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Aversive smell associations shape social judgment

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ABSTRACT

Once associating another person with an unpleasant smell, how do we perceive and judge this person from that moment on? Here, we used aversive olfactory conditioning followed by a social attribution task during functional magnetic resonance imaging to address this question. After conditioning, where one of two faces was repeatedly paired with an aversive smell, the participants reported negative affect when viewing the smell-conditioned but not the neutral face. When subsequently confronted with the smell-conditioned face (without any smell), the participants tended to judge both positive and negative behaviors as indicative of personality traits rather than related to the situation. This effect was predicted by the degree of the preceding olfactory evaluative conditioning. Whole brain analysis of stimulus by stage interaction indicated differential activation of the ventromedial prefrontal cortex and right angular gyrus to the conditioned versus the neutral person during the attribution phase only. These results suggest that negative smell associations do not simply induce a negative perception of the target person but rather bias the attribution style towards trait attributions. The fact that this bias was evident regardless of behavior valence suggests it may reflect enhanced psychological distance. Thus, the known observation of social rejection triggered by aversive smell may be driven by a shift in social attribution style.

1. Introduction

From bullying the "smelly kid" in class to the booming fragrance industry – the impact of smell on social life is proverbial. People with an unpleasant body odor, for instance, are often stigmatized and suffer social discrimination. How do smell associations shape the way we judge other people long after the smell has evaporated? As social beings, we constantly judge other people. We observe what they do and speculate why they do it. Upon doing so, we tend to attribute behavior primarily to the person's personality instead of considering the context. When observing Mike's apparent rude behavior, for example, we tend to infer that Mike must be a rude person, rather than considering the context, which may offer other explanations (Gilbert & Malone, 1995; Heider, 1958; Jones & Harris, 1967; Ross, 1977). Previous research showed that cognitive load or depleted motivational resources as well as psychological distance increase the tendency to attribute behavior to the person instead of the context (Gawronski, 2004; Nisbett & Ross, 1980; Trope, 1982, 1986; Trope & Cohen, 1989; Trope & Gaunt, 2000; Trope & Liberman, 1993), but the role of aversive smell on social attribution has not been studied before. We theorized that smell may affect social judgment by shaping attribution style.

We used aversive olfactory conditioning to establish a relationship between an aversive smell and the target person. Subsequently, without the smell, we tested how evaluative smell conditioning influenced the process of drawing personality attributions from observed behavior, as well as liking and morality judgments. Participants were instructed to judge positive and negative behaviors that included a situational constraint during functional magnetic resonance imaging (fMRI), which allowed us to test the trait attribution tendency as a function of behavior valence. We hypothesized two possible outcomes. One possibility was that olfactory conditioning would result in more negative and fewer positive personality attributions for the target person, consistent with an overall negative affect towards the target person that informs the attribution process. The alternative prediction was that

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participants would take any behavior as indicative of personality traits, resulting in more personality attributions irrespective of behavior valence.

As for the liking and morality judgments, previous research have shown that these could be influenced by aversive odors (Alaoui-Ismaili, Robin, Rada, Dittmar, & Vernet-Maury, 1997; Croy, Olgun, & Joraschky, 2011; Herz, Schankler, & Beland, 2004; Kirk-Smith, Van Toller, & Dodd, 1983; Reicher, Templeton, Neville, Ferrari, & Drury, 2016; Rozin & Fallon, 1987; Schnall, Haidt, Clore, & Jordan, 2008; Stevenson, 2010; Yeshurun & Sobel, 2010), but whether odor evaluative conditioning would similarly shape morality and liking judgments is unclear.

We combined the behavioral manipulation with neuroimaging because we were not only interested in the behavioral effects of aversive olfactory conditioning on social judgments but also their neural correlates. We expected that the two competing behavioral hypotheses we proposed would be reflected by the direction of activity changes in a network of brain regions previously implicated in mentalizing (Moran, Jolly, & Mitchell, 2014) and information integration (Roy, Shohamy, & Wager, 2012). Mentalizing – the ability to infer mental states of others – has been shown to positively correlate with the tendency to make trait attributions (Moran et al., 2014). We therefore expected to find activity changes during attribution when comparing CS+ to CS− in regions possibly involved in mentalizing such as the dorsomedial prefrontal cortex, posterior cingulate cortex, and angular gyrus. Regarding information integration, the computation of a single meaning from different sources of information critically depends on the ventromedial prefrontal cortex (VMPFC; Roy et al., 2012). Previous work has indicated that activity in the VMPFC is involved in the evaluation of smell (Howard, Kahnt, & Gottfried, 2016) and in tracking the devaluation of a smell when it is described as aversive instead of appetitive (de Araujo, Rolls, Velazco, Margot, & Cayeux, 2005), thereby updating the meaning by a context assessment.

