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Author for correspondence:

Nadia Guerouaou

e-mail: nadia.guerouaou@chru-lille.fr

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The shallow of your smile: the ethics of expressive vocal deep-fakes

Nadia Guerouaou^{1,2}, Guillaume Vaiva² and Jean-Julien Aucouturier^{3,4}

¹Science and Technology of Music and Sound, IRCAM/CNRS/Sorbonne Université, Paris, France

²Lille Neuroscience and Cognition Center (LiNC), Team PSY, INSERM U-1172/CHRU Lille, France

³FEMTO-ST, UBFC/CNRS, Besançon, France

⁴Alta Voce SAS, Houilles, France

⁴Centre National de Ressource et Résilience (CN2R Lille Paris), Lille, France

NG, 0000-0003-2319-623X

Rapid technological advances in artificial intelligence are creating opportunities for real-time algorithmic modulations of a person’s facial and vocal expressions, or ‘deep-fakes’. These developments raises unprecedented societal and ethical questions which, despite much recent public awareness, are still poorly understood from the point of view of moral psychology. We report here on an experimental ethics study conducted on a sample of $N = 303$ participants (predominantly young, western and educated), who evaluated the acceptability of vignettes describing potential applications of expressive voice transformation technology. We found that vocal deep-fakes were generally well accepted in the population, notably in a therapeutic context and for emotions judged otherwise difficult to control, and surprisingly, even if the user lies to their interlocutors about using them. Unlike other emerging technologies like autonomous vehicles, there was no evidence of social dilemma in which one would e.g. accept for others what they resent for themselves. The only real obstacle to the massive deployment of vocal deep-fakes appears to be situations where they are applied to a speaker without their knowing, but even the acceptability of such situations was modulated by individual differences in moral values and attitude towards science-fiction.

This article is part of the theme issue ‘Voice modulation: from origin and mechanism to social impact (Part II)’.

1. Introduction

The human facial and vocal expressions have evolved as signals to inform and manipulate others [1,2]. By continuously modulating our facial muscles and the phonatory and articulatory structures of our vocal apparatus, we provide a rich, flexible non-verbal back-channel to our daily conversations, communicating our emotional states such as joy or surprise [3,4], our social intents such as warmth or dominance [5,6] or our epistemic attitudes, such as certainty or doubt [7,8].

While our facial and vocal expressions were shaped by a long and delicate interplay of biological and cultural evolution [9,10], spectacular technological advances occurring in the past few years may soon dramatically alter how we use and experience these behaviours in daily life. Recent progress in signal processing have indeed made possible the real-time manipulation of e.g. facial expressions such as smiles [11] and vocal expressive cues such as pitch [12] or timbre [11]. Perhaps even more radically, recent advances in deep neural network architectures have provided a flexible way to learn and generate mappings (or ‘deep-fakes’ [13]) between pairs of stimuli, and opened possibilities to parametrically manipulate individual facial actions [14] (figure 1b) or convert one voice into several emotional variants [15]. In just a few years, combined with the unprecedented adoption of remote communication software such as video conferencing and virtual meetings, we have come to a situation where it is



Figure 1. From Darwin to deep-learning: rapid technological advances in artificial intelligence create opportunities for real-time algorithmic modulations of facial and vocal expressions, which raises unprecedented societal and ethical questions. From left to right: (a) Original studies of human facial expressions employed electric stimulation to induce muscle contraction (Guillaume Duchenne de Boulogne, reproduced in [1]); (b) Manipulation of individual action units in still photographs using Generative Adversarial Networks (GANimation [14]); (c) Real-time smile filters in commercial video sharing platforms (Tiktok, ByteDance Ltd., Beijing, China); (d) Still from the *Arkangel* episode of dystopian science fiction television series *Black Mirror* (Endemol Shine UK Ltd., 2017) in which parents equip their children with anti-violence visual filters via a brain implant. Here, the device visually filters out a dog aggressively barking at the child, directly in the child's mind. (Online version in colour.)

difficult to trust whether the smiles, laughs and frowns of our conversation partners are genuine or algorithmically modulated (figure 1c).

The goal of this paper is to initiate the data-driven study of expressive deep-fakes ethics (specifically here, *vocal* deep-fakes) and, inspired by the methodology of 'experimental ethics' [16], to quantify societal expectations about the principles that should guide their deployment.

The realistic, artificial manipulation of expressive behaviour raises unprecedented societal and ethical questions. First, it raises concerns about truthfulness. Because expressive behaviours are often thought to provide genuine cues about the sender's emotional states [17], the ability to arbitrarily manipulate these displays opens avenues for deception: one may use, e.g. a facial filter to fake a smile despite having no intent to affiliate, or a voice transformation to appear more certain than one really is. Second, they raise concerns about fairness. Expressive behaviours in verbal interactions strongly influence subsequent behaviours. It is already known that vendors displaying positive, authentic expressions while interacting with customers sell more mobile phones [18], or that negotiators faking anger in commercial discussions obtain better prices [19]. The algorithmic manipulation of expressions designed for such situations may coerce people into making unwarranted or unfair decisions. Third, they raise concerns about autonomy. Non-verbal influences on behaviour are often non-conscious: in a study with voice transformation, mock patients calling 911 medical triage with a more dominant voice obtained more urgent medical responses from doctors but doctors did not attribute the cause of their behaviour to the patient's voice; rather, they wrongly attributed it to more urgent medical situations [20] (figure 2, bottom). Technologies able to trigger such unconscious reactions are therefore intrinsically manipulative, as people may not be able to identify the transformation as the cause for their subsequent behaviour. Finally, they also raise concerns about transparency, as their deployment in virtual conversations lends itself to situations where a speaker doesn't know *how* their interlocutor is hearing or seeing them, i.e. whether a transformation of their own voice or face is applied without their knowing.

However, none of these deontological concerns warrants a straightforward moral objection to the deployment of expressive transformation technologies, because each of them also

create opportunities for highly desirable situations. First, the fact that e.g. a smiling voice transformation can be used to appear happier than one really is becomes highly desirable in the case of patients who cannot easily express emotions (e.g. Amyotrophic lateral sclerosis patients who rely on assistive voice technology for communication, [22]). Second, the fact that voice or face transformations can coerce observers into subsequent actions can be desirable in interventions where people are nudged into positive behaviour [23], for instance reducing aggressive behaviour in call-centre conversations by transforming the operator's fatigued voice [24], or applying a gender voice transformation on an online hiring platform to alleviate gender biases [21] (figure 2, top). Third, the fact that expressive transformations can be processed unconsciously may be desirable in situations where this increases their effectiveness, as seen e.g. in emotional vocal feedback [25].

Societal expectations in such situations are non-trivial and important to understand in order to inform and regulate the deployment of deep-fakes in commercial products or clinical protocols. A recently emerging methodology for doing so is that of experimental ethics, in which moral judgements about various situational vignettes are collected from relatively large samples of online participants. In recent years, this methodology has been applied to quantify societal attitudes towards new technologies such as autonomous vehicles [16] or brain stimulation [26], potential public policies such as legalizing payments to kidney donors [27], but also downright futuristic scenarios such as mind upload [28], sex robots [29] or cognitive enhancement with brain implants [30] (figure 1d). The experimental ethics approach allows comparing different situation variants that may make or break dilemmas (e.g. whether imagining oneself as the conductor of an autonomous car changes one's attitude to how one reacts to accidents—[16]) and whether these effects are modulated by individual differences (e.g. whether a person's familiarity with science-fiction themes modulate their attitude towards robots—[29]).

