

**What Your Nose Knows:  
Affective, Cognitive, and Behavioral Responses to the Scent of Another Person**

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## **Abstract**

People readily perceive and react to the body odors of other people, with a wide range of implications for affective, cognitive, and behavioral responses. This article provides an overview of recent research in this area. It summarizes the process by which people associate body odors with different kinds of interpersonally relevant information, briefly reviews two lines of research on responses to strangers' body odors (research on olfactory cues and emotions; research on olfactory cues and impression formation), and also reviews new research on the psychological consequences of smelling loved ones' odors—including consequences for stress reduction and sleep enhancement. It concludes with a discussion of emerging research questions and methodological considerations that may help guide future inquiry into the various ways that the odors of other people influence our emotions, cognitions, relationships, and health.

People smell. Every person emits a body odor which lingers even when the person is not physically present. A person's body odor is comprised of dozens of distinct chemical compounds (Lundstrom & Olsson, 2010) and is as much a part of that person's phenotype as their physical appearance. Like physical appearance, body odor reflects personal characteristics and temporary circumstances (e.g., people smell differently depending on their sex, age, health, and even their transient emotional states; de Groot, Semin & Smeets 2017); and, like physical appearance, body odor reflects an individual's genome (Natsch & Emter, 2020). Different people smell different.

Can people perceive, and differentiate between, these different body odors? Yes they can. Although people are popularly presumed to be the olfactory dunces of the animal kingdom, that belief is "a 19<sup>th</sup>-century myth" (McGann, 2017). Humans have a sophisticated olfactory system that discriminates between a wide range of scents—including the odors of other people. The perceptual processing of body odors occurs through neural mechanisms responsible for the processing of a wide range of social information obtained through various sensory modalities, and this processing typically occurs without conscious awareness (Lundstrom & Olsson, 2010; Pause, 2012). The implication is that, just as the human brain evolved to efficiently extract information from other individuals' appearances, it also evolved to efficiently extract information from their smells.

If so, then functional considerations that govern social perception more generally (e.g., Neuberg & Schaller, 2015) would be expected to apply to the process through which people draw inferences from others' odors. The governing principle here is that human perception is sensitive to social cues that, throughout human evolutionary history, had implications for survival and reproductive fitness. Thus, just as perceivers are sensitive to facial features that identify someone as a friend or relative, or heuristically connote particular kind of threat or opportunity, so too perceivers are likely to be sensitive to elements of odors that indicate fitness-relevant identities, threats, or opportunities.

Table 1 identifies three broad categories of inferences that perceivers make on the basis of body odor, and provides a roadmap for the rest of this article. In the following two sections, we highlight several lines of research that exemplify the fitness-relevant inferences that people draw from strangers' odors—including inferences about their transient emotional states, and about more enduring personal characteristics. We then review research on the psychological consequences of smelling a familiar body odor, and highlight new work on the implications of smelling the scent of a loved one—such as stress-reduction and improved sleep. Finally, we identify emerging research questions and methodological considerations that may guide future inquiry into the ways that the smell of other people can influence emotions, cognitions, relationships, and health.

Table 1. *Three categories of inferences that perceivers make on the basis of other people's body odors, and some of the psychological consequences of these inferences (with illustrative research examples).*

Functional basis for inference	Inferences and psychological consequences	Illustrative research example
Different body odors are associated with different emotional states	<p>Tacit inferences about other individuals' emotional states</p> <p>Emotion-congruent appraisals of one's environment; responses reflecting those appraisals</p>	<p>The scent of a fearful person enhances perceivers' anxiety and propensity to trust others (Quintana et al., 2019)</p>
Different body odors are associated with different personal characteristics	<p>Tacit inferences about other individuals' personal characteristics</p> <p>Interpersonal judgments; decisions reflecting those judgments</p>	<p>The scent of a sick person leads to decreased liking by perceivers (Sarolidou et al., 2020)</p>
Different body odors are associated with specific people	<p>Tacit inferences about presence of a specific person</p> <p>Appraisals of and responses to one's environment consistent with the presence of that specific person</p>	<p>The scent of a romantic partner increases perceivers' sleep efficiency (Hofer &amp; Chen, 2020)</p>

### **Body odors and inferences about emotional states**

When someone experiences an emotion, it is typically a response to a functionally-relevant event (e.g., threat or opportunity) that may be relevant not only for the person experiencing the emotion, but also people in their immediate environment. The experience of an emotion is associated with distinctive physiological changes in the body that are thought to affect body odor (Kadohisa, 2013). Therefore, just as perceivers can infer someone's emotional state from viewing their emotion expressions, perceivers may also infer someone's emotional state from their odor (de Groot, Semin & Smeets, 2017). These inferences can guide how perceivers respond to these individuals and their shared environment.

