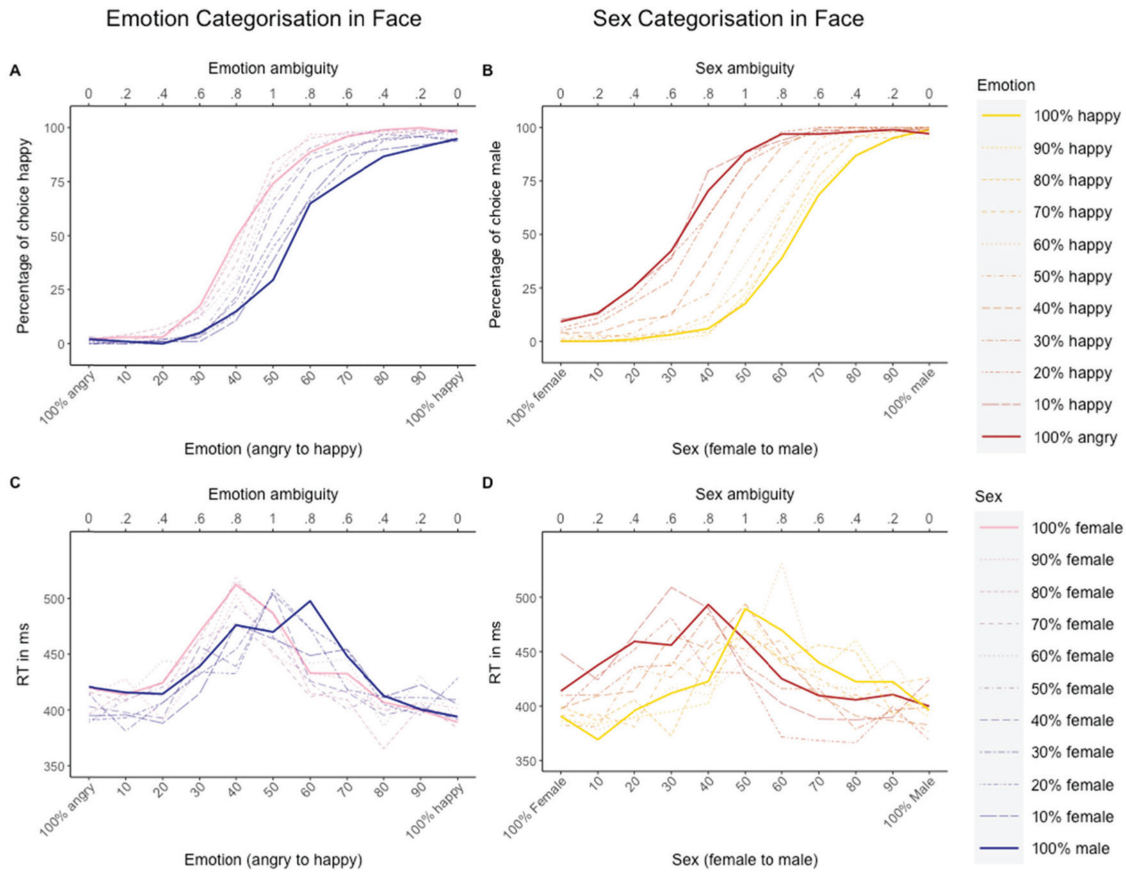
Average RT did not differ significantly (t(214) = −.25, p = .80) between EmoCat (M = 407.8, SD = 211.8) and SexCat (M = 404.02, SD = 205. 02, see also online Supplemental Materials Figure S1), suggesting that the two tasks were of comparable difficulty. For the EmoCat task, a LMM on log-transformed RT (model: RT ~ Emotion * Sex + [1 | Participant]) resulted in a significant main effect of Emotion (F(10, 11,890) = 39.03, p < .001), and a significant Emotion × Sex interaction (F(10, 11,890) = 4.21, p < .001). The interaction was driven by increasingly slower RTs to happy faces depending on the masculinity of the face, and to angry faces depending on the femininity of the face (Figure 4C). These effects emerged only for faces with 40% and 60% happiness, that is, with an ambiguous emotional expression (p = .003 and .002, respectively). Similarly, for RTs in the SexCat task (model: RT ~ Emotion * Sex + [1 | Participant]) significant effects of Sex (F(10, 12,028) = 19.50, p < .001) and Emotion × Sex (F(10, 12,028) = 17.32, p < .001) were found, as well as a marginally significant effect of Emotion (F(1, 12,028) = 3.29, p = .07). In the SexCat task RTs were slower for female faces with an expression of anger, and for male faces with an expression of happiness (Figure 4D). Post hoc comparisons showed that the effect of emotion was significant for faces with 20–40 and 60–90% of femaleness, which present more ambiguous sexual features, but not for faces with 0, 10, 50, or 100% of femaleness.

Directly comparing explicit and implicit effects of stimulus' sex and emotion on categorization choices across the EmoCat and SexCat tasks (model: Choice ~ Task * Explicit * Implicit + [Task * Explicit * Implicit | Participant], family = binomial) resulted in all main and interaction effects to be significant (all z > 2.3, all p < .02), including the triple interaction of Task × Explicit × Implicit (b = −.18, 95% CI [−.33, −.03], z = −2.36, p = .02).

[3] Unless the models did not converge, in which case the random effects structure was gradually simplified.

Figure 4

Results of Face Categorization (Experiment 2)



Note. Average percentage of happy choices (A) and Average reaction times (C) for responses in the emocat task by emotion (x-Axis) and sex (line types); average percentage of male choices (B) and average reaction times (D) for responses in the sexcat task by sex (x-axis) and emotion (line types). A and B are also available as three-dimensional (3D) versions (https://plot.ly/~skorb/48, https://plot.ly/~skorb/50). See the online article for the color version of this figure.