Here, we employed the methodology of experimental ethics to gauge societal attitudes towards emotional voice transformation technology. We asked $N = 303$ online participants to read 24 short text vignettes describing potential applications of vocal deep-fakes, and rate how morally acceptable they thought each scenario is. Participants were presented a cover story describing an imaginary hardware

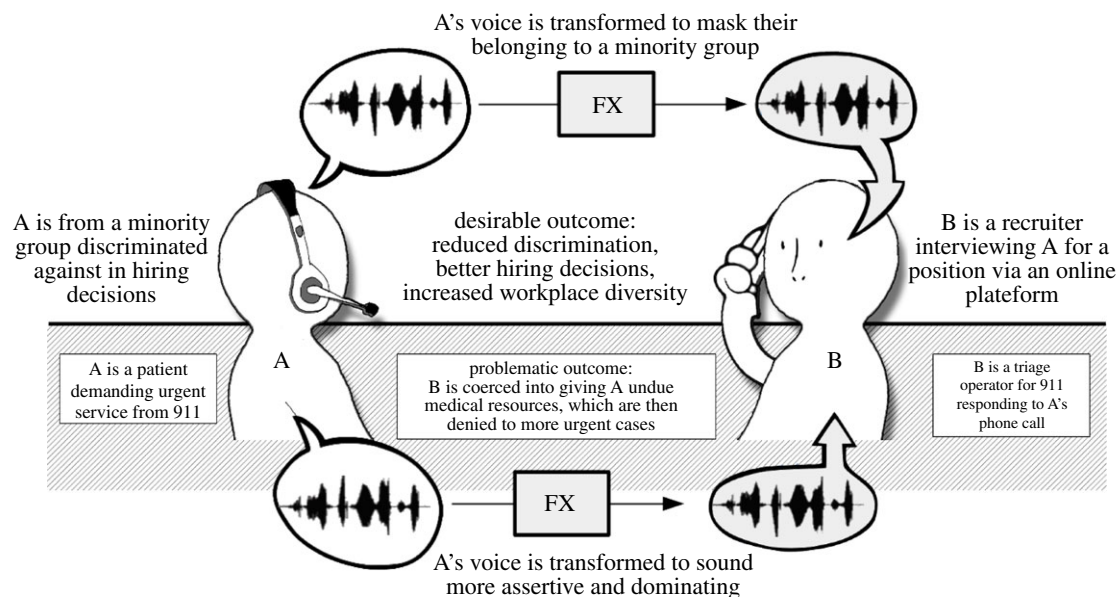


Figure 2. Very similar uses of voice transformation technology can lead to both desirable or problematic situations. Top: a voice transformation is used to mask the sex, accent or ethnicity of a user to eliminate discrimination in online hiring services. Situation inspired by genuine practice by the [interviewing.io](#) company [21]. Bottom: a voice transformation is used to increase the perceived dominance of a patient calling emergency medical services, who consequently gets undue medical resources from triage operators at the expense of other more urgent cases. Situation inspired by the authors' experimental work [20].

device (MyVoicePlus) able to transform the emotional quality of a voice in real-time, which was said to be currently considered by a startup company for commercial deployment in various situations. The vignettes describing potential applications of the device varied among four factors:

- (i) whether the user of the device was the participant or an unknown other
- (ii) whether the transformations were used therapeutically, or to enhance user capacities
- (iii) whether the transformations operated on positive (enhancing smiling) or negative emotional expressions (reducing anxiety, reducing anger)
- (iv) and whether the transformation affected how the user's voice is heard by others (i.e. the user's production), how the user hears other persons' voices (i.e. the user's perception), or whether it is used in a situation where the user hears their own manipulated voice (i.e. feedback).

For each vignette, participants first rated the acceptability of the situation, and were then presented with two potential dilemmas involving lying about the true purpose of the transformation in order to improve its effectiveness. Finally, for all of these judgements, we examined associations with individual differences in participants' attitudes towards morality (Moral Foundations Questionnaire MFQ [31], measuring factors of harm-care, fairness-cheating, loyalty-betrayal, authority-subversion and purity-degradation) and toward technology and science fiction (Science Fiction Hobbyism Scale SFH; [28]), two factors found relevant in previous research about the moral reception of new technologies [26,28,29,32] (See *Methods* for details of the procedure).

Although our study is exploratory and we did not preregister any formal hypotheses, a number of loose predictions can be made from the literature about how our variables of interest impact participants' moral judgements. First, similar experiments with emerging technologies such as autonomous

vehicles [16] or brain stimulation [26] have documented situations of social dilemma, in which participants accept things for themselves (i.e. a car that favours its driver, rather than pedestrians) that they would otherwise reject for others. Second, across diverse forms of enhancement (e.g. memory, general intelligence, mood, etc.), participants are widely reported to be more comfortable with technologies that enhance capacities towards the norm (i.e. that are used therapeutically) than above the norm [30,33]. Finally, to the best of our knowledge, there is no straightforward equivalent in the literature of whether e.g. manipulating positive or negative emotions, or manipulating a user's perception or production, has any impact on participant's judgement of acceptability. Whether participants feel more comfortable with e.g. smiling or anxiety filters, and filters that affect their produced voice or their perception of how others sound, is an open non-trivial question [34], which our study wishes to address.

2. Results

(a) Acceptability of overtly using the technology

We first evaluated how morally acceptable our participants ($N = 303$) thought the use of a voice transformation device, when the true purpose of the technology was overtly known to all involved parties.

(i) Voice transformations are in general well accepted in the population

Across situations, the moral acceptability of overt vocal transformation was strongly significantly higher than neutral ($M = 6.49 > 5$; one-sample t -test against mid-point, averaging all acceptance scores across vignettes: $t(302) = 146, p < 0.001$).

Because of heteroscedasticity (Breusch-Pagan: $F(6, 296) = 3.23, p = 0.004$), we tested the effect of individual characteristics on this judgement with multiple iterated re-weighted least squares (IRLS) regression (Huber weights, HC3

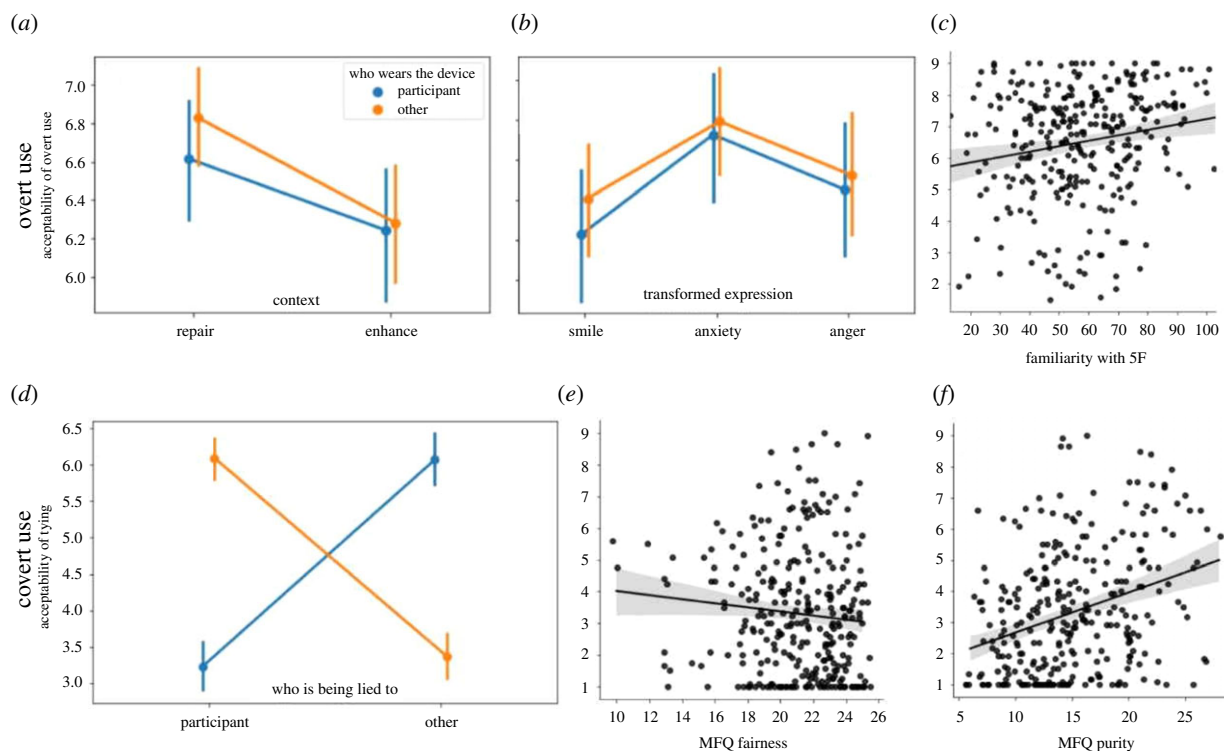


Figure 3. Moral judgements of overt and covert use of voice transformations. Top: Overt use. (a) The moral acceptability of overt vocal transformation was higher than the neutral midpoint, and therapeutic transformations even more so than transformations used to enhance user capacities. (b) Situations in which transformations aimed at weakening the two negative emotions of anxiety or anger were better accepted than situations in which transformations aimed to enhance smiling. (c) Across situations, acceptability was positively associated with the participants' familiarity with science-fiction. Bottom: Covert use involving lying about the true purpose of the transformation in order to improve its effectiveness. (d) Participants considered it morally acceptable that the user of the transformation hides its true purpose to others but hiding the transformation to the person using the device was totally unacceptable. (e–d) The acceptability of lying to the person using the device was negatively associated with the participants' concern with fairness, and positively with purity. (a,b,d) Across conditions, there was no effect of whether the user of the device was the participant or an unknown other. Error bars: 95% confidence intervals. (Online version in colour.)

correction). Acceptability was significantly associated with positively associated with the participants' familiarity with science fiction ($\beta = 0.014$, $z = 2.75$, $p = 0.006$; figure 3c) and marginally positively associated to participant's reliance on MFQ purity ($\beta = 0.04$, $z = 1.85$, $p = 0.064$). No other MFQ factors regressed significantly (all $ps > 0.1$). The marginal positive association with MFQ PU differed from others studies of similar technologies where purity was found negatively correlated with acceptability (e.g. mind upload [28]; sex robots [30]).