The smell of fear may be of particular immediate relevance to perceivers because it connotes potential danger. Olfactory communication of fear has been well documented (for a review, see de Groot & Smeets, 2017). In several studies, people watched either a neutral or fear-inducing film clip while their body odors were collected on an absorbent material. Later, when new participants smelled that material, they too exhibited responses consistent with fearfulness. For instance, in one recent study, people interacted with a virtual character while smelling body odor collected from either a fearful person or a non-fearful person; those smelling the fearful odor experienced greater anxiety themselves and were less trusting of the virtual character (Quintana, Nolet, Baus & Bouchard, 2019).

### **Body odors and inferences about personal characteristics**

People engage in many different kinds of interactions with many different people. The outcomes of those interactions depend, in part, on specific characteristics of an interaction partner, including enduring traits (e.g., sex, genetic fitness) as well as more transitory states (e.g., sickness, sexual interest). A person's body odor contains information that can help perceivers identify these characteristics. For example, using cues from odor alone, perceivers can infer a variety of functionally-relevant

demographic characteristics, such as sex, age, and genetic relatedness (de Groot, Semin & Smeets 2017; Lundström & Olsson, 2010).

In the domain of mating, there is some evidence that body odor may provide clues to variables—such as relationship status and sexual arousal—indicative of another person’s potential receptivity to a mating relationship (Mahmut & Stevenson, 2019; Wisman & Shrira, 2020), and to traits or states that might make them more desirable mating partners. For instance, throughout much of human history, a woman’s desirability as a mate is likely to have been influenced, in part, by her capacity to conceive a child. One consequence is that perceivers may be sensitive to body odors that are associated with a woman’s likelihood of conception. Consistent with this analysis, several studies show that when women have a higher likelihood of conception, their scents are judged by men to be more appealing and stimulate higher levels of male sexual arousal (e.g. Hoffmann, 2019; for a brief review of earlier studies—including non-replications—see Haselton & Gildersleeve, 2016).

A woman’s potential to conceive may also affect her own scent-based inferences about potential mates. It has been hypothesized that, when conception risk is higher, women will be more highly attuned to male characteristics that, historically, were associated with greater reproductive fitness (e.g. symmetrical features, dominance; Gildersleeve, Haselton, & Fales, 2014). Some of these characteristics may also be associated with distinctive body odors. One fascinating finding shows that when women’s conception risk is higher, they prefer the body odors of more highly symmetrical men (Gangestad, Thornhill, & Garver-Apgar, 2005). A note of caution is in order, however: This particular finding has been documented in only a few studies using small samples of participants, and results of a meta-analysis led to the conclusion (which still stands today) that more data were needed to determine the robustness of this effect (Gildersleeve et al., 2014).

In addition to implications specific to the mating domain, body odors can also provide information about whether another person poses a threat of some kind—such as the threat posed by an infectious disease. Many diseases are associated with changes in body odor (Shirasu & Touhara, 2011); and multiple studies have shown that, just as other animals use olfactory cues to identify and avoid infected individuals (Kavaliers & Choleris, 2017), humans also appear to be able to infer illness from body odor (e.g., Olsson et al., 2014). For instance, sick people produce body odors that (compared to odors of healthy individuals) lead perceivers to judge them to be less likeable (Sarolidou et al., 2020).