Bigger effects of Emotion than Sex were found at both the explicit level (Figure 5A; Task × Explicit: $z = -5.22$, $p = .001$) and implicit level (Figure 5B; Task × Implicit: $z = 5.19$, $p = .001$).

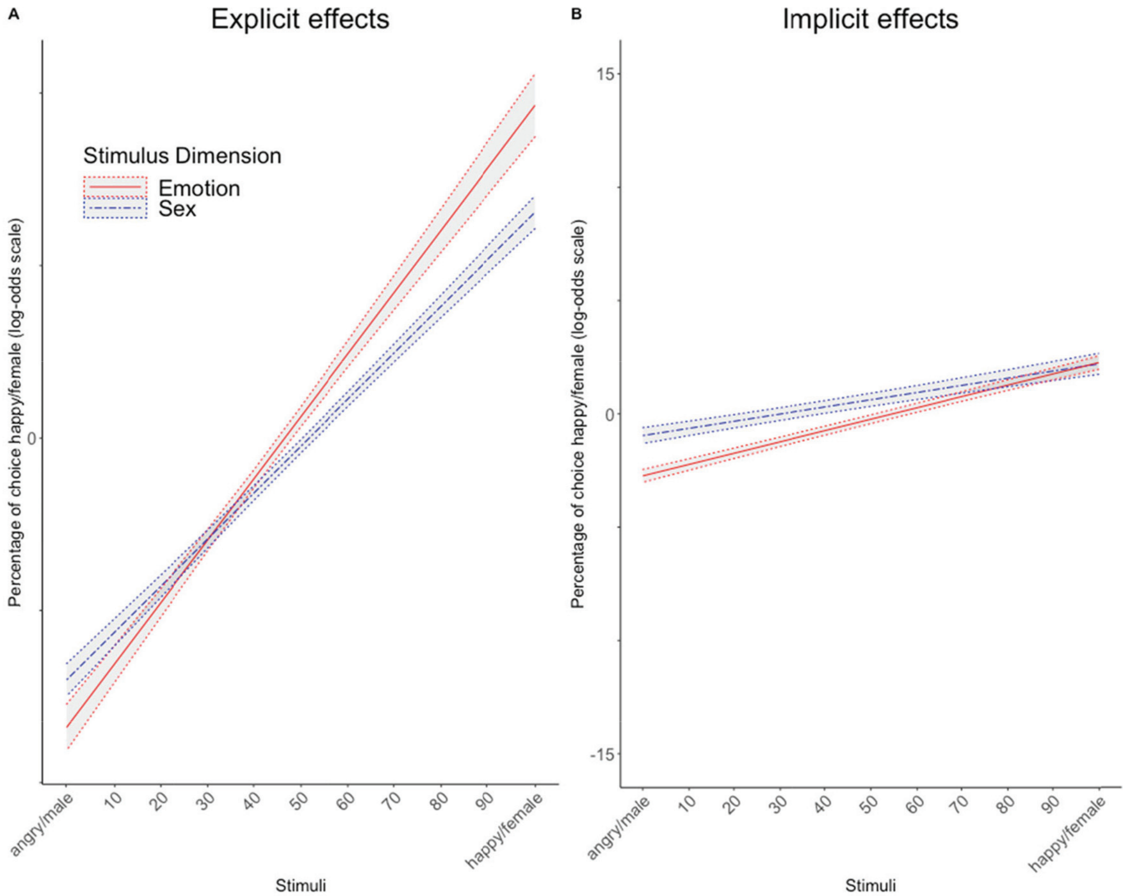
The LMM fitted on the implicit effects of RT data (model: RT ~ Task * Implicit + [Implicit | Participant]) resulted in a main effect of Implicit ($F(1, 107.19) = 29.15$, $p < .001$), due to slower RTs when the explicit and implicit dimensions went against their stereotypical male-anger and female-happiness association.[4] For example, in the EmoCat task, with increasing levels of femaleness in the implicit dimension sex, the point where RTs were the slowest shifted toward anger. Conversely, with increasing levels of maleness, slowest RTs were found for ambiguously happy faces. This finding in RTs is in line with the results obtained from participants' categorization choices. The main effect of task was not significant ($F(1, 2156.03) = 3.05$, $p = .08$). A significant Task × Implicit interaction ($F(1, 2155.01) = 7.19$, $p = .007$) reflected that implicit effects of emotion ($b = -.12$) were larger than implicit effects of sex ($b = -.08$; see Figure 6B). Similarly to the results obtained from the analysis carried out on participants' categorization choices, the RT data suggests that implicit effects of emotion prevail over implicit effects of sex.

Discussion of Experiment 2

Experiment 2 used the same face stimuli as Experiment 1, but measured accuracy and RTs during emotion/sex categorization in the laboratory. Moving away from ratings provided on a visual analogue scale allowed us to investigate if the findings of Experiment 1 would hold when participants are answering more rapidly. The results were in line with those of Experiment 1. First, categorization accuracy of the explicitly evaluated stimulus' emotion and sex were influenced by the, respectively, implicit stimulus dimension. Second, this effect was strongest for more ambiguous stimuli, that is, emotion categorization was most influenced by stimulus' sex for faces with blends of emotion (Figure 4A), and sex categorization was most influenced by stimulus' emotion for androgynous faces (Figure 4B). Similar findings emerged for RTs, which were slower for mildly happy male and mildly angry female faces (Figure 4C) as well as for ambiguously female angry and ambiguously male happy faces (Figure 4D). In line with our findings, slower RTs for the categorization of happy male and angry

[4] See Method section for more details.