(ii) A therapeutic context makes them even more acceptable

We tested the effect of the goal to repair or enhance on situation acceptability by averaging within-participant scores for overt acceptability over therapeutic ($n = 6$ vignettes) and enhancing situations ($n = 6$ vignettes), and testing for population differences with a one-way repeated-measure ANOVA. Repair–enhance had a significant main effect on situation acceptability ($F(1, 302) = 47$, $p < 0.001$), with therapeutic situations ($M = 6.7$) being (even) more acceptable than enhancing situations ($M = 6.2$; figure 3a).

To test whether the effect of repair or enhance was associated with individual characteristics, we computed the within-participant difference between acceptability scores averaged over both types of vignettes, and computed multiple ordinary least-square (OLS) regression (Breusch–Pagan heteroscedasticity test: $F(6, 296) = 0.39$, $p = 0.88$). The better acceptability of repair situations was not significantly associated with individual differences in MFQ or Science fiction familiarity ($R^2 = 0.008$, $F(6, 296) = 0.38$, $p = 0.89$).

(iii) Manipulating perception is less acceptable than manipulating production

Similarly, we tested the effect of whether situations described voice transformation as affecting how the user's voice is heard by others (condition *production*: $n = 4$ vignettes), how the user hears other persons' voices (condition *perception*: $n = 4$ vignettes), or whether the user hears their own manipulated voice (condition *feedback*: $n = 4$ vignettes) by averaging acceptability scores within-participant over the three types of vignettes and testing for population differences with a one-way repeated-measure ANOVA. There was a significant effect of the production–perception–feedback variable ($F(2, 604) = 7.5$, $p = 0.001$), with transformations affecting the user's production being more acceptable than perception and feedback. Both latter conditions share the fact that the device manipulates what the participant hears, regardless of whether it is the participant's own voice or that of another person.

We tested for associations with individual characteristics by computing the within-participant pairwise differences between acceptability scores averaged over all three types of vignettes, and computing multiple OLS regression (Breusch–Pagan heteroscedasticity test: perception–production $F(6, 296) = 0.27$, $p = 0.96$; feedback–production $F(6, 296) = 0.66$, $p = 0.6815$). The difference of acceptability between these situations was not associated with participant MFQ or SFH (perception–production: $R^2 = 0.006$, $F(6, 296) = 0.31$, $p = 0.93$; feedback–production: $R^2 = 0.011$, $F(6, 296) = 0.571$, $p = 0.75$).

(b) Acceptability of covert uses

For each situation, we then tested the acceptability of lying about the true purpose of the device, in order to increase the transformation's effectiveness, in two situations which either involved the user's lying to their interlocutors, or the device's prescriber's lying to the user themselves. Because using the transformation overtly was generally well accepted (see above), and because we presented situations in a context where lying about the transformations would also improve their effectiveness (see *Methods*), these situations can be regarded as genuine moral dilemmas in which the deontologically blamable act of lying is balanced by the utilitarian value of the resulting improvement of performance.

(i) Using the transformation covertly is not a problem

Although more acceptable situations were more acceptable to lie about (OLS regression over vignettes averaged between-participants: $R^2 = 0.61$, $F(1, 22) = 34.61$, $p < 0.001$; Breusch–Pagan heteroscedasticity test: $F(1, 22) = 0.13$, $p = 0.72$), lying was generally regarded as non acceptable by our participants ($M = 4.69 < 5$, $t(302) = 3.19$, $p = 0.001$).

However, there was a very large interaction with which person is being lied to (one-way rm-ANOVA: $F(1, 302) = 631$, $p < 0.001$; figure 3d): somewhat surprisingly, participants considered it morally acceptable that the user of this device hides its true purpose to others ($M = 6.08$ [5.87, 6.3]; one-sample t -test against mid-point: $t(302) = 9.99$, $p < 0.001$).

Because of marginal heteroscedasticity (Breusch–Pagan: $F(6, 296) = 1.72$, $p = 0.11$), we tested the association of the acceptability of users' lying to others with individual characteristics with multiple IRLS regression. The acceptability of lying to others was not found associated with any of the MFQ subscales (best, PU: $\beta = 0.033$, $z = 1.33$, $p = 0.18$), but was positively influenced by science fiction familiarity ($\beta = 0.01$, $z = 1.95$, $p = 0.05$).

(ii) ...unless it is hidden from the user of the device

However, hiding the transformation to the person using the device appeared totally unacceptable ($M = 3.3 < 5$, one-sample t -test against mid-point: $t(302) = -14.9$, $p < 0.001$), even though the transformation was presented as more effective for the user when doing so (figure 3d).

As above, we tested the association of the acceptability of lying to the device's user with individual characteristics, using with multiple IRLS regression (Breusch–Pagan heteroscedasticity test: $F(6, 296) = 1.28$, $p = 0.26$). The low acceptability of lying to the user was driven (i.e. negatively associated) by participants high on the MFQ subscale of fairness ($\beta = -0.1395$; $z = -3.461$, $p = 0.001$; figure 3e) but attenuated (i.e. positively associated) for participants high on MFQ purity ($\beta = 0.0930$, $z = 3.65$, $p < 0.001$; figure 3f) and loyalty ($\beta = 0.09$, $z = 2.71$, $p = 0.007$). The acceptability of lying to the user was also associated with science fiction familiarity ($\beta = 0.014$, $z = 2.38$, $p = 0.017$), with greater familiarity making lying to the user more acceptable.

(c) Acceptability of voice transformations is not influenced by seeking self profits

To test for the effect of either depicting situations where the user was the participant or an unknown person, we conducted a mixed ANOVA with self–other as a between-participant

factor, and vignette conditions (repair–enhance, positive–negative transformation, production–perception–feedback) as within-participant factors. There was no statistical difference of acceptability between overt situations which depicted the participant as the user benefiting of the device ($M = 6.43$), and situations where the user was an unknown person ($M = 6.55$; no main effect, $F(1, 301) = 0.37$, $p = 0.54$). Neither did the effect of self–other interact with any of the other variables: regardless of whether the user was themselves or others, participants thought similarly of differences between situations meant to repair and enhance (no interaction self – other \times repair – enhance: $F(1, 301) = 1.68$, $p = 0.20$; figure 3a), of differences between situations involving smiling, anger or anxiety (no interaction self – other \times transformation: $F(1, 301) = 1.43$, $p = 0.23$; figure 3b), and of differences between devices affecting the user's production, perception or feedback (no interaction self–other \times production–perception – fb: $F(2, 602) = 0.047$, $p = 0.95$).

Similarly, participants did not judge less acceptable the covert situations where they were hidden the true purpose of the device (regardless of whether they were its user, or not), compared to situations where it was hidden to unknown others (rm-ANOVA, with concealed participant–other as within-participant factor, $F(1, 302) = 0.0026$, $p = 0.87$; figure 3d). In other words, the relatively high acceptability of users' lying to others did not depend on whether the participant was the user of the device or the person to whom the transformation is hidden from; and the low acceptability of lying to the device's users did not depend either on whether the user was the participant themselves or an unknown other.

In sum, contrary to situations like e.g. pedestrian dilemmas in autonomous vehicles [16], there was radically no evidence of social dilemma regarding the use of voice transformations, in which one would e.g. accept for themselves what they would blame for others, even in situations involving the blamable act of lying.