### **Body odors and inferences about specific people**

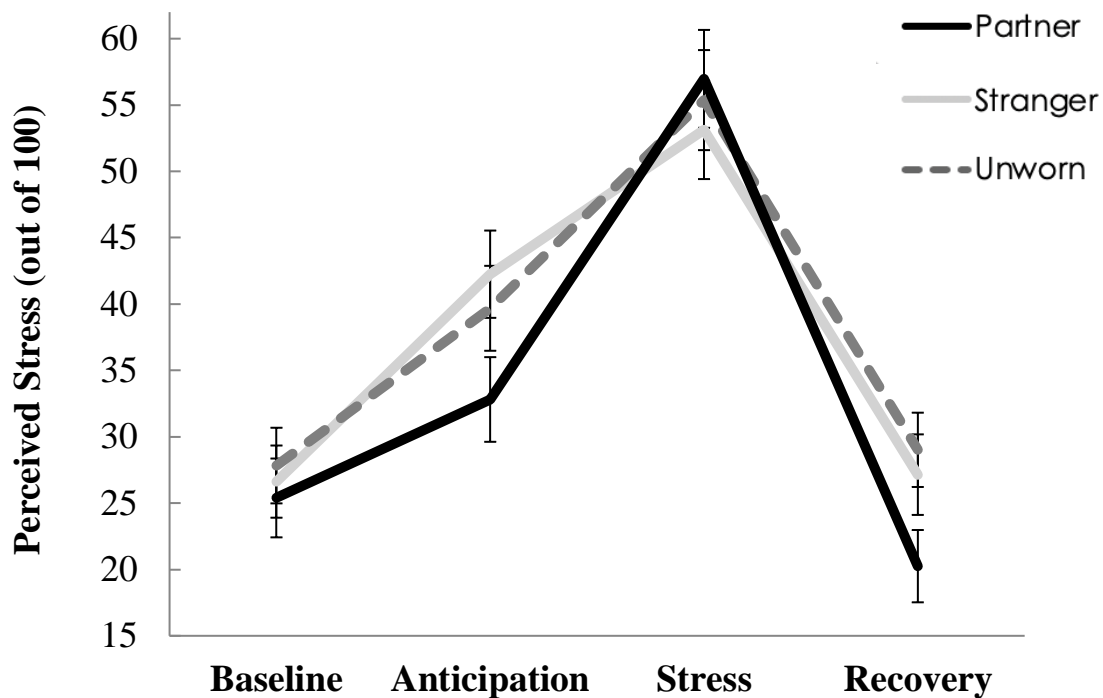
The research reviewed thus far focused on the scents of strangers. What happens when we come into contact with the scent of someone we know? Because each individual has a unique body odor, once people have learned to associate a particular odor with a particular person—such as a lover, friend or family member—they may use that odor to infer the individual’s identity (Lundström & Olsson, 2010). Furthermore, the smell of a particular person may provide tacit evidence of that person’s current or recent physical presence, with downstream consequences for the perceiver.

One especially close relationship is a mother’s connection to her baby. Mothers can readily identify their baby by scent, find this odor pleasant, and prefer it to the scent of an unfamiliar child (Schäfer, Sorokowska, Sauter, Schmidt & Croy, 2020). Reciprocally, babies benefit from exposure to scents from their mother. In one study, preterm infants who were exposed to maternal scents transitioned more quickly from feeding tubes to oral feeding and were discharged from hospital an average of 4 days sooner than babies exposed to no odor (Yildiz, Arikan, Gözüm, Taştekin & Budancamanak, 2011). Other studies indicate that infants exposed to maternal scents (compared to control scents) during a briefly painful event displayed reduced pain reactions, lower heart rates, and lower cortisol responses—



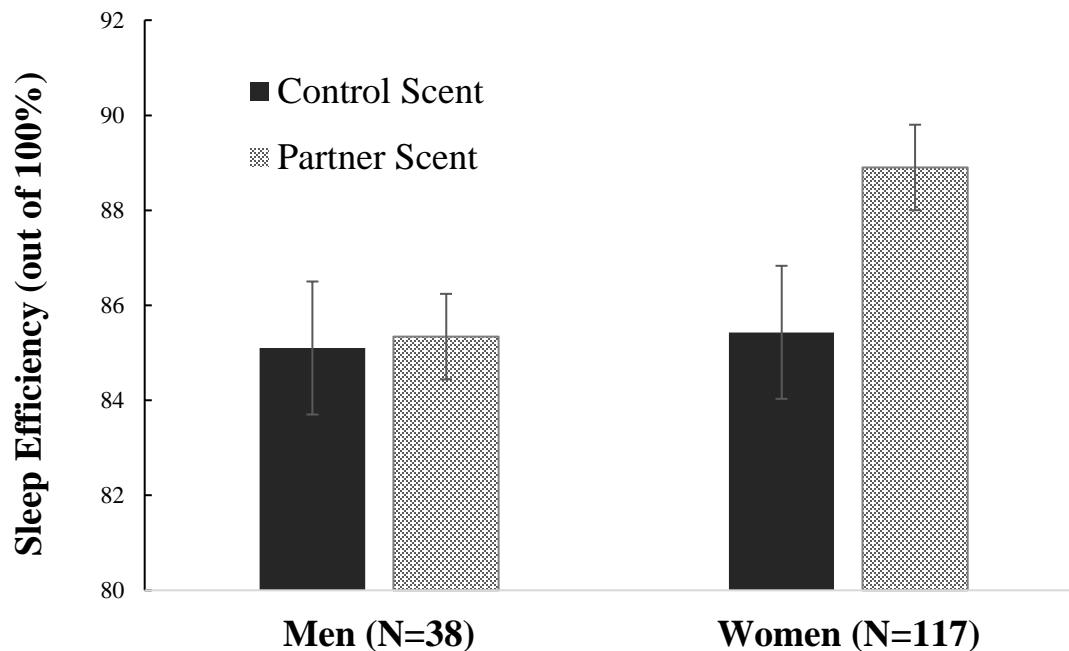
indicating that infants find the mere scent of their mother comforting (Akcan & Polat, 2016; Badiee, Asghari & Mohammadizadeh, 2013).