Figure 5
Comparison of Explicit and Implicit Effects on Face Categorization (Experiment 2)



Note. (A) Explicit effects are large and similar across stimulus dimensions: The likelihood of categorizing a face as happy increases with the actual happiness of the stimulus (Explicit effect of emotion), similarly (similar slope) to the way the likelihood of categorizing a face as female increases with the actual femaleness of the stimulus (Explicit effect of sex). (B) Implicit effects are smaller than explicit ones, and they differ between stimulus dimensions: the likelihood of categorizing a face as female increases with the happiness of the stimulus (Implicit effect of emotion), and this effect is larger (steeper slope) than the amount by which the likelihood of categorizing a face as happy increases with the femaleness of the stimulus (Implicit effect of sex). See the online article for the color version of this figure.

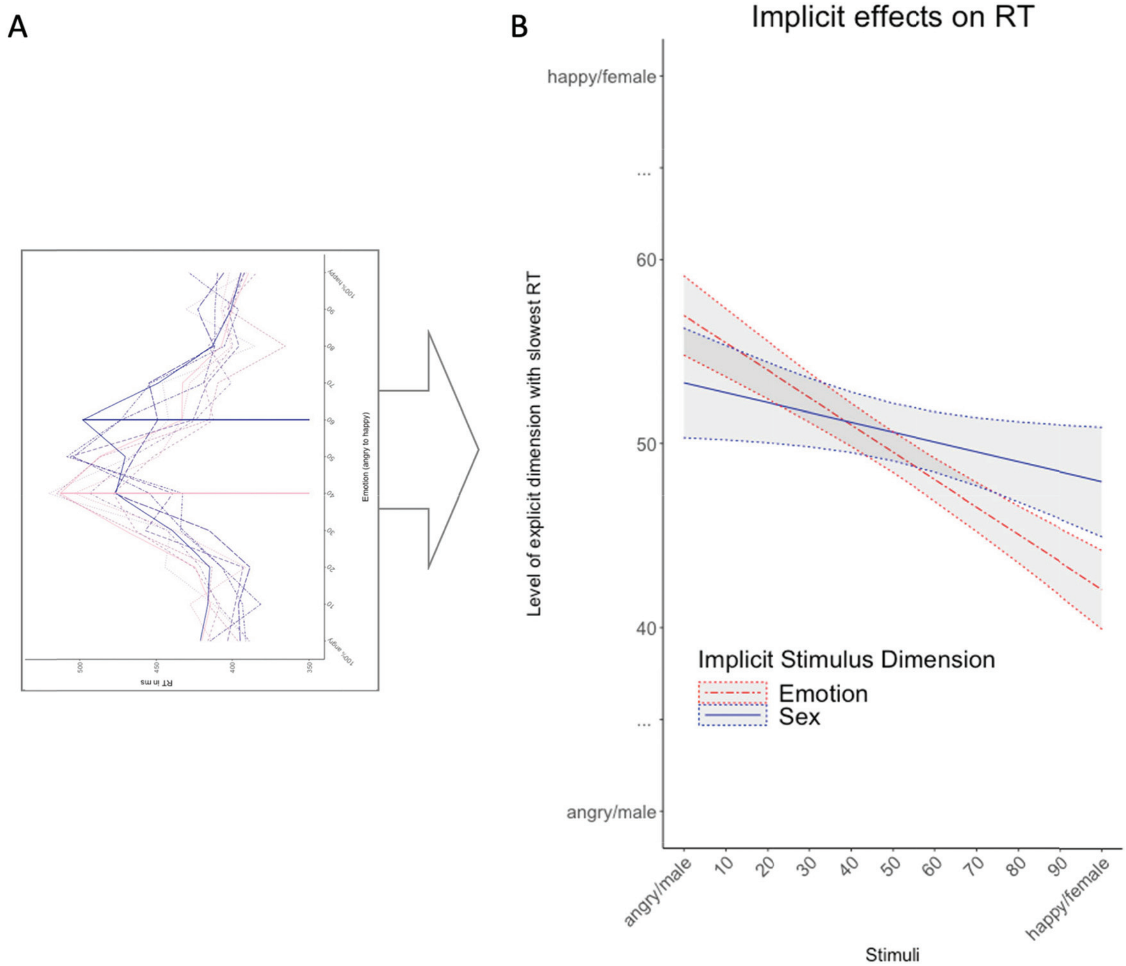
female faces had previously been reported (Aguado et al., 2009; Becker et al., 2007). These results did not change when controlling for participants' sex, autism, alexithymia, mood, or gender stereotypes about the experience and expression of emotions. Finally, effects of stimulus' emotion prevailed over effects of stimulus' sex for the categorization choices, at both the explicit and implicit level (see Figure 5). Implicit effects were also larger for emotion than sex in RT data (see Figure 6). This asymmetry is unlikely to be due to differences in task difficulty, as RTs did not differ between emotion and sex categorization.

Experiment 3: Rating of Voices

Experiment 1 and 2 confirmed the presence of a reliable association, in participants' ratings and categorizations, of happiness with female and anger with male faces. Moreover, implicit effects were greater for emotion than sex. Explicit effects were also found to be greater for emotion than sex in Experiment 2, but not in Experiment 1. However, little is known about whether the mutual influence of emotion and sex cues also extends to other sensory modalities (for initial evidence in favor see Bonebright et al., 1996), and if task-relevant versus -irrelevant dimensions influence emotion and sex recognition in a similar way outside of the visual modality. These questions were investigated in a preregistered (https://osf.io/vhc9g) online rating experiment, using as stimuli 121 human vocalizations gradually varying in emotional expression and sexual characteristics. In two separate tasks completed in counterbalanced order, participants rated the emotional expression and the sex of each voice.

