

Effects and Mechanisms of Olfaction on Social Judgment and Decision-Making

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Abstract

Olfaction is an evolutionary “adaptive mechanism” that humans have developed to solve problems of survival and reproduction. Extensive research has confirmed that olfaction influences interpersonal perception and moral judgment, and affects decision-making regarding prosocial behavior, risk behavior, and consumer behavior; however, no literature has systematically examined the underlying mechanisms of these effects. Based on a comprehensive review of existing studies, and from the dimensions of phylogeny, physiology, emotion, cognition, and interpersonal relations, this paper organizes and summarizes five hypotheses—the evolutionary hypothesis, physiological hypothesis, emotion induction hypothesis, embodied cognition hypothesis, and social construction hypothesis—to elucidate the mechanisms through which olfaction influences social judgment and decision-making at multiple levels. Current research is limited by issues such as individual differences in odor perception, inconsistent manipulation methods regarding odor dosage and exposure duration across studies, and insufficient consideration of cross-modal information integration in olfaction. Future research should strengthen investigations into olfaction in cross-modal, localized, and cross-cultural contexts, as well as in social life domains such as consumer psychology.

Full Text

The Influence and Mechanisms of Olfaction on Social Judgment and Decision-Making

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Abstract

Olfaction is an evolutionary adaptation that enables humans to solve problems related to survival and reproduction. Numerous studies have confirmed that olfaction influences interpersonal perception and moral judgment, as well as decisions regarding prosocial behavior, risk-taking, and consumption. However, no systematic review has yet examined the underlying mechanisms of these effects. By synthesizing diverse empirical studies, this paper organizes and summarizes five hypotheses—evolutionary, physiological, emotion-induction, embodied cognition, and social construction hypotheses—that explain the mechanisms through which olfaction affects social judgment and decision-making from phylogenetic, bodily, emotional, cognitive, and interpersonal dimensions. Current research suffers from several limitations, including individual differences in odor perception, inconsistent manipulation of odor dosage and exposure duration across studies, and inadequate consideration of cross-modal information integration in olfaction. Future research should strengthen investigations into olfaction’s role in cross-modal processing, localization and cross-cultural contexts, and social life applications such as consumer psychology.

Keywords: olfaction, social judgment, social decision-making, mechanism

“From afar I know it’s not snow, for a subtle fragrance comes.” Olfaction is one of the most ancient senses in human evolution, arising when odorant molecules stimulate receptors in the olfactory mucosa, generating neural impulses that travel along the olfactory nerve to the olfactory bulb (Chen et al., 2017). Compared to other senses, olfaction can receive chemical information over long distances, influencing human food and mate selection and playing a vital role in survival and reproduction (Ferdenzi et al., 2016; Velluzzi et al., 2022). Current olfactory research primarily focuses on physiology and medicine, exploring the neural mechanisms and treatment of olfactory disorders (Li et al., 2020; Zhang et al., 2021). In psychology, early research concentrated on emotion and memory, while recent years have witnessed growing interest in how olfaction influences social judgment and decision-making. People can infer others’ age, gender, and even health status through smell (Boesveldt & Parma, 2021). However, such research remains scattered across empirical studies from various perspectives, lacking a comprehensive literature review. This paper aims to synthesize empirical studies, review olfaction’s influence on social decision-making, and propose five theoretical hypotheses to explain its underlying mechanisms.

1.1.1 The Influence of Non-social Olfactory Information on Interpersonal Perception and Judgment

First, non-social odors affect how individuals perceive and judge others. Cook et al. (2015) examined how inhaling three odors—jasmine fragrance, methyl mercaptan (a foul smell), and clean air—influenced ratings of pleasantness for neutral facial expressions. Results showed that neutral faces were rated most

pleasant in the jasmine condition and least pleasant in the methyl mercaptan condition. Even when odor and face presentation were asynchronous, odors still altered judgments of facial pleasantness. When neutral faces were repeatedly paired with aversive odors, individuals developed more negative evaluations of those faces, experienced more negative emotions, and tended to ignore situational factors, attributing negative evaluations to personal traits (Homan et al., 2017). Sellaro et al. (2015) found that compared to odorless and peppermint (arousal-enhancing) conditions, lavender odor (a relaxing and calming scent) led individuals to perceive greater commonality between themselves and others. Croijmans et al. (2021) discovered that in the presence of pleasant fragrances, women rated men in videos as having higher self-esteem and attractiveness.