Just like infants, adults also find the smell of a loved one comforting (McBurney, Shoup, & Streeter, 2006). Hofer, Collins, Whillans and Chen (2018) placed female participants in a stressful situation (involving a mock job interview and a mental math task) during which they sniffed either a shirt previously worn by their romantic partner, a shirt previously worn by a stranger, or an unworn shirt. Compared to women who smelled strangers' or unworn shirts, women who smelled their partner's body odor reported experiencing less stress both before and after the stressor (Figure 1).



**Figure 1.** The body odors of 96 men—all of whom were in romantic relationships with women—were collected by having them wear a clean T-shirt for 24 hours. The men’s female romantic partners smelled a shirt before learning about an upcoming stressful situation (“Baseline”) as well as immediately prior to, during, and after a stressful situation (“Anticipation,” “Stress,” and “Recovery” phases, respectively). Depending on experimental condition, the shirt had been previously worn by—and retained the scent of—either the participant’s romantic partner or a stranger, or had never been worn. The graph depicts the subjective experience of stress reported by participants. During the Anticipation phase, women who smelled their romantic partner’s body odor felt less stressed than women who smelled a stranger’s odor. In addition, during the Recovery phase, women who smelled their romantic partner’s body odor felt less stressed than women who smelled a stranger’s or an unworn shirt. (This figure is based on results reported in Hofer, Collins, Whillans, & Chen, 2018. Error bars represent  $\pm 1$  SEM).

If indeed the smell of one's romantic partner has a stress-buffering effect, then there may be downstream consequences for other psychological phenomena. In a recent set of experiments, Hofer and Chen (2020) examined implications for sleep. Across multiple nights, participants—all of whom were in romantic relationships—slept alone with a t-shirt on their pillow. On some nights that shirt had been previously worn by their romantic partner; on other nights it was a control shirt. Sleep efficiency was assessed using a wrist-worn actigraphy watch. Although results for male sleepers were equivocal, results for female sleepers were clear: Women's sleep efficiency was higher on the nights that they slept with the shirt that retained the smell of their romantic partner (Figure 2). This result occurred regardless of whether participants were able to identify which nights they slept with their partner's scent.



**Figure 2.** Across four separate nights, 155 people in romantic relationships slept with a shirt as a pillow cover. For two nights, this pillow-cover was a shirt that had been previously worn by—and retained the scent of—their romantic partner (“Partner Scent”); for the other two nights, this pillow-cover was a control shirt that had either been previously worn by a stranger or had never been worn (“Control Scent”). Participants wore an actigraphy monitoring device that measured sleep efficiency (time spent asleep divided by total time spent attempting to sleep). Results indicate that women sleep more efficiently on nights when they smelled their romantic partner’s body odor. (This figure is based on results reported in Hofer & Chen, 2020. Error bars represent  $\pm 1$  SEM).

The stress-buffering, and sleep-inducing, effects of romantic partner's odor are likely to be contingent upon the expectation that one's partner provides a source of safety or support. If so, then these effects may vary depending on the extent to which romantic relationships are perceived to be safe and supportive. Granqvist et al. (2019) recently reported results that provided some preliminary support for this hypothesis. Participants experienced electric shocks as less uncomfortable while smelling their partner's scent, compared to their own scent (conceptually replicating the subjective stress-buffering effect reported by Hofer et al., 2018). Additionally, participants who reported higher levels of attachment security had a lower autonomic stress response when exposed to their partner's scent, while those who reported lower attachment security had an elevated stress response. An important direction for future research will be to identify additional factors that might influence whether the smell of one's romantic partner has a calming effect (or, such as in the case of an abusive relationship, might even have the opposite effect).