Past research in the voice domain has shown that stimuli obtained through morphing between emotions can be reliably recognized by participants (Bestelmeyer et al., 2010; Laukka, 2005). Recently it

Figure 6
Comparison of Implicit Effects on RT during Face Categorization (Experiment 2)



Note. (A) visualization explaining how we identified in the EmoCat task, for each level of the explicit dimension Emotion, the level of the implicit dimension Sex with the slowest reaction time (RT). The example shows this for the 40% and 60% happiness and for the 100% male (solid blue line) and 100% female (solid pink line) sex levels in the EmoCat task. But the same procedure was applied to all levels in both the EmoCat and SexCat tasks, and per participant. (B) Implicit effects are larger for emotion than sex, as shown by the steepness of the slopes. See the online article for the color version of this figure.

was also shown that the early brain responses to these type of stimuli reflect categorical perception, while later stages of perception reflect more dimensional perception (Giordano et al., 2021). However, no study has yet investigated the perception of human voices gradually changing in both their emotional expression and sex.

The following hypotheses were made based on the literature and Experiments 1 and 2 (see preregistration). We predicted that ratings in both the EmoRate and SexRate tasks would be predicted by the explicit as well as the implicit stimulus dimension—that is, we expected greater ratings of happiness for female compared with male voices, and greater ratings of maleness for angry compared with happy voices. We also expected that the effects of the implicit dimension would become especially visible when the explicit dimension is ambiguous. Finally, we expected greater implicit effects of emotion than sex, but no difference of emotion and sex at the explicit level.

Method

Participants

Sample size was estimated based on Experiment 1. As statistics carried out on within-subjects designs are statistically more powerful, we decided to recruit about half the sample size tested in Experiment 1, plus some extra participants to make up for eventual data loss. Moreover, we set a 1-month time frame. Our goal was to collect data from at least 50 participants during 1 month. Data collection was not continued after data analysis. The study was approved by the Ethics Committee of the University of Essex, United Kingdom.

Participants were recruited through announcements on social media, and were randomly assigned to one of two task orders (first EmoRate or first SexRate). After exclusion of participants older than 45 years (as this was the age limit approved by the Ethics

Committee), and who took more than 45 min to complete the survey (this duration suggesting, based on pilot testing, that they did not complete the task without interruption), the final sample included 72 people (20 males, 52 females, age range 21 to 45 years, M_{age} = 29.6, SD = 6.25).

Stimuli

A voice stimulus set analogous to the face stimuli was created using the voices of two young adults (White, one female, M_{age} = 24.4, SD = .4 years). Speakers were instructed to repeatedly vocalize "A" with intonations of happiness or pleasure and anger, while picturing themselves in the respective situations. Voice recordings were made in a sound-proof chamber with calibrated microphone and digitized to a computer using the software Praat (http://www.praat.org). Two vocalizations of 500 ms duration were selected for each speaker. Background noise was removed using audacity (https://audacityteam.org) and mean intensity was normalized to 70 db. Mean intensities did not differ significantly (F(3, 88,196) = .02, p = .99). For each speaker, anger was morphed into happiness in 11 steps using the STRAIGHT software (Kawahara et al., 1999). At each emotion level, the male voice was then morphed into the female voice, again in 11 steps. The full set comprises 121 voices and is available online (https://bit.ly/2JkXrpy).

Procedure

Ratings were collected online (www.soscisurvey.de), using a similar procedure as Experiment 1. In each trial, a voice was played, with the 'play' icon on the top, and a rating scale on the bottom of the screen. Participants rated each voice by moving with the computer mouse a cursor on the scale, and clicked on a button to move to the next trial. Participants were free to replay each voice as often as they wanted, but were encouraged to progress quickly through the task. In a within-subjects design, participants judged in separate tasks (order counterbalanced) the emotional expression of voices by moving a cursor on a visual analogue scale with the left and right ends, respectively, labeled happy and angry (EmoRate), and the biological sex of voices by moving the cursor on a scale with the left and right ends labeled male and female (SexRate). The same rating scales were used as in Experiment 1. During each task, every participant judged 121 voices, which were presented in random order without repetitions and varied across 11 levels on both the Emotion and the Sex dimension. Participants also provided their age and gender at the beginning of the experiment, and filled out the PANAS questionnaire (Watson et al., 1988), which assesses positive and negative affect, at the end.

Analyses

All measures, manipulations, and exclusion procedures in the study are disclosed. The data and analysis scripts are available online (https://bit.ly/2JkXrpy). We conducted the same analyses as for Experiment 1. In addition, we controlled for participants' gender, age, and mood as measured with the PANAS, by including them as covariates. Complete model tables are provided in the online supplemental materials.

Results

The following model was fitted to the EmoRate task ratings: Emotion + Sex + Ambiguity + Sex: Ambiguity + (Emotion + Sex + Ambiguity + Sex: Ambiguity | Participant). As expected, ratings of emotional expression in the EmoRate task were significantly predicted by stimulus' Emotion (b = 7.09, 95% CI [6.56, 7.61], F(1, 71.01) = 698.50, p < .001), confirming that participants carried out instructions and were able to distinguish happy from angry voices (Figure 7A and 7C). There was also a small but significant Emotion × Sex interaction (b = .04, 95% CI [.00, .08], F(1, 70.44) = 4.54, p = .04). No other effects were significant or marginally significant. The results did not change when including the covariates participant age, gender, and mood. Emotion ratings were not, as expected (H2–3), influenced by the task-irrelevant dimension of stimulus' sex.