(d) The nature of the emotion impacts the moral acceptability of the transformation

Finally, we tested the impact of what emotion is transformed on the acceptability of the situation, as well as the interaction with repair–enhance factor. We averaged within-participant scores of overt acceptability over repair – enhance situations concerning anxiety ($n = 4$ vignettes; repair: 2), anger ($n = 2$ vignettes; repair: 1) and smile vignettes ($n = 6$; repair: 3), and tested for population differences with a two-way rm-ANOVA.

There was a main effect of emotion: situations in which transformations aimed at weakening the two negative emotions of anxiety ($M = 6.8$) or anger ($M = 6.5$) were better accepted than situations involving transformations enhancing smile ($F(2, 604) = 24.47$, $p < 0.001$), although the latter remained well accepted at $M = 6.3$ (figure 3b).

The effect of emotion also interacted significantly with the repair–enhance factor ($F(2, 604) = 21.3$, $p < 0.001$), with transformations aiming to weaken negative emotions benefiting more of the therapeutic condition ($\Delta = +0.56$) than the transformation targeting positive emotions ($\Delta = +0.35$). The effect was maximal for the repairment of anxiety (Repair: $M = 7.17$; Enhance: $M = 6.34$).

Similarly, in covert situations, it was more more acceptable to hide the purpose of a transformation aiming to

weaken negative emotions than a transformation aiming to enhance smile (one-way rm-ANOVA; main effect of transformation: $F(2, 604) = 8.3, p < 0.001$).

Finally, we tested whether these differences between positive and negative transformations were associated with individual differences, by computing the within-participant pairwise differences between acceptability scores averaged over all three types of transformations, and computing multiple OLS regression (Breusch–Pagan heteroskedasticity test: anxiety–smile $F(6, 296) = 0.59, p = 0.74$; anger–smile $F(6, 296) = 0.73, p = 0.62$). The difference of acceptability between these situations was not associated with participant MFQ or SFH (anxiety–smile: $R^2 = 0.031, F(6, 296) = 1.58, p = 0.15$; anger–smile: $R^2 = 0.023, F(6, 296) = 1.137, p = 0.34$).

3. Discussion

We reported here on an experimental ethics study in which $N = 303$ online participants evaluated the acceptability of vignettes describing potential applications of expressive voice transformation technology. We found that vocal deep-fakes were generally well accepted, notably in a therapeutic (versus enhancement) context; when they corrected negative emotions rather than enhanced positive emotions; and when they manipulated a speaker's production rather than perception. Surprisingly, transformations remained well-accepted even when the user lied to their interlocutors about using them and, unlike other emerging technologies like autonomous vehicles, there was no evidence of social dilemma in which one would e.g. accept for others what they resent for themselves. The only real moral objection to vocal transformations appeared related to situations in which they were applied to a speaker without their knowing, with the acceptability of such situations being modulated by individual differences in moral values and attitude towards science-fiction.

The fact that voice transformations are generally well-accepted, with average scores across situations well above the scale mid-point, first and foremost shows that the western, young, educated population studied here is sympathetic to the idea of customizing one's own emotional expression with technology, when these technologies become available. This attitude, at least for the range of scenarios tested here, seems consistent with transhumanistic views for which technology should be used to enhance human capacities and improve happiness [35] as well as control for emotional or neurological limitations (e.g. taking anti-love drugs to curb affect in divorce situations [36]).

Contrary to other moral psychology studies where individual attitudes to MFQ Purity negatively correlated with e.g. acceptability of cognitive enhancement or mind upload [28], acceptability here was facilitated by the participants' reliance on the purity dimension. This may suggest that voice transformations are not seen as a breach of human integrity, but rather as a way to improve control and self-determinacy (i.e. an *anthropotechnical tool* for self-customization [37]). In a contemporary society promoting continuous self improvement, the good reception of this kind of technology is thus perhaps not surprising [38]. However, it should be noted that the MFQ purity construct has come under recent debate (e.g. it may be interpreted differently by religious and non-religious individuals [39]), and further research is needed to ascertain what this construct measures in our specific sample of participants.

The good general acceptance of voice transformations was further improved in therapeutic situations, which were judged more acceptable than situations merely aiming to enhance user capacities [40]. This attitude is consistent with what is reported in other empirical studies of cognitive enhancement [26,30,33], and with imperatives put forward by the bioethics literature [41,42]. It confirms that the therapy-enhancement distinction is morally salient to the public concerning potential display of expressive voice transformation technology.

Acceptance was also higher for situations which manipulated the production of an expression than situations which manipulating its perception. That participants should be biased against the latter somehow contradicts the expectation that covert changes that are internal to the individual would have less broad impact on others than changes affecting their outward expression [43]. This preference may reflect a worry about having one's real experience distorted, as one could worry e.g. about mood-enhancers drugs such as SSRIs altering one's sense of living truly (*is it me or the Prozac enjoying this?* [40,44]), even though in the case of Prozac these bioethical concerns do not seem shared by the general population [45]. Since the production and perception situations could be compared respectively with the use of *Instagram* filters (which are now common; figure 1c) over augmented-reality (AR) glasses (which aren't yet), it would be interesting to follow up on these results in the next few months, as several announced AR devices such as Apple Glasses may gain popularity and modify these attitudes ([46]; see also below about science-fiction familiarity).

In a second set of questions, we collected judgements about concealed-use situations, and presented them in a context where lying about the transformations would also improve their effectiveness (see Methods *Judge how acceptable it is to lie to your entourage [...], knowing that this would improve the effectiveness of the device*). The fact that voice transformations are generally thought desirable in 'overt' situations makes these 'covert' situations appear as genuine moral dilemmas, in which the deontological imperative against lying is balanced against the utilitarian benefits of self-improvement. For these situations, both sides of the debate were clearly reflected in participant judgements: one the one hand, acceptance of lying was negatively associated with MFQ fairness; on the other hand, as was the case of overt situations, acceptance scores for these situations were also positively associated with MFQ purity, which attenuated the generally low acceptability of covert use.

Strikingly though, in all of these dilemma as well as in the less problematic 'overt' situations, we found radically no evidence of a social dilemma where one would e.g. refuse for oneself what they think acceptable for others. This held whether participants envisioned to modify their own voice, or that of others; and whether participants were being lied to regarding their perception, or whether they lied to others. This absence of effect of who benefits from the device when judging its acceptability is in stark contrast with typical sacrificial scenarios (like the trolley problem or, more recently, pedestrian versus driver dilemma in autonomous vehicles), in which participants tend to value self-preservation [16,47]. This suggests that participants judge voice-transformation technology primarily with a utilitarian perspective, treating the welfare of everyone as of equal importance, 'from the point of view of the universe' [48]

379 regardless of whether they are near or far, our children and
380 friends or absolute strangers, human or animal [43]. While
381 this doesn't mean that self-preservation biases could not be
382 created, for instance for situations involving finite supply
383 [26] or larger individual cost [16], the fact that voice transforma-
384 tion should be judged so impartially suggests that there
385 currently is no social obstacle to the massive deployment of
386 such technologies in (here, western) societies.

387 Even though there was no effect of self–other, covert
388 dilemma were very strongly biased against lying to the
389 person wearing the prosthesis (i.e. regardless of who that
390 person was: self or other). This attitude may be an effect of
391 describing the device in our cover story as a physical prosthe-
392 sis, for which ‘installing’ it covertly would be seen as an
393 unacceptable breach of consent–autonomy [49]. To control
394 for physicality, future work could e.g. extend this study to
395 assess the acceptability of software effects (filters) deployed
396 in virtual meeting software.

397 Unexpectedly, transformations aiming to enhance positive
398 expressions (smiles) were judged less acceptable than those
399 aiming to reduce negative expressions (anxiety, anger). This
400 asymmetric pattern of result contrasts with a purely hedonic
401 view, in which making people ‘feel as good as possible, and
402 feel least bad’ [50] would be equally valued. Rather, it may
403 indicate that curbing negative expressions is valued less for
404 the gain of valence than for an Aristotelian inclination for
405 control over oneself, because negative emotions such as por-
406 trayed here (stress, anxiety, fear) are viewed as less deliberate
407 and more automatic than smiling [51]. This view is also con-
408 sistent with our interpretation of MFQ purity as valuing self-
409 determinacy. If true, this may prefigure a situation where,
410 when broadly adopted, expressive technology would shift
411 the moral responsibility associated to certain emotions or
412 behaviours: expressions which were once normal to not con-
413 trol (e.g. one cannot be blamed for stress [51]) may become
414 controllable, and thus blamable and subjected to social
415 demand (e.g. ‘why didn't you put stress-control on?’, [52]). To
416 further test this idea, it would be interesting to examine scen-
417 arios involving non-deliberate positive expressions (eg. using
418 a transformation to avoid giggling uncontrollably at a fun-
419 eral) or to examine how the present results are modulated
420 by cultural differences in emotional display norms [53].