Second, non-social odors influence perceptions and judgments of interpersonal relationships. On one hand, olfaction affects trust toward others. Van Nieuwenburg et al. (2019) found that hexanal, a grassy compound present in body odor and lavender, increased interpersonal trust and enhanced trustworthiness judgments of random faces. On the other hand, olfaction influences acceptance of out-groups. Compared to odorless conditions, individuals showed significantly greater rejection of gay men when exposed to sweat (highly aversive) and cheese (moderately aversive) odors, suggesting that aversive olfactory stimuli may be an important factor causing individuals to avoid out-groups (Cunningham et al., 2013). Survey research further revealed that individuals more sensitive and averse to malodors exhibited higher prejudice toward immigrant and refugee groups, more readily believing that out-groups' hygiene habits fundamentally differed from their own, indicating that olfaction likely participates in and shapes social attitudes toward out-groups (Zakrzewska et al., 2019).

Finally, non-social odors affect self-perception and judgment. Research found that when Alzheimer's patients answered "Who am I?" in the presence of odors, they produced more statements about their physical, psychological, and social roles, preliminarily indicating that odor exposure can improve patients' ability to access self-concept (Glachet & Haj, 2020). Barnett et al. (2022) compared individuals exposed to putrescine (the odor of decaying organic matter, known as "the smell of death"), ammonia (present in many cleaning products), or water (odorless). Results showed that both putrescine and ammonia groups reported higher life satisfaction compared to the odorless group, suggesting that aversive odors may activate individuals' psychological threat systems, leading them to cherish their own lives more and consequently report higher life satisfaction.

1.1.2 The Influence of Non-social Olfactory Information on Moral Judgment and Decision-Making

Non-social odors affect moral judgment and decision-making. Disgusting odors make moral judgments stricter, while pleasant odors make them more lenient. When exposed to citrus cleaner odors, individuals activated cleanliness concepts, became more sensitive to cleanliness-related words, and engaged in more cleaning behaviors such as bathing and room cleaning (Holland et al., 2005).

When exposed to strong and mild foul odors, individuals made harsher moral judgments than in odorless conditions, indicating that disgusting odors tighten moral evaluation standards (Schnall et al., 2008). Liljenquist et al. (2010) investigated how clean scents influenced reciprocity and charitable behavior, finding that compared to odorless controls, individuals exposed to clean scents showed more cleaning behaviors, greater mutual assistance in anonymous games, and more generosity in donation activities. De Lange et al. (2012) conducted a field experiment on trains, releasing clean scents in two carriages. Compared to two normal-scent carriages, passengers in scented carriages discarded significantly less garbage by weight and quantity. In areas with pleasant ambient odors (such as around pastry or cake shops), pedestrians were more willing to help experimenters pick up dropped gloves, demonstrating that pleasant environmental odors promoted helping behavior (Guéguen, 2012a). Cecchetto et al. (2017) found that even neutral odors affect moral decision-making. Compared to butyric acid at sub-threshold concentration (which has hedonic ambiguity—individuals may perceive it as pleasant or unpleasant), cedarwood oil (a neutral odor) made individuals more inclined to accept moral deontology (judging morality based on the act itself rather than its utilitarian outcomes). Previous research found that high physiological arousal leads to utilitarian moral decisions, while deontological choices show the opposite pattern (Moretto et al., 2009). Cedarwood oil may influence decision-making by reducing individuals' arousal levels.

The reasons why olfaction influences moral judgment and decision-making are complex. Physiologically, Sharvit et al. (2020) compared the roles of disgusting olfactory stimuli and painful thermal stimuli in moral cognition, finding that after reading about moral transgressions, brain regions related to olfaction were activated while pain-related regions were not, suggesting a specific neural link between olfactory disgust and moral cognition. Cognitively, Białek et al. (2021) placed animal repellent in trash cans to create disgusting odors and found that different concentrations of disgusting odors had no differential effect on moral judgment, but the higher the self-reported disgust level, the stricter the moral standards. Emotionally, some research suggests that during moral judgment and decision-making, moral dilemmas or violations themselves induce disgust, which changes attitudes toward neutral behaviors and makes moral behavior more likely (Landy & Goodwin, 2015). However, Kugler et al. (2021) questioned this, using different methods to induce disgust but finding no effect on moral behavior.