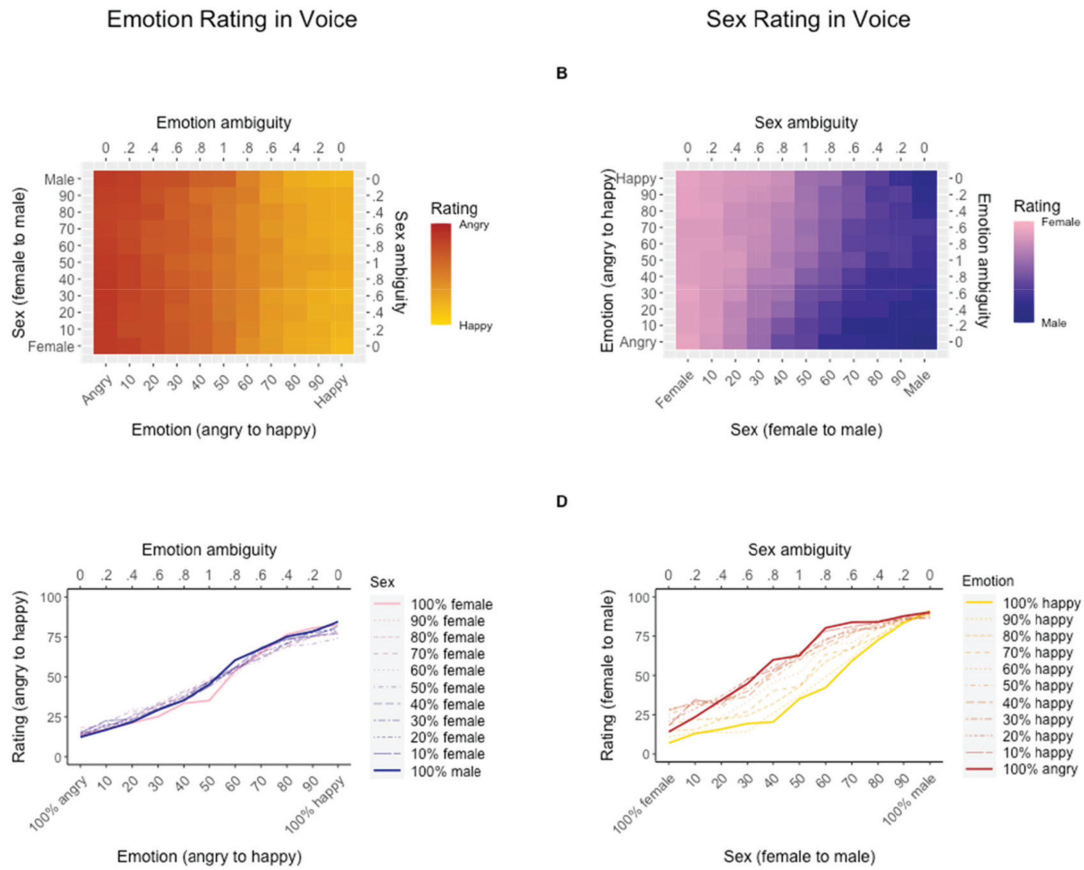
We fitted the following model to the rating data from the SexRate task (Figure 7B and D): Emotion + Sex + Ambiguity + Emotion: Ambiguity + (Emotion + Sex + Ambiguity + Emotion: Ambiguity | Participant). Participants were, as expected (H4), able to correctly recognize the sex of the stimulus voice, as indicated by a significant main effect of Sex (b = 7.74, 95% CI [7.22, 8.26], F(1, 70.9) = 856.41, p < .001). In line with H5, ratings were also influenced by the other stimulus dimension, as indicated by a marginally significant main effect of Emotion (b = .46, 95% CI [−.06, .98], F(1, 94.8) = 3.04, p = .08) and a statistically significant Emotion × Ambiguity interaction (b = 3.45, 95% CI [3.03, 3.87], F(1, 8329.1) = 259.59, p < .001). As expected, ratings of maleness gradually increased from happy to angry voices, especially when the sex of the voice was ambiguous.

We then directly compared explicit and implicit effects of stimulus' sex and emotion across tasks (model: Rating ∼ Task + Explicit + Implicit + Task: Explicit + Task: Implicit + Explicit: Implicit + [Task + Explicit + Task: Explicit + Task: Implicit + Explicit: Implicit | Participant). A significant Explicit × Implicit interaction (b = .98, 95% CI [.63, 1.34], F(1, 71.9) = 29.43, p < .001) reflected greater explicit than implicit effects overall (steeper slopes in Figure 8A than 8B). Moreover, in line with the ratings of faces in Experiment 1, implicit effects of emotion (b = 6.42) in voices were larger than implicit effects of sex (b = −.29), as shown by a significant Task × Implicit interaction (b = 3.35, 95% CI [2.48, 4.23], F(1, 72.1) = 56.20, p < .001). Unexpectedly, effects of sex (b = 24.5) were larger than emotion (b = 22.4) at the explicit level (b = 1.05, 95% CI [.03, 2.03], F(1, 72.0) = 4.08, p = .047), although this difference was small. The results suggest (in agreement with Hypothesis 7 [H7]) that emotion and sex mainly differed in how they modulated participants' ratings when they were not task-relevant. In particular, the implicit effect of emotion was larger than the implicit effect of sex (Figure 8B), while explicit effects of emotion and sex were similar (Figure 8A).