We hypothesized that the distinction between the overall negative affect towards the target person informing the attribution process, and the alternative prediction that participants would take any behavior as indicative of personality traits, should be evident by the direction of the activity changes at the inference stage. The less effortful and cognitively less demanding process of attributions that do not consider the situational context should result in activity decreases in the VMPFC and mentalizing network, while an inference mode that does take the situational context into account (at least for positive behaviors) should be cognitively more demanding and reflected by an activity increase in these regions.

Finally, to also address the specificity of aversive olfactory conditioning, we conducted a second experiment using visual aversive stimuli to test whether the effect on social judgment was specific to aversive smell. Given that odors can induce strong affects (Alaoui-Ismaili et al., 1997; Herz et al., 2004; Kirk-Smith et al., 1983; Rozin & Fallon, 1987; Schnall et al., 2008; Stevenson, 2010; Yeshurun & Sobel, 2010), we hypothesized that the conditioning effect induced by olfactory stimuli might be more enduring and the effect on social judgments thus specific to olfactory stimuli compared to visual stimuli.

2. Materials and methods

2.1. Participants

We recruited 19 (10 female) right-handed healthy human participants without any medical conditions. One female and one male participant were excluded due to scanner problems during conditioning and the social judgment task, respectively, resulting in missing imaging data. The final sample thus consisted of 17 participants (9 female) with a mean age of 27.7 (3.9) years. All participants provided written informed consent and were financially compensated for their participation. The experiment was approved by the Internal Review Board of the Icahn School of Medicine at Mount Sinai.

2.2. Experimental design

This was a within-subjects design in healthy volunteers involving olfactory conditioning outside the scanner (duration: about 12 min) and a social judgment paradigm (duration: about 16 min) during functional magnetic resonance imaging (fMRI) in a single session. Smell was delivered only during the conditioning phase. Participants first underwent olfactory conditioning (Fig. 1a). Before and after the conditioning, participants rated their emotions. Immediately afterwards, they completed a social judgment paradigm during fMRI (Fig. 2a). The within-subject manipulation was olfactory conditioning, as each participant was repeatedly exposed to both the CS+ person (paired with the smell) and the CS− person (never paired with the smell) during conditioning and then again during the social judgment paradigm (when no smell was delivered).

2.3. Olfactory conditioning

2.3.1. Stimuli

For the olfactory conditioning paradigm, two male faces with neutral facial expression were used, both of which were taken with an identical lighting source and camera angle (Extended Yale Database B).

2.3.2. Conditioning task

Two male faces (“Mike” and “Steve”) were shown in a pseudo-randomized order 9 times each (for 6 s). One face (conditioned stimulus; CS+) terminated with an aversive odor (unconditioned stimulus; US) in 1/3 of the trials while the other (CS−) was never paired with the odor. Between each face a fixation cross was shown for an intertrial interval varying between 6 and 10 s. The odor was delivered for 6 s per US trial. After the odor delivery a fixation cross was shown for another 14 s during which unscented air was delivered to the mask. The experimental order was randomized and counterbalanced across participants so that either Mike or Steve was paired with the odor. E-Prime 2.0 (Psychology Software Tools Inc., Pittsburgh, PA; http://www.pstnet.com) was used as presentation software.

2.3.3. Olfactometer

Participants wore a phantom nasal CPAP mask (SleepNet Corporation, Hampton, NH) and were exposed to the odor through an in-house built computerized 12-channel olfactometer based on the principles of air dilution olfactometry (Ng, Evaes, Carpenter, & Tang, 2011). The olfactometer consisted of a controlled valves unit, a signal control unit, a PC laptop computer, an air compressor, and a vacuum pump. The control interface programs were written in LabVIEW (a graphical programming language from National Instruments – Austin, Texas) and communicated with the olfactometer through NI USB-6221. Unscented air was delivered to the mask throughout the conditioning task unless a trial terminated with a US, in which case, the mask was filled with the aversive odor. Thus, unscented air was the neutral baseline to which the aversive odor was compared. It took approximately 400 ms to fill the mask with the odor and about the same time to vacuum it out. The odor was a commercially available flatulence odor consisting of an aqueous solution of ammonium sulfide that emitted hydrogen sulfide, a component of natural flatulence odor, when exposed to air. The odor was physically harmless but unpleasant. The unpleasantness of the smell was validated in a