1.1.3 The Influence of Non-social Olfactory Information on Other Social Decisions

First, non-social odors affect risk decision-making. Overman et al. (2011) found that releasing fragrances during the Iowa Gambling Task activated the orbitofrontal cortex in men, making their decisions more emotional, reducing cognitive capacity, and decreasing win rates. Other researchers found that in

monetary gambling tasks, exposure to aversive odors (methyl mercaptan) increased loss aversion, while exposure to pleasant odors (jasmine) did not change loss aversion (Stancak et al., 2015). Helversen et al. (2020) built upon this research with a real-consequence risk decision experiment where task failure required smelling a disgusting odor (such as feces), but allowed participants to pay money to avoid it. Results showed individuals were willing to pay more to avoid disgusting odors.

Second, non-social odors influence consumer decision-making. Davis et al. (2013) found that scent descriptions in advertisements created an illusion of actually smelling the scent, significantly affecting potential consumers' emotional responses and purchase intentions. Another study used three concentrations of melon fragrance in a large store, finding that higher concentrations positively affected shoppers' store evaluations, time spent in store, and sales volume, while effectively alleviating customer anxiety (Leenders et al., 2019). Additionally, the match between ambient odor and product affects consumer decisions. De Luca and Botelho (2020) found that compared to visual priming (images), pleasant odors (olfactory priming) increased brand logo recognition speed, improved efficiency of odor-based product categorization, and prompted consumers to purchase more products consistent with the primed odor. Using appropriate scents in retail environments can not only induce pleasant shopping experiences but also facilitate consumer decisions such as brand recall and product selection. Another study examined the relationship between warm (e.g., cinnamon) and cool (e.g., peppermint) odors and spatial perception in shopping environments, finding that warm odors made individuals feel the environment was more tense, increased power desire, and made them willing to spend more money on luxury goods (Madzharov et al., 2015). Building on this, Lefebvre and Biswas (2019) explored how ambient odor temperature affected food consumption, finding that compared to cool ambient odors (e.g., eucalyptus), individuals exposed to warm ambient odors (e.g., cedar) were more likely to choose low-calorie foods. Food odors promote eating behavior and physiological responses to food intake. Research found that individuals' appetite scores were significantly higher under food odor conditions, and under high-energy food odors (such as chocolate or milk), food intake and saliva secretion increased significantly. This effect of food odors on eating is specific: individuals tend to prefer foods with similar flavors or energy density to the smelled odor (Proserpio, de Graaf et al., 2017; Proserpio, Invitti et al., 2019).

1.2 The Influence of Social Olfactory Information on Social Judgment and Decision-Making

First, social odors affect how individuals perceive and judge others. Human pheromones can influence emotional perception of potential mates in a sexual orientation-specific manner. For example, heterosexual women (but not men) who smelled androstadienone rated point-light walkers as happier and more relaxed when they appeared male. In contrast, smelling estradiol made hetero-

sexual men (but not women) perceive women (but not men) as happier and more relaxed (Ye et al., 2019). In trust games, investment amounts correlated positively with the pleasantness of agents' body odor, with agents having pleasant body odor receiving higher investments (Lobmaier et al., 2020). Individuals with congenital olfactory impairment experience more insecurity in intimate relationships, with men showing less sexual impulse and women showing less interpersonal trust (Croy et al., 2013). Additionally, same-sex friends have more similar body odors than randomly paired same-sex individuals (Ravreby et al., 2022), suggesting olfaction may participate in human social interaction and matching, with humans selecting allies with similar scents through smell. Gaby and Zayas (2017) found that when individuals smelled a particular T-shirt odor, they made more positive evaluations of the stranger who wore it regarding friendliness and warmth; in a second experiment where they smelled the same stranger's odor, they still made more positive evaluations, suggesting that judgments based on social olfactory information have stability.