Discussion Experiment 3

This is, to the best of our knowledge, one of very few demonstrations (see Bonebright et al., 1996) that emotion and sex features influence each other during human voice perception. The results replicate, with some differences, previous findings relating to the same phenomenon in visually presented face stimuli. Both stimulus' emotion and sex were well recognized, when they were task-relevant (confirming H1 and H4). The emotion of the stimulus also influenced ratings of sex when the emotion dimension was not task-relevant (H5), particularly when the stimulus' sex was ambiguous (Hypothesis 6 [H6]). However, the reverse was not

Figure 7
Results of Voice Ratings (Experiment 3)



Note. (A) Heat map of all stimuli showing ratings of emotion (happy to angry); (B) heat map showing ratings of sex (male to female); (C) emotion ratings by stimulus' emotion (*x*-axis) and sex (line types); (D) sex ratings by stimulus' sex (*x*-axis) and stimulus' emotion (line types). See the online article for the color version of this figure.

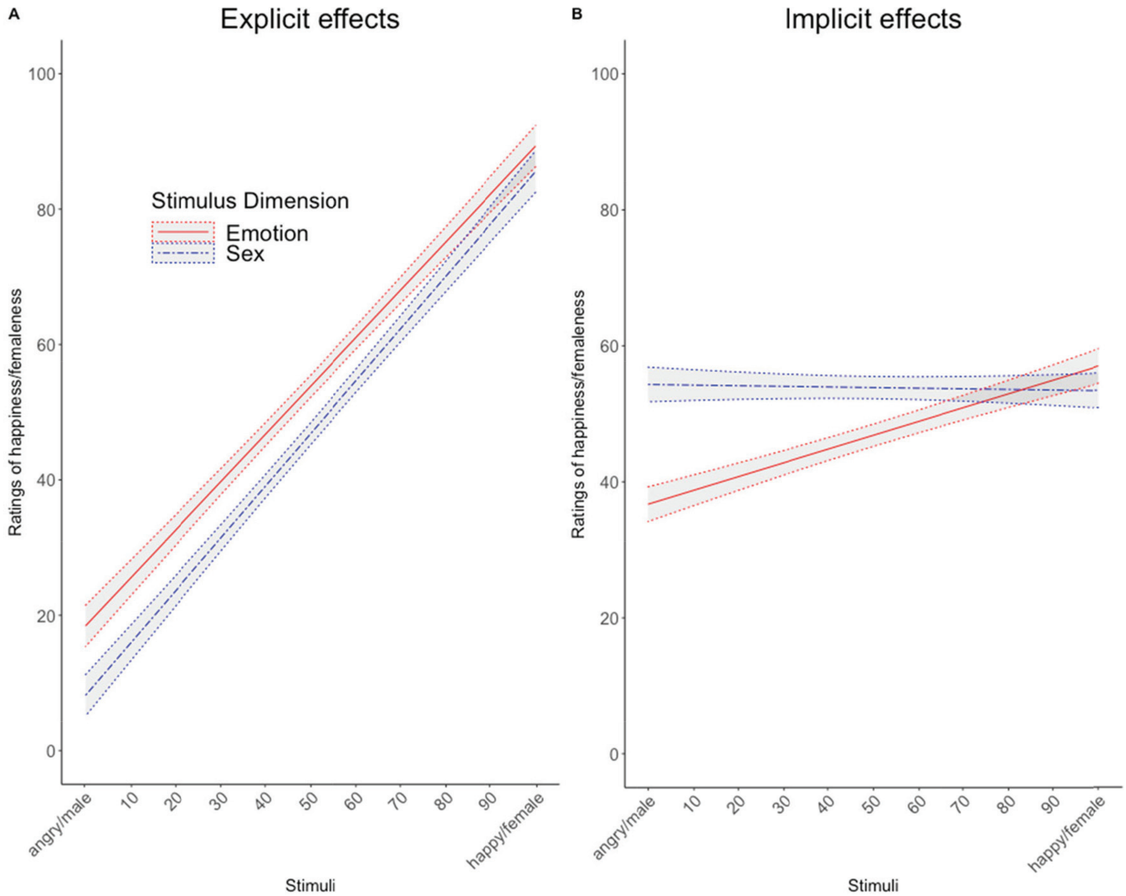
true, as ratings of emotion were not influenced by the task-irrelevant dimension of stimulus' sex. H2 and H3 were not confirmed. Moreover, when directly comparing explicit and implicit effects across tasks, the effect of emotion was clearly larger than the effect of sex at the implicit level, and nearly identical (although significantly smaller) at the explicit level. Differences between explicit stimulus dimensions were minor, and should not be over-interpreted. Instead, there was a clear difference at the implicit level, with an effect of emotion on explicit sex ratings, but not vice versa. Overall, the results speak for H7, that is, a greater implicit effect of emotion than sex, and no (or small) differences between the effects of emotion and sex at the explicit level.

In the current study, we have found that implicit effects of emotion supersede implicit effects of sex during voice perception, which is in line with the findings of Experiments 1 and 2, relating to face perception. We suggest that these findings are best explained by an automatic emotion-processing system, which can operate outside the focus of attention and across sensory modalities, and that may increase evolutionary fitness by prioritizing the processing of the information conveyed by social stimuli that is most relevant. Indeed, it is arguably more important for survival to quickly recognize if a conspecific sounds friendly or threatening, than if they are male or female. As indicated by Error Management Theory, evolution is likely to have favored an increased sensitivity for the social features whose misinterpretation results in higher costs (Haselton & Nettle, 2006). In encounters with strangers, people might be more sensitive to cues that are indicative of future intentions, and emotion, more than sex, might be a better predictor of future behavior. More research is needed, however, to investigate the mechanism underlying the emotion-sex interactions here reported.