421 Finally, across-the-board positive associations with the
422 participants' familiarity with science-fiction indicate a robust
423 effect of cultural conditioning on the acceptance of voice trans-
424 formation technology. As already remarked for brain implants
425 [28] or cognitive enhancement [30], exposure to futuristic
426 themes and ideas appears associated with less resistance to
427 technologies which challenge our conception of human
428 nature. The influence of science-fiction themes is already
429 well studied as a source of inspiration for real-world techno-
430 logical innovation, e.g. in space [54] or nanotechnologies
431 [55], but it appears that it also plays a role in the reception of
432 new technology by the general public [56]. One consequence
433 is that the attitude towards voice transformations may
434 co-vary with cultural differences in attitudes towards new
435 technology (e.g. robots in Japan [57]).

436 One obvious limitation of this work is our focus on a
437 sample of predominantly young and educated western par-
438 ticipants (i.e. college students), which is representative
439 neither of the generation population in western countries
440 (as would e.g. survey pools constructed to match the compo-
441 sition of a given adult population by gender, age, education

and ethnicity - [27]), nor of the more global non-WEIRD
population [58]. Although research suggests that instruments
such as the MFQ are relatively stable across cultures [59],
there is an emerging corpus of work attempting to diversify
in moral psychology research samples [60,61], and to conduct
cross-cultural comparisons with massive online method-
ologies [62]. Such initiatives will be particularly needed
when evaluating the acceptability of information technol-
ogies such as deep-fakes, which are spreading equally fast
in western and non-western countries [63].

The use of vignettes in experimental ethics approaches
also comes with several limitations. First, the intensity of
reactions elicited by the stories may be limited by the
immersion of the participant, or the vividness of their
imagination [30], and reading a vignette, especially one
describing an intense emotional situation, may not elicit reac-
tions as strong as in the corresponding real-life situations [64].
Here, we moderate these limitations by including an elabor-
ate cover story presenting the device as being considered
for commercialization by an actual voice technology com-
pany, and stating that participant responses will weight in
future commercial decisions. Second, all of these scenarios
consider idealized transformations which are assumed to be
non-identifiable as fake, and properly recognized as their
intended emotion. As these technologies soon become
available, future work could consider measuring reactions
to more tangible situations (e.g. upon hearing one's own
voice modified by the device), studying situations in which
voice transformations are not recognized as genuine behav-
iour (e.g. how comfortable am I to use a filter than may
sound robotic at times?), or combining the approach with
qualitative ethnographic methods documenting the appro-
priation of the device by potential users (e.g. how real call-
centre operators end up using a smile transformation) [65].
Finally, it should also be noted that, even though we designed
the present 12 vignettes to span a wide range of situations, it
remains an open question whether our conclusions generalize
to other types of vocal deep-fakes, and/or other types of
situations than those tested here.

Feelings and emotions are at the forefront of the political
behaviour of citizens and policy makers [66]. It will be essen-
tial for our societal future to clarify the determinants of moral
judgements about technologies able to customize and control
these behaviours, in order to guide norm-setting regarding
their applications.

4. Material and methods

(a) Participants

$N = 303$ participants ($M = 25.7$; female: 156) took part in an online
study, administered via a Qualtrics questionnaire (Qualtrics Inter-
national Inc., Seattle, WA). All were French residents, recruited by
the INSEAD-Sorbonne Université Behavioural Laboratory among a
population consisting mainly of university students. 213 partici-
pants (70.3%) had completed at least a Bachelor's degree, and 116
(38%) had at least a Master's degree. Participants were random-
ised into one of two self–other conditions. For each condition,
participants were presented 12 vignettes of scenarios assessing
three within-factors factors tested for their possible impact on
moral acceptability (see details of vignettes below). For each vign-
ette, participants answered three questions about their perceived
moral acceptability of the situation (see Measures below), which
creates a total of 36 answers for each participant.

(b) Procedure

Participants were initially presented a cover story describing an imaginary hardware device able to transform the emotional quality of a voice in real-time, both in the user's voice (for others to hear) and in the user's ear (i.e. transforming the emotions of others' voices). The device, named 'MyVoicePlus', was presented as being considered for possible commercial and/or clinical deployment by a French startup company. The cover story included mock photographs of the device (consisting of both an in-ear prosthesis and a larynx piece, disguised as jewelry), as well as references to technical voice-transformation literature (e.g. [67]) allegedly describing the algorithms implemented in the device (see electronic supplementary material). Participants were told that the startup was commissioning the study to evaluate the societal acceptability of their technology in various usage scenarios, and that their collective judgements would condition the deployment of the technology.

After reading the cover story, participants were presented a series of $n = 12$ short situational vignettes, each describing a potential application of the voice-transformation device (see *Vignettes*, below). There were two between-participant conditions, in which participants either read vignettes that described the participant as the user of the device (condition *self*; $N = 150$), or vignettes describing otherwise-identical situations in which the device was applied to others and in which participants were in the position of the user's conversation partners (condition *other*; $N = 153$). In each self-other condition, vignettes included a number of within-participant conditions, which we describe below. For each vignette, participants were asked to answer three questions about how morally acceptable they think the situation was (see *Measures*, below).

Finally, after completing the questions for all vignettes, participants were asked to complete two standard questionnaires measuring attitudes towards morality (Moral Foundations Questionnaire MFQ; [31]) and toward technology and science fiction (Science Fiction Hobbyism Scale; [28]). The study lasted on average 30 min.

(c) Vignettes

We created $n = 12$ short text vignettes describing potential applications of the voice-transformation device in concrete daily life situations. Vignettes varied among three situational factors, which were encoded as within-participant variables to test for their impact on the acceptability of the device:

- (i) whether voice transformations are used to repair (e.g. therapeutically) or enhance user capacities (condition *repair*: $n = 6$; *enhance*: $n = 6$). Examples of *repair* vignettes included e.g. using the device to help a depressive patient communicate with their close ones with a more enthusiastic tone of voice; examples of *enhance* situations included e.g. using the same transformation to help a politician gather more following. In *repair* vignettes, the device was described as being prescribed to the user by a doctor; in *enhance* vignettes, the device was recommended by a life coach.
- (ii) the kind of voice transformation operated by the device, either reducing *anger* ($n = 2$; e.g. making angry customers' voice less taxing to attend to, for call-centre operators), reducing *anxiety* ($n = 4$; e.g. helping a budding actor overcome stage-fright) or enhancing *smile* ($n = 6$; e.g. helping a waiter gather more tips from customers).
- (iii) whether the voice transformation affects how the user's voice is heard by others (condition *production*: $n = 4$), how the user hears other persons' voices (condition *perception*: $n = 4$), or whether it is used in a situation where the user hears their own manipulated voice (condition

feedback: $n = 4$). Examples of the feedback condition include e.g. having a post-traumatic stress disorder (PTSD) patient listen to their own voice made less anxious as they retell their traumatic event [68].

All 12 vignettes were written in two matched versions, in which the user of the device was either the participant (e.g. *imagine you are a depressive patient, and your doctor is advising you to use a voice-transformation device*...; condition *self*: $n = 12$) or an unknown other (e.g. *A depressive patient*...; condition *other*: $n = 12$). Condition *self-other* was randomly assigned between-participant; all other conditions were varied within-participant, in random order. All vignettes are available with English translation in electronic supplementary material.