Second, social odors affect prosocial behavior decisions. Infants connect with the outside world through smell to survive their vulnerable period. When infants smell breast milk, they show more prosocial behavior, greater willingness to explore new environments, and higher neural synchrony when interacting with strangers (Endevelt-Shapira et al., 2021). Another study collected body odors from cooperative and uncooperative men through games and used them as olfactory stimuli. Results showed that women were more likely to cooperate with men in the cooperative odor condition and actively avoided interacting with men in the uncooperative odor condition (Tognetti et al., 2022).

Finally, social odors affect other social decisions. In moral dilemma situations, exposure to body odor in a room (with no one actually present) made individuals subconsciously perceive someone as actually there, making them more hesitant when deciding to harm others and showing more deontological moral decision tendencies (Cecchetto et al., 2019). Additionally, body odor affects risk decision-making. Research found that compared to exposure to sweat odor from non-risk-takers, exposure to sweat odor from high-risk-takers made individuals more likely to choose riskier tasks with lower win rates but higher payouts (Haegler et al., 2010). Another study found that compared to odorless conditions and sweat from general exercisers, sweat odor from anxious individuals made women more likely to make negative outcome predictions, resulting in less risky behavioral decisions (Meister & Pause, 2021).

2 Five Hypotheses on the Mechanisms of Olfaction's Influence on Social Decision-Making

Olfaction indeed significantly influences social decision-making. However, most existing empirical studies focus on whether such influences exist rather than systematically examining the underlying mechanisms. This paper synthesizes and organizes discussions from various scattered empirical studies, proposing five hypotheses from phylogenetic, physiological, emotional, cognitive, and in-

terpersonal perspectives to explain these mechanisms (see Figure 1 [Figure 1: see original paper]).

2.1 Evolutionary Hypothesis

The evolutionary hypothesis, from a phylogenetic perspective, posits that olfaction is an “adaptation” evolved by humans to solve early survival and reproduction pressures. It enables humans to infer others’ emotions, identify kin and caregivers, and find healthy mates without learning, allowing individuals to produce “instinctive”-like social judgments and decisions in response to specific odors.

First, olfaction is an evolutionary adaptation that solves survival and reproduction-related problems through “psychological mechanisms” (a set of processing processes organisms possess). For human ancestors, determining which foods were nutritious and which were toxic was one of the most critical survival questions. Obviously, evaluating food’s “color,” “aroma,” and “taste” through seeing, smelling, and tasting was an adaptive mechanism to solve this problem. Regarding smell, “fragrant” foods were often nutritious, while “foul” foods were inedible or even poisonous. Decaying matter or feces carry bacteria and viruses, and humans gradually evolved to perceive their odors as “foul,” automatically avoiding them and reducing disease probability. In other words, whether decaying matter and feces smell “foul” is not determined by their chemical structure or human noses, but by the 利害关系 (benefit-harm relationship) between humans and these substances. Additionally, olfaction helps individuals detect environmental dangers and react quickly to predators, prey, other objects, and terrain (Wilson, 2002).

Second, olfaction influences social judgment and decision-making processes effortlessly through “psychological mechanisms.” Prokosch et al. (2021) studied the relationship between olfactory acuity, disgust sensitivity, and mating strategies, finding that sexual disgust mediated the relationship between olfactory acuity and short-term sexual behavior tendencies, with individuals having keen olfaction being less willing to engage in short-term sexual behavior. Women prefer the body odor of men with different human leukocyte antigen (HLA) features (Jacob et al., 2002), because mating with HLA-different partners produces offspring with more diverse immunological profiles and better adaptive immune function. Individuals can also identify kin through body odor to avoid inbreeding (Porter, 1998). This may stem from the major histocompatibility complex (MHC) gene, which controls immune response. Similar MHC genes suggest shared ancestry. The human main olfactory system can decode MHC information (Schaefer et al., 2001). Selecting MHC-different mates avoids inbreeding, a mating mechanism widespread across species and a genetic strategy formed through evolution. Miller and Maner (2011) found that fertility-related female scent cues could activate male sexual motivation, promoting psychological and behavioral processes related to pursuing sexual partners. Therefore, women may use perfume to enhance feminine characteristics in their body odor

to attract mates (Allen et al., 2016). Olfaction is also modulated by certain factors. For example, women have keener olfaction during menstruation and pregnancy (Pause et al., 1996; Olofsson et al., 2005), when olfaction may help select partners and identify harmful substances to protect fetuses. Autistic individuals have difficulty correctly interpreting emotional cues in social odors (Endevelt-Shapira et al., 2018), and depression and schizophrenia patients often show olfactory identification deficits (Chen et al., 2019), suggesting that abnormal social cognition may affect normal olfactory function expression, and impaired olfactory adaptation may be an early indicator of mental illness.