General Discussion

The creation of a highly controlled stimulus set consisting of 121 avatar faces, and 121 human vocalizations, both varying in 11 steps along the emotion dimension (happy to angry) and the sex dimension (male to female), has allowed us to systematically investigate across sensory modalities how social judgments of emotion are influenced by the sender's sex, and vice versa. Three different dependent variables—participants' ratings, categorization choices, and reaction times—were obtained and analyzed across three

Figure 8
Comparison of Explicit and Implicit Effects on Voice Ratings (Experiment 3)



Note. (A) Explicit effects are large and similar for both stimulus dimensions: the likelihood of rating a voice as happy increases with the actual happiness of the stimulus (Explicit effect of emotion), and similarly the likelihood of rating a voice as female increases with the actual femaleness of the stimulus (Explicit effect of sex). (B) Implicit effects are overall smaller than explicit ones, and they clearly differ between stimulus dimensions: the likelihood of rating a voice as female increases with the happiness of the stimulus (Implicit effect of emotion), and this effect is bigger (steeper slope) than the amount by which the likelihood of rating a voice as happy increases with the femaleness of the stimulus (Implicit effect of sex). See the online article for the color version of this figure.

separate experiments (two of which were preregistered on osf.io). Stimulus set and task design allowed us to estimate and compare the size of explicit and implicit effects of emotion and sex.

The results from Experiment 1 and 2 confirm previous reports of an association in faces between anger and maleness, and happiness and femaleness (Aguado et al., 2009; Becker et al., 2007; Harris et al., 2016; Hess et al., 2009), and reveal that cross-influence of these facial features occurs most strongly for ambiguous, that is, less prototypical, faces (e.g., in line with Condry & Condry, 1976; Plant et al., 2004), for which greater competition between mental categories can be expected (Stolier & Freeman, 2016). Experiment 3 found similar effects in judgments of human vocalizations, with the difference that emotion judgments showed little influence by the voice's sex, but importantly sex judgments showed the same modulation by emotion as previously found in faces. This is, to the best of our knowledge, the first demonstration that judgments about voices are influenced by their emotion and sex characteristics in similar ways to judgments of faces.

The well-balanced stimulus set also allowed us to record and to directly compare the size of explicit and implicit effects of the emotion and sex dimensions. The outcome of this comparison is relevant to clarify the cognitive nature of the effect of sex on emotion appraisal, and vice versa, during the processing of faces and voices. Explicit effects of stimulus' emotion and sex were variable and similar to each other in all three experiments. Specifically, the Task × Explicit interaction was significant in Experiments 2 and 3 only. The direction of the interaction in Experiment 2, with Emotion > Sex, was opposite to that found in Experiment 3, with Sex > Emotion. However, one should be careful to overinterpret this difference, as the effect in Experiment 3 was rather small (F = 4.08, p = .047). This, together with the lack of a significant Task × Explicit interaction in Experiment 1 and of a difference in RTs between the emotion and sex categorization tasks in Experiment 2, suggests that the two dimensions of emotion and sex were well-balanced in both the face and voice stimulus sets. Explicit effects were also greater than implicit effects, confirming that participants correctly followed instructions and were able to focus on one stimulus dimension in particular. In contrast, the Task × Implicit interaction was significant in all three experiments, and implicit effects of emotion were consistently larger than those of sex. In Experiment 2, this was the case for both categorization choices and RTs. In other words, the emotion of a face or voice influenced its rating or categorization as male or female to a greater extent than the sexual features of a face or voice influenced its rating or categorization as happy or angry.

A possible explanation for the finding of larger implicit emotion effects, is that the information conveyed by the emotional expression of a face or voice is of greater importance, and is possibly extracted faster, than that conveyed by its sexual features. In line with this hypothesis, emotional faces and voices activate the amygdala and other brain areas relevant for emotional responses, including when processed implicitly or without awareness (Critchley et al., 2000; Frühholz & Grandjean, 2013; Frühholz et al., 2012; Pessoa, 2005; Schirmer & Adolphs, 2017; Schirmer & Kotz, 2006; Vuilleumier et al., 2001). Similarly, awareness occurs faster for fearful than neutral faces in a continuous flash suppression paradigm (Yang et al., 2007). In contrast, sex does not seem to be represented in the amygdala, at least for faces (Kaul et al., 2011), and its processing may require greater conscious awareness (Amihai et al., 2011). The finding of greater effects of emotion than sex on social judgments is also in line with the assumption, based on evolutionary theory, that it is more relevant to quickly detect and accurately recognize if somebody is approaching us with a threatening (angry) emotion, than to determine if we are in front of a male or female person—immediate survival goals have priority over reproductive goals (Kenrick et al., 2010). Applying the same reasoning to the interaction of emotion and sex, one can speculate about the evolutionary advantage of being biased to perceive males as angry (and approaching, see Brooks et al., 2008), as it allows to prepare for fight or flight. In other contexts, the relative importance of emotion versus sex may change, however, depending on the perceivers' goals.

The finding of larger implicit effects of emotion than sex in faces stands in contrast to some of those from studies using Garner's selective attention paradigm, in which trials with changes in one or two dimensions are presented in separate blocks, and in which the critical dependent variable is RT (averaged per condition). Indeed, the Garner paradigm has generally revealed a greater implicit effect of sex, although results have also been mixed. For example, Le Gal and Bruce (2002) found that RTs during the categorization of faces into male and female was not influenced by changes in the face's emotional expression, and vice-versa, pointing to an independence of sex and expression processing in faces. Others have instead found an influence of sex and emotion, which was either mutual (Aguado et al., 2009), or asymmetric in favor of sex (Atkinson et al., 2005). Gilboa-Schechtman et al. (2004) showed that the ability to pay selective attention to the sex of a face and ignore its emotional expression is impaired in depression. No specific association between a face's sex and emotion (e.g., happiness and female) was found using the Garner task.

Several things can explain the disparity between our results in Experiment 2, and those obtained with the Garner paradigm. One of them is the type of stimuli used, and more specifically the inclusion of stimuli that present ambiguous features. Most Garner task studies used faces with full-blown emotional expressions, as well as clearly recognizable male or female features (Experiments 1A and 1B in Atkinson et al., 2005; Gilboa-Schechtman et al., 2004; Le Gal & Bruce, 2002). Fewer studies with the Garner paradigm used morphing to create ambiguous facial expressions (Experiments 2A and 2B in Atkinson et al., 2005; Schweinberger et al., 1999), ambiguous same-sex identities (Schweinberger et al., 1999), or ambiguous sexual features (Atkinson et al., 2005; Experiments 2A and 2B). Instead, we presented a large variety of faces with fine changes on both the emotional and the sex dimension. Arguably, introducing ambiguity is especially important for making the emotion and sex categorization tasks more equal to each other. Indeed, most of past studies with the Garner paradigm have found faster RTs during sex categorization than emotion categorization, even when the authors made efforts to make the sex and emotion categorization tasks, respectively, harder and easier (e.g., cropping the hairline, and exaggerating emotional expressions Atkinson et al., 2005). In contrast, task difficulty of emotion and sex categorization did not differ with our stimuli, as suggested by the absence of a significant difference in average RTs in Experiment 2. It probably also matters which specific emotional expressions are used, as the association of some emotions with male or female sex is likely to vary depending on the specific emotions. Other parameters that can affect the results are the size and familiarity of the stimulus set (Ganel & Goshen-Gottstein, 2004; Lipp et al., 2015), the repetition of stimuli in separate blocks with trials varying either in two or only in one feature (as it is done for the Garner task), as well as the dependent variable at the focus of analyses (categorization choices vs. RTs—but see Figure 6). Clearly, more research is needed to clarify the relative importance of the emotion and sex features during the perception of both faces and voices.

The stimulus set used here provides several advantages, but suffers from limitations as well. It is highly controlled at the level of low-level visual features (symmetry of morphology and expression, facial expression based on FACS, alignment of eyes and most face elements, luminance, no difference in high spatial frequencies due to closed mouth in all cases), which makes it suitable for experiments that require this level of control, for example, for electroencephalography and/or continuous flash suppression. At the same time, face contours were not occluded, as the facial width-to-height ratio (Geniole et al., 2015), or the more squared jaw in males and the higher cheekbones in females, constitute important sexually dimorphic features. Other peripheral features relevant to the male/female categories from a more social point of view (style of hair and clothing) were omitted. It is likely that their inclusion would speed up the activation of the male/female categories and their accompanying stereotypes.

To create a fully symmetrical stimulus set, the two emotions morphed into each other without passing through neutral. Neutral expressions were not included for the following reasons. First, the existence of a truly neutral expression is debated, as they can appear emotional depending on the context, and objectively resemble emotional expressions based on face morphology (Said et al., 2009; Zebrowitz et al., 2010). Comparable effects are expected to occur for voices, given that the functional architecture is similar for faces and voices, and that the voice can be considered an "auditory face" (Belin et al., 2004). Similarly, the concept of neutrality makes little sense in terms of biological sex, explaining why neutral expressions were omitted to allow the creation of a fully symmetrical stimulus set. This may be seen as a limitation of the stimuli, although blends of emotional expressions can occur in real life (Le Mau et al., 2021), do not appear unrealistic when created artificially in the laboratory (Du et al., 2014), and are frequently used in research on emotions and embodiment, where they have been shown to elicit facial mimicry in the perceiver (Korb et al., 2016). It would be interesting to test how much anger and happiness are detected in these faces by computational models trained to recognize facial expressions (Said et al., 2009; Zebrowitz et al., 2010). A more data-driven approach may also be useful to determine with more precision which aspects of emotional faces (e.g., action unit changes in time) have the greatest impact on participants' judgment of social categories (Jack & Schyns, 2017). And it should be investigated, whether the association of female cues and happiness holds in the same way for smiles of reward, affiliation, and dominance, which are believed to serve different social functions (Niedenthal et al., 2010; Rychlowska et al., 2017).

Similar effects were found here across sensory modalities, even though the face stimulus set was composed of avatars with artificially generated facial expressions, while the emotional vocalizations were recorded from human speakers. The fact that we find stronger effects of implicit emotion than sex using both avatar faces and human voices speaks for the robustness of the phenomenon. However, future work might want to use other techniques to generate synthetic vocal stimuli, such as speech synthesis (Arias et al., 2018, 2021). Doing so would allow us to obtain and compare facial and vocal stimuli that have both been generated artificially.

Although the categorization task used in Experiment 2 emphasized response speed more than the rating tasks used in Experiments 1 and 3, it may still not be the ideal task to ensure that task-irrelevant stimulus dimensions are not attended to (see also differences to findings using the Garner paradigm). Future research may use continuous real-time motoric measures of categorization under greater time pressure, such as the mouse tracker task (Freeman & Ambady, 2010; Freeman et al., 2008). These may also be combined with brain imaging, to investigate the neural bases of the representations corresponding to the social categories male/female and the emotional categories happy or angry (Stolier & Freeman, 2016, 2017).

To conclude, our judgment of the emotional expression of a face or voice is heavily influenced by morphological sex cues, and vice versa. When emotional features are not at the center of attention, they nevertheless affect sex judgments of the face or voice implicitly. The reverse effect of sex cues on emotion judgments is less strong. This asymmetry in the bidirectionality of the effects of emotion and sex is relevant to cognitive models of face processing.

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