(d) Measures:

After reading each vignette, participants answered three questions about:

- (i) how morally acceptable they think the situation is (*Judge how morally acceptable it is to use the MyVoicePlus device in such a situation*'; FR: *A quel point jugez-vous cette utilisation du produit MyVoicePlus™ moralement acceptable?*)
- (ii) how morally acceptable they think it would be for the user to use the device covertly, i.e. to lie to their conversation partners that they are either talking to them, or hearing them, with a modified voice, knowing that this may improve the effectiveness of the device by up to 70%. (*Judge how acceptable it is to lie to your entourage about using the voice transformation, knowing that this would improve the effectiveness of the device*'; FR: *'A quel point jugez-vous acceptable le fait de cacher -votre entourage l'existence de la transformation de voix, en sachant que cela augmente considérablement l'efficacité du dispositif?*)
- (iii) how morally acceptable they think it would be to hide the true purpose of the device from its own user, i.e. that the users themselves do not know that they either talking, or hearing others, with a modified voice. (*Judge how acceptable it is that the [doctor/coach] should lie to the user about the voice transformation, knowing that this would improve the effectiveness of the device*'; FR: *A quel point jugez-vous acceptable le fait que le médecin vous cache l'existence de la transformation de voix, en sachant que cela augmente considérablement son efficacité?*)

Answers to all three questions were rated using a 9-point Likert scale, anchored by 1 *totally unacceptable* and 9 *totally acceptable*.

(e) Attitude questionnaires

In addition to providing moral judgements about the vignettes, participants completed two questionnaires measuring their attitudes toward morality (Moral Foundations Questionnaire MFQ; [31]) and toward technology and science fiction (Science Fiction Hobbyism Scale SFH; [28]).

The MFQ consists in 32 short questions (30 items + 2 foil items) about how relevant various considerations (e.g. *Whether or not someone suffered emotionally*) are when deciding whether something is right or wrong, rated from 1 (*not at all relevant*) to 7 (*extremely relevant*), and how much the participant agrees with various moral positions (e.g. *Compassion for those who are suffering is the most crucial virtue*; rated from 1 (*strongly disagree*) to 7 (*strongly agree*). In accordance with typical MFQ analysis [31], we grouped and averaged each participant responses along the five subscales of care-harm (6 items; e.g. *whether or not someone suffered emotionally*), fairness-cheating (5 items; e.g. *whether or not some people were treated differently from others*), loyalty-betrayal

(6 items; e.g. *whether or not someone did something to betray their group*), authority–subversion (5 items; e.g. *whether or not an action caused chaos or disorder*), and purity–degradation (6 items; e.g. *whether or not someone violated standards of purity and decency*). None of the items were reverse-coded. In this work, we used the back-translated French-language version of the MFQ designed by [69]. A previous study [69] validated MFQ-French on a sample of similar demographics as the present study and found it had acceptable internal validity ($N = 538$ participants; care: Cronbach $\alpha = 0.64$; fairness: $\alpha = 0.67$; loyalty: $\alpha = 0.65$; authority: $\alpha = 0.73$; purity: $\alpha = 0.79$) and one-month test-retest validity ($N = 40$; care: $r = 0.53$, 95% CI [0.26, 0.72]; fairness: $r = 0.66$, [0.43, 0.80]; loyalty: $r = 0.66$, [0.44, 0.81]; authority: $r = 0.75$, [0.57, 0.86], purity: $r = 0.88$, [0.78, 0.94]; all $ps < 0.01$). The fit to a 5-factor structure, while significantly better than an alternative 3-factor model, was comparably poorer ($N = 538$; Comparative Fit Index CFI: 0.82; Root mean squared error of approximation RMSEA: 0.065), a known issue common to the American version and discussed elsewhere [70,71].

In accordance with recommendations of [69] and compared to the American version, two MFQ items (fairness: *I think it's morally wrong that rich children inherit a lot of money while poor children inherit nothing*; authority: *Men and women each have different roles to play in society*) were removed from the French translation to improve internal consistency. In our data ($N = 303$), the internal validity of the 5 MFQ constructs was comparable to the sample of [69] for purity–degradation ($\alpha = 0.74$, [0.70, 0.78]), fairness–cheating ($\alpha = 0.65$, [0.58, 0.70]), loyalty–betrayal ($\alpha = 0.63$, [0.56, 0.69]) and authority–subversion ($\alpha = 0.68$, [0.62, 0.73]), but was poor for the care–harm construct ($\alpha = 0.55$, 95% CI [0.45, 0.61]). Confirmatory factor analysis for the 5-factor model was significant (GLS fit, $\chi^2(340) = 575$, $p < 0.001$), fitting data adequately on some measures (RMSEA = 0.048) but relatively poorly on others (CFI = 0.48). We opt to conform to the recommendations of a more extensive validation (with a sample size nearly twice as big as our current sample [69]) and use the 5-factor model for our current analysis. However, the present data adds evidence to the fact that, as already discussed elsewhere [71], significant elements of the MFQ covariance structure are not captured by this model.

The SFH scale [28] consists of 12 items and measures individuals' cultural exposure to futuristic technology and science fiction themes (examples of items: *I often think about what machines are like in the future, I often spot science or technology related errors in science fiction films, TV series, or books*). All items are rated from 1 (*strongly disagree*) to 7 (*strongly agree*), with higher scores indicating higher science fiction familiarity. None of the items were reverse-coded. A previous study [29] validated the scale on $N = 172$ participants and found it had good psychometric properties (all factor loadings > 0.57 ; Cronbach's $\alpha = 0.92$). In this work, we used our own, non-validated French-language translation of the SFH. In our data ($N = 303$), the internal validity of the SF construct was also good ($\alpha = 0.89$, [0.888, 0.898]).

References

- Darwin C. 1872 *The expression of the emotions in man and animals*, 1998 edn. Oxford, UK: Oxford University Press.
- Knapp ML, Hall JA, Horgan TG 2013 *Nonverbal communication in human interaction*. Cengage Learning.
- Bachorowski J-A, Owren MJ. 1995 Vocal expression of emotion: acoustic properties of speech are associated with emotional intensity and context. *Psychol. Sci.* **6**, 219–224. (doi:10.1111/j.1467-9280.1995.tb00596.x)
- Jack RE, Sun W, Delis I, Garrod OGB, Schyns PG. 2016 Four not six: revealing culturally common facial expressions of emotion. *J. Exp. Psychol.: General* **145**, 708. (doi:10.1037/xge0000162)
- Oosterhof NN, Todorov A. 2008 The functional basis of face evaluation. *Proc. Natl Acad. Sci. USA* **105**, 11 087–11 092. (doi:10.1073/pnas.0805664105)
- Ponsot E, Arias P, Aucouturier JJ. 2018 Uncovering mental representations of smiled speech using reverse correlation. *J. Acoust. Soc. Am.* **143**, EL 19–EL 24. (doi:10.1121/1.5020989)
- Bitti PER, Bonfiglioli L, Melani P, Caterina R, Garotti P. 2014 Expression and communication of doubt/uncertainty through facial expression. *Ricerche di Pedagogia e Didattica. J. Theories Res. Edu.* **9**, 159–177.

(f) Statistical analyses

There were two dependent variables (DVs) in the study, measuring the acceptability of overt (DV1) and covert (DV2) use of voice transformations. DV2 was constructed by recoding the two questions about concealed use (lying to the user, and lying to others) as a single DV measured in two conditions (who is being lied to).

The study's vignettes spanned a number of situation characteristics, each described as a combination of independent variables (IVs). There were one between-participant IV (self–other), three within-participant IVs for DV1 (repair–enhance, smile–anxiety–anger, production–perception–feedback) and an additional two within-participant IVs for covert DV2 (lying to user–other, and lying to participant–other). We analysed the effect of IVs on both DVs using one-way, repeated-measures or mixed ANOVAs, by averaging acceptability scores within-participant over the vignettes corresponding to each condition tested.

In addition, there were six measures of individual characteristics (MFQ: 5 constructs; SFH: 1 construct). We tested the association of these individual characteristics with the study's DVs by computing within-participant averages of acceptability scores (one data point per participant) and multiple regression. We tested for residual–prediction heteroscedasticity with the Breusch–Pagan test. In case of homoscedasticity, we used multiple ordinary least square (OLS) regression; in case of heteroscedasticity, we used iterated re-weighted least-square (IRLS) regression with Huber weighting and HC3 correction. All analyses were conducted in Python (3.6.8), using the pingouin (0.3.12) and statsmodels (0.12.2) packages.

Ethics. All participants tested at the Sorbonne-INSEAD Center for Behavioral Science. The experiment was approved by the Institut Européen d'Administration des Affaires (INSEAD) IRB (Study 202058; 'Study of the moral attitudes and willingness towards the use of a voice transformation device'; decision of 18 June 2020). All participants gave their informed consent for the study, were debriefed after the study, and were compensated for their participation at a standard rate.