In summary, the evolutionary hypothesis follows the logic “olfaction → psychological mechanism as adaptation → social judgment and decision-making.” Through continuous evolution, humans use olfaction to identify dangers and select mates, maximizing survival and reproductive success. Foul odors cause avoidance—for example, in Barnett et al.’s (2022) study, putrescine’s rotten smell activated psychological defense mechanisms, prompting avoidance behavior. Pleasant odors cause approach—for example, Hirsch’s (1995) study found that casinos with fragrance attracted more visitors. As an adaptation for survival and reproduction, olfaction works automatically through psychological mechanisms, changing judgment and decision-making without individuals’ awareness. For instance, olfactory dysfunction patients show reduced sensitivity to spoiled food but significantly increased disgust toward poor hygiene (Ille et al., 2016).

2.2 Physiological Hypothesis

The physiological hypothesis, from a bodily perspective, posits that odor molecules enter the bloodstream through nasal or pulmonary mucosa, affecting the autonomic nervous system, central nervous system, or endocrine system, changing physiological states and arousal levels, thereby potentially influencing social judgment and decision-making.

This hypothesis is supported by extensive research. Haze et al. (2002) found that compared to odorless solvents, inhaling essential oils from pepper, mugwort, and fennel increased sympathetic activity by 1.5-2.5 times, while inhaling rose or patchouli oil decreased sympathetic activity by 40%. Inhaling pepper oil increased plasma adrenaline concentration by 1.7 times, while inhaling rose oil decreased it by 30%. Ogata et al. (2020) observed that after human participants inhaled lavender odor, both systolic and diastolic blood pressure decreased and Self-Rating Depression Scale (SDS) scores significantly reduced. In mice, lavender inhalation increased intracellular calcium concentration in hypothalamic oxytocin neurons, indicating lavender produced sedative effects in both humans and mice. This may explain Sellaro et al.’s (2015) findings that lavender odor made individuals feel more relaxed, reduced vigilance toward others, and led them to perceive more commonality and greater harmony with others. Choi et al. (2022) found that after inhaling jasmine fragrance, individuals’ alpha brain waves significantly increased, indicating a relatively stable and relaxed brain

state. This may explain Cook et al.'s (2015) results, where jasmine's pharmacological effects changed brain physiological states, inducing more relaxed and pleasant moods that led to higher ratings of neutral faces.

In summary, the physiological hypothesis follows the logic "olfaction → physiological state and arousal level → social judgment and decision-making." It explains olfaction's influence on social decisions from physiological and pharmacological perspectives. However, as Herz (2009) noted, if odor molecules need to cross the blood-brain barrier through blood circulation to take effect, it would require at least 20 minutes, yet most current studies find immediate effects of odors on emotion and behavior. This temporal discrepancy suggests that the theoretical basis and mechanisms of the physiological hypothesis require further exploration.

2.3 Emotion-Induction Hypothesis

This hypothesis, from an emotional perspective, posits that ambient olfactory stimuli change individuals' emotional states, which in turn influence and modify social judgment and decision-making.