### **Future Directions**

These bodies of research reveal that people extract a great deal of useful inferential information from others' odors (often without even being aware of it). Future research could productively explore ways in which different lines of inquiry might be integrated. For instance, research on olfactory communication of emotions has typically focused on odor-based inferences about the emotions of strangers. Very little is known about odor-based inferences about the emotions of friends, lovers and family members. Research on the smell of sickness has also focused on the smells of strangers. Might people be differentially sensitive to infection-connoting odor cues, depending on their relationship to the infected individual? Parents, for example, might be especially sensitive to olfactory cues of sickness in their children, and these cues might plausibly elicit approach-oriented responses, rather than the avoidance responses elicited by the smell of a sick stranger.

Another interesting future direction will be to compare how body odors contribute to inferences relative to other sensory cues. Research on emotions indicates that another person's fear smell may be as informative as audio and visual cues (de Groot, Semin & Smeets, 2014), and research on the smell of sickness has begun to examine whether body odor uniquely influences appraisals of illness, even when encountered alongside visual cues that are also diagnostic of infection (Sarolidou et al., 2020). These lines of work represent important steps toward understanding of the ways in which body odor might uniquely influence interpersonal appraisals within the multi-modal perceptual complexity of social life.

While it has become clear that humans can perceive specific body odors that convey specific kinds of functionally useful information to perceivers, the exact chemical nature of many of these odors remains a mystery. Research has primarily focused on body odor from the armpit region; these odors are produced by sweat interacting with skin bacteria to produce a complex mixture of odorous volatile molecules (Natsch & Emter, 2020). A few pioneering studies have attempted to identify the molecular structure of body odors, including odors associated with specific emotions, sicknesses and individual identities (Trivedi et al., 2020; Smeets et al., 2020; Penn et al., 2007). Results are awaiting replication and, as a next step, manipulation of the identified compounds. Methodological advances may aid in this endeavor by allowing scientists to assess the air surrounding people in real time. For instance, one study measured airborne chemical compounds in a movie theatre and detected increased levels of specific compounds as the audience responded to suspenseful movie scenes (Williams et al., 2016). This method creates the opportunity to isolate and identify which compounds are emitted in response to certain events—such as the experience of fear. The identification of the specific chemical structures that communicate specific states, traits, and individual “odor prints” will be an important step forward scientifically, and may also have useful practical applications (e.g., diagnoses of diseases with specific odor profiles).

It will also be useful to pursue research on exactly how people acquire the knowledge they use to make odor-based inferences. One useful theoretical framework highlights the role of associative learning mechanisms as a means through which people come to associate specific body odors with specific traits and states (de Groot, Semin & Smeets, 2017). A related question of perennial interest is this: To what extent might there be an innate component underlying specific responses to specific odors. There are, of course, innate bases for the learning mechanisms through which learned associations are acquired, and—as with analogous responses to other kinds of perceptual stimuli (e.g., conditioned taste aversions, fearful responses to the sight of snakes)—it is likely that there are innate predispositions to efficiently learn specific associations with specific body odor profiles. However, there is limited evidence for any *purely* innate response to a specific human odor. One possible candidate for a purely innate response is a newborn’s positive reaction to the scent of human breastmilk: even exclusively bottle-fed infants prefer the scent of a lactating woman’s breast to the scent of their own familiar formula; see Schaal et al., 2020 for a comprehensive review of relevant evidence. However, while this phenomenon is consistent with an innate attraction to the odor of breastmilk, it may also be explained as a learned response acquired through prenatal exposure to chemicals in the fetal environment (Schaal et al., 2020). Stevenson (2010, p. 15) emphasized “the importance and ubiquity of learning in supporting all aspects of olfactory function.” Research in the last decade has supported this point. Obtaining a nuanced understanding of specific learning mechanisms, and the specific ways that they apply to specific phenomena, remains a challenge for future research.

To answer all these questions will involve substantial collective research effort, requiring attention from researchers with diverse areas of expertise who, ideally, will collect data from diverse segments of the human population (Roberts, Havlíček & Schaal, 2020). This kind of research is rarely cheap or easy, which can pose a practical barrier to researchers with limited resources (and, even when

resources are available, may be a disincentive within a scientific community that prizes large sample sizes). An additional obstacle for new researchers will be to navigate the various methodological decisions that need to be made (often without well-defined best practices) such as selecting control variables and deciding between diverse scent collection and scent presentation techniques. Increased international collaboration may provide a route to meet and overcome these challenges, and to produce exciting new insights into the many psychological consequences that arise when people smell other people's smells.



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