Data accessibility. Experimental data and analysis code (open-source, Python) made available as electronic supplementary material at <https://github.com/creamlab/deep-ethics>.

Authors' contributions. N.G. and J.J.A. designed the study and analysed data. N.G. and J.J.A. wrote the manuscript, with contributions from G.V.

Competing interests. J.J.A. is scientific advisor for voice transformation start-up *Alta Voce SAS*.

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- 568 8. Goupil L, Ponsot E, Richardson D, Reyes G,
569 Aucouturier J-J. 2021 Listeners' perceptions of the
570 certainty and honesty of a speaker are associated
571 with a common prosodic signature. *Nat. Commun.*
572 **12**, 1–17. (doi:10.1038/s41467-020-20649-4)
- 573 9. Jack RE, Garrod OGB, Yu H, Caldara R, Schyns PG.
574 2012 Facial expressions of emotion are not culturally
575 universal. *Proc. Natl Acad. Sci. USA* **109**, 7241–7244.
576 (doi:10.1073/pnas.1200155109)
- 577 10. Safra L, Chevallier C, Grèzes J, Baumard N. 2020
578 Tracking historical changes in trustworthiness using
579 machine learning analyses of facial cues in
580 paintings. *Nat. Commun.* **11**, 1–7. (doi:10.1038/
581 s41467-020-18566-7)
- 582 11. Arias P, Rachman L, Liuni M, Aucouturier J-J. 2020
583 Beyond correlation: acoustic transformation methods
584 for the experimental study of emotional voice and
585 speech. *Emotion Rev.* **13**, 12–24. (doi:10.1177/
586 1754073920934544)
- 587 12. Rachman L *et al.* 2017 David: an open-source
588 platform for real-time transformation of infra-
589 segmental emotional cues in running speech.
590 *Behav. Res. Methods* 1–21.
- 591 13. Westerlund M. 2019 The emergence of deepfake
592 technology: a review. *Technol. Innovation Manage.*
593 *Rev.* **9**. (doi:10.22215/timreview/1282)
- 594 14. Pumarola A, Agudo A, Martinez AM, Sanfeliu A,
595 Moreno-Noguer F. 2018 Ganimation: anatomically-
596 aware facial animation from a single image. In *Proc.*
597 *of the European Conf. on Computer Vision (ECCV)*,
598 pp. 818–833.
- 599 15. Luo Z, Chen J, Takiguchi T, Ariki Y. 2017 Emotional
600 voice conversion using neural networks with
601 arbitrary scales f0 based on wavelet transform.
602 *EURASIP J. Audio, Speech Music Process.* **2017**,
603 1–13. (doi:10.1186/s13636-016-0099-4)
- 604 16. Bonnefon J-F, Shariff A, Rahwan I. 2016 The social
605 dilemma of autonomous vehicles. *Science* **352**,
606 1573–1576. (doi:10.1126/science.aaf2654)
- 607 17. Porter S, Brinke LT. 2008 Reading between the lies:
608 identifying concealed and falsified emotions in
609 universal facial expressions. *Psychol. Sci.* **19**,
610 508–514. (doi:10.1111/j.1467-9280.2008.02116.x)
- 611 18. Tang C, Seal CR, Naumann SE. 2013 Emotional labor
612 strategies, customer cooperation and buying
613 decisions. *J. Manage. Market. Res.* **13**, 1.
- 614 19. Côté S, Hideg I, Van Kleef GA. 2013 The
615 consequences of faking anger in negotiations.
616 *J. Exp. Soc. Psychol.* **49**, 453–463. (doi:10.1016/j.
617 jesp.2012.12.015)
- 618 20. Boidron L, Boudenia K, Avena C, Boucheix J-M,
619 Aucouturier J-J. 2016 Emergency medical triage
620 decisions are swayed by computer-manipulated
621 cues of physical dominance in caller's voice. *Sci.*
622 *Rep.* **6**, 1–7. (doi:10.1038/srep30219)
- 623 21. Lerner A. We built voice modulation to mask
624 gender in technical interviews. here's what
625 happened. Accessed from <https://blog.interviewing.io/we-built-voice-modulation-to-mask-gender-in-technical-interviews-heres-what-happened> on
626 2021-03-16.
- 627 22. Nijboer F, Morin FO, Carmien SP, Koene RA, Leon E,
628 Hoffmann U. 2009 Affective brain-computer
629 interfaces: psychophysiological markers of emotion
630 in healthy persons and in persons with amyotrophic
631 lateral sclerosis. In *2009 3rd Int. Conf. on Affective
632 Computing and Intelligent Interaction and
633 Workshops*, pp. 1–11. IEEE.
- 634 23. Bovens L. 2009 The ethics of nudge. In *Preference
635 change*, pp. 207–219. New York, NY: Springer.
- 636 24. Rohrman S, Bechtoldt MN, Hopp H, Hodapp V,
637 Zapf D. 2011 Psychophysiological effects of
638 emotional display rules and the moderating role of
639 trait anger in a simulated call center. *Anxiety, Stress
640 & Coping* **24**, 421–438. (doi:10.1080/10615806.
641 2010.530262)
- 642 25. Goupil L, Johansson P, Hall L, Aucouturier J-J. 2021
643 Vocal signals only impact speakers' own emotions
644 when they are self-attributed. *Conscious Cogn.* **88**,
645 103072. (doi:10.1016/j.concog.2020.103072)
- 646 26. Medaglia JD, Yaden DB, Helion C, Haslam M.
647 2019 Moral attitudes and willingness to enhance
648 and repair cognition with brain stimulation.
649 *Brain Stimulat.* **12**, 44–53. (doi:10.1016/j.brs.2018.
650 09.014)
- 651 27. Elias JJ, Lacetera N, Macis M. 2019 Paying for
652 kidneys? A randomized survey and choice
653 experiment. *Am. Econ. Rev.* **109**, 2855–2888.
654 (doi:10.1257/aer.20180568)
- 655 28. Laakasuo M, Drosinou M, Koverola M, Kunnari A,
656 Halonen J, Lehtonen N, Palomäki J. 2018 What
657 makes people approve or condemn mind upload
658 technology? Untangling the effects of sexual
659 disgust, purity and science fiction familiarity.
660 *Palgrave Commun.* **4**, 1–14. (doi:10.1057/s41599-
661 018-0124-6)
- 662 29. Koverola M, Drosinou M, Palomäki J, Halonen J,
663 Kunnari A, Repo M, Lehtonen N, Laakasuo M. 2020
664 Moral psychology of sex robots: an experimental
665 study- how pathogen disgust is associated with
666 interhuman sex but not interandroid sex. *Paladyn,
667 J. Behav. Rob.* **11**, 233–249. (doi:10.1515/pjbr-
668 2020-0012)
- 669 30. Koverola M, Kunnari A, Drosinou M, Palomäki J,
670 Hannikainen IR, Sundvall J, Laakasuo M. 2020 Non-
671 human superhumans-moral psychology of brain
672 implants: exploring the role of situational factors,
673 science fiction exposure, individual differences and
674 perceived norms.
- 675 31. Graham J, Nosek BA, Haidt J, Iyer R, Koleva S, Ditto
676 PH. 2011 Mapping the moral domain. *J. Pers. Soc.*
677 *Psychol.* **101**, 366. (doi:10.1037/a0021847)
- 678 32. Körner A, Deutsch R, Gawronski B. 2020 Using the
679 cni model to investigate individual differences in
680 moral dilemma judgments. *Pers. Soc. Psychol. Bull.*
681 **46**, 1392–1407. (doi:10.1177/0146167220907203)
- 682 33. Cabrera LY, Fitz NS, Reiner PB. 2015 Empirical
683 support for the moral salience of the therapy-
684 enhancement distinction in the debate over
685 cognitive, affective and social enhancement.
686 *Neuroethics* **8**, 243–256. (doi:10.1007/s12152-014-
687 9223-2)
- 688 34. Rini R. 2020 Deepfakes and the epistemic backstop.
689 *Phil. Imprint* **20**.
- 690 35. Pearce D. 1995 *Hedonistic imperative*. Self-
691 published. Retrieved on 26-03-2021 from [http://](http://happymutations.com/ebooks/david-pearce-the-hedonistic-imperative.pdf)
- 692 36. Earp BD, Wudarczyk OA, Sandberg A, Savulescu J.
693 2013 If i could just stop loving you: anti-love
694 biotechnology and the ethics of a chemical breakup.
695 *Am. J. Bioethics* **13**, 3–17. (doi:10.1080/15265161.
696 2013.839752)
- 697 37. Goffette J 2006 *Naissance de l'anthropotechnie: de la
698 médecine au modelage de l'humain*. Vrin.
- 699 38. Clarke AE, Shim JK, Mamo L, Fosket JR, Fishman JR.
700 2003 Biomedicalization: technoscientific
701 transformations of health, illness, and us
702 biomedicine. *Am. Sociol. Rev.* 161–194. (doi:10.
703 2307/1519765)
- 704 39. Davis D, Dooley M, Hook J, Choe E, McElroy-Heltzel
705 S. 2016 The purity/sanctity subscale of the moral
706 foundations questionnaire does not work similarly
707 for religious versus non-religious individuals.
708 *Psychol. Religion and Spirituality* **9**, 124. (doi:10.
709 1037/rel0000057)
- 710 40. Kass L 2003 *Beyond therapy: biotechnology and the
711 pursuit of happiness*. Executive Office of the
712 President.
- 713 41. Persson I, Savulescu J. 2008 The perils of cognitive
714 enhancement and the urgent imperative to enhance
715 the moral character of humanity. *J. Appl. Phil.* **25**,
716 162–177. (doi:10.1111/j.1468-5930.2008.00410.x)
- 717 42. Sahakian BJ, Morein-Zamir S. 2011
718 Neuroethical issues in cognitive enhancement.
719 *J. Psychopharmacol.* **25**, 197–204. (doi:10.1177/
720 0269881109106926)
- 721 43. Kahane G. 2015 Sidetracked by trolleys: why
722 sacrificial moral dilemmas tell us little (or nothing)
723 about utilitarian judgment. *Social Neurosci.* **10**,
724 551–560. (doi:10.1080/17470919.2015.1023400)
- 725 44. Schermer M 2015 Ethics of pharmacological mood
726 enhancement. In *Handbook of Neuroethics*,
727 pp. 1177–1190, New York NY: Springer
- 728 45. Kramer PD, Brody EB. 1994 Listening to prozac: a
729 psychiatrist explores antidepressant drugs and the
730 remaking of the self. *J. Nervous Mental Dis.* **182**,
731 362. (doi:10.1097/00005053-199406000-(00017))
- 732 46. Michaud T 2020 *Science fiction and innovation
733 design*. John Wiley & Sons.
- 734 47. Greene JD, Sommerville RB, Nystrom LE, Darley JM,
735 Cohen JD. 2001 An fmri investigation of
736 emotional engagement in moral judgment.
737 *Science* **293**, 2105–2108. (doi:10.1126/science.
738 1062872)
- 739 48. Sidgwick H 1874 *The methods of ethics*. Macmillan
740 and Company, limited; New York, NY: The
741 Macmillan Company.
- 742 49. Trippett D. 2017 Music and the transhuman ear:
743 ultrasonics, material bodies, and the limits of
744 sensation. *Musical Q.* **100**, 199–261. (doi:10.1093/
745 musqtl/gdy001)
- 746 50. Kahane G. 2011 Reasons to feel, reasons to take
747 pills. In *Enhancing Human Capacities*, pp. 166–178.
- 748 51. Ben-Ze'ev Aaron. 1997 Emotions and morality.
749 *J. Value Inquiry* **31**, 195–212. (doi:10.1023/
750 A:1004236823330)
- 751 52. Theriault JE, Young L, Barrett LF. 2021 The sense of
752 should: a biologically-based framework for

- 631 modeling social pressure. *Phys. Life Rev.* **36**,
632 100–136. (doi:10.1016/j.plrev.2020.01.004)
- 633 53. Matsumoto D, Yoo SH, Fontaine J. 2008 Mapping
634 expressive differences around the world: the
635 relationship between emotional display rules and
636 individualism versus collectivism. *J. Cross-Cultural
637 Psychol.* **39**, 55–74. (doi:10.1177/00220221
638 07311854)
- 639 54. European Space Agency. 2002 Innovative
640 technologies from science fiction for space
641 applications.
- 642 55. Thomas LB. 2014 Nanotech ideas in science fiction
643 literature.
- 644 56. Michael K, Abbas R, Roussos G, Scornavacca E,
645 Fosso-Wamba S. 2020 Dealing with technological
646 trajectories: where we have come from and where
647 we are going. *IEEE Trans. Technol. Soc.* **1**, 2–7.
648 (doi:10.1109/TTS.2020.2976425)
- 649 57. Haring KS, Mougenot C, Ono F, Watanabe K. 2014
650 Cultural differences in perception and attitude
651 towards robots. *Int. J. Affect. Eng.* **13**, 149–157.
652 (doi:10.5057/ijae.13.149)
- 653 58. Henrich J, Heine SJ, Norenzayan A. 2010 Most
654 people are not weird. *Nature* **466**, 29–29. (doi:10.
655 1038/466029a)
- 656 59. Doğruyol B, Alper Sn, Yilmaz O. 2019 The five-factor
657 model of the moral foundations theory is stable
658 across weird and non-weird cultures. *Pers. Individual
659 Differences* **151**, 109547. (doi:10.1016/j.paid.2019.
660 109547)
- 661 60. Atari M, Graham J, Deghani M. 2020 Foundations
662 of morality in iran. *Evol. Hum. Behav.* **41**, 367–384.
663 (doi:10.1016/j.evolhumbehav.2020.07.014)
- 664 61. Berniūnas R. 2020 Mongolian yos surtakuun and
665 weird 'morality'. *J. Cultural Cogn. Sci.* **4**, 59–71.
666 (doi:10.1007/s41809-019-00045-1)
- 667 62. Awad E, Dsouza S, Shariff A, Rahwan I, Bonnefon
668 J-F. 2020 Universals and variations in moral
669 decisions made in 42 countries by 70,000
670 participants. *Proc. Natl Acad. Sci. USA* **117**,
671 2332–2337. (doi:10.1073/pnas.1911517117)
- 672 63. Wu F, Ma Y, Zhang Z. 2021 'I found a more
673 attractive deepfaked self': the self-enhancement
674 effect in deepfake video exposure. *Cyberpsychology,
675 Behav. Soc. Netw.* **24**, 173–181. (doi:10.1089/cyber.
676 2020.0173)
- 677 64. Parkinson B, Manstead ASR. 1993 Making
678 sense of emotion in stories and social life. *Cogn.
679 Emotion* **7**, 295–323. (doi:10.1080/0269993
680 9308409191)
- 681 65. Rey B, Simoncini N, Tridot M. 2021 Les sciences
682 humaines et sociales en recherche technologique:
683 vers une démarche de conception fondée sur
684 l'ethnographie.
- 685 66. Tsakiris M. 2021 How should the political animals of
686 the 21st century feel?: Comment on 'the sense of
687 should: a biologically-based framework for
688 modelling social pressure' by JE Theriault et al. *Phys.
689 Life Rev.* **36**, 77–79. (doi:10.1016/j.plrev.2020.06.
690 008)
- 691 67. Khosravani S, Mahnan A, Yeh I-L, Aman JE,
692 Watson PJ, Zhang Y, Goding G, Konczak J. 2019
693 Laryngeal vibration as a non-invasive
694 neuromodulation therapy for spasmodic
695 dysphonia. *Sci. Rep.* **9**, 1–11. (doi:10.1038/s41598-
696 019-54396-4)
- 697 68. Aucouturier J-J, Johansson P, Hall L, Segnini R,
698 Mercadié L, Watanabe K. 2016 Covert digital
699 manipulation of vocal emotion alter speakers'
700 emotional states in a congruent direction. *Proc. Natl
701 Acad. Sci. USA* **113**, 948–953. (doi:10.1073/pnas.
702 1506552113)
- 703 69. Métayer S, Pahlavan F. 2014 Validation of the moral
704 foundations questionnaire in French. *Revue Int. de
705 Psychologie Sociale* **27**, 79–107.
- 706 70. Curry OS, Chesters MJ, Van Lissa CJ. 2019 Mapping
707 morality with a compass: testing the theory of
708 'morality-as-cooperation' with a new questionnaire.
709 *J. Res. Personal.* **78**, 106–124. (doi:10.1016/j.jrp.
710 2018.10.008)
- 711 71. Zakharin M, Bates T. 2021 Remapping the
712 foundations of morality: well-fitting
713 structural model of the moral foundations
714 questionnaire.