On one hand, olfaction affects emotion. First, at the neural mechanism level, compared to other senses like vision, olfaction has a more direct and intimate connection with emotion. Central neural structures involved in olfactory processing include the amygdala, orbitofrontal cortex, hippocampus, and insula. The amygdala is a key region for processing disgust and fear, working with the hippocampus to form emotional memories (Richardson et al., 2004). When individuals smell strangers' odors, the amygdala responsible for fear and vigilance activates, but not when smelling friends' odors (Ravreby et al., 2022). The orbitofrontal cortex is both an important physiological basis for olfaction and a key neural structure for emotional processing and cognitive decision-making (Bechara et al., 2000). The insula integrates bodily sensory information including olfaction, providing references for individuals to evaluate emotional states (Paulus & Stein, 2006). These central neural structures establish the neural foundation for olfaction-emotion interactions. Second, numerous studies directly demonstrate olfaction's effect on emotion. After smelling body odors from people in different emotional states (including fear, happiness, and neutral), individuals showed distinctly different facial muscle activity patterns (de Groot, Smeets et al., 2015; de Groot, van Houtum et al., 2018). When healthy and olfactory-impaired groups viewed emotional and neutral pictures, healthy groups showed hippocampus, amygdala, and anterior cingulate activation for emotional pictures compared to neutral ones, while olfactory-impaired groups did not, possibly related to abnormal emotion processing caused by olfactory dysfunction (Han et al., 2019). Additionally, field surveys of car passengers found that pleasant odors increased positive emotions like happiness, calmness, and well-being, and increased travel satisfaction (Silva et al., 2021). Although external environmental odors (non-social olfactory information) typically regulate emotion through odor valence, while human sweat and body odors (social

olfactory information) inherently carry social-emotional information, with different brain encoding and emotion system effects, both prove that olfaction and emotion are inseparable at both neuroimaging and behavioral levels (Zhou & Feng, 2012).

After olfaction influences emotion, emotional changes potentially affect social judgment and decision-making. Odors typically have different emotional valences, and their induced emotional perceptions affect judgment and decision-making (Royet et al., 2003). Gambetti and Giusberti (2012) found that trait anger led individuals to invest in different stock types, perceiving stocks as more predictable and preferring riskier decisions, while trait anxiety led to perceptions of low predictability and preference for low-risk portfolios. Introverted individuals induced negative emotions when facing personal moral dilemmas, leading to more deontological decisions—judging morality based on utilitarian outcomes rather than moral rules (Tao et al., 2020). Rainone et al. (2021) examined emotion’s effect on bias in ethical decision-making, finding that compared to neutral affective states, happiness reduced moral bias while sadness increased it. Women perceived less stress when smelling their partner’s odor than when smelling their own or strangers’ odors (Granqvist et al., 2019; Hofer et al., 2018). Releasing appropriate scents like peppermint in workplaces can enhance alertness, thereby improving work enthusiasm and efficiency (Lwin et al., 2021).

In summary, the emotion-induction hypothesis follows the logic “olfaction → emotion → social judgment and decision-making,” where olfaction changes emotion, which further influences social judgment and decision-making. Pleasant ambient odors induce positive emotions in women, making them more receptive to men’s courtship requests (Guéguen, 2012b). Disgusting ambient odors induce negative emotions, reducing ratings of neutral faces’ attractiveness (Cook et al., 2015). Sweat odor from anxiety induced by risk-taking behavior leads individuals toward riskier decisions (Haegler et al., 2010). However, other research found that anxious individuals’ sweat odor made people feel more unhappy, reduced trust, and led to more risk-averse decisions (Meister & Pause, 2021). These differences may stem from variations in experimental paradigms and methods of inducing anxiety odors.

2.4 Embodied Cognition Hypothesis

The embodied cognition hypothesis, from a cognitive perspective, posits that individuals use bodily olfactory sensations as concrete, familiar metaphorical sources to help understand social events through embodied metaphors, thereby potentially influencing social judgment and decision-making.

First, individuals cognize the world through olfactory metaphors. Olfactory metaphors like “fragrant” and “foul” are important pathways for humans to understand more abstract social events. “Fragrance that lasts for centuries” uses “fragrance” to refer to “noble morality.” “When you give someone roses,

fragrance remains on your hand” uses “fragrance” to describe the moral experience of self-satisfaction and self-enhancement after helping others. “Fragrance” also refers to beautiful women, as in phrases like “national beauty with heavenly fragrance” and “cherishing fragrance and jade,” linking floral and feminine scents with rich emotional imagination. In summary, “fragrance” is often associated with positive qualities and things, while “foulness” represents disgusting, contemptible qualities and things. For example, “notoriously foul” and “leaving a foul reputation for millennia” describe evil, morally corrupt, or despicable people. “Foul temper” describes irritable people, “smell of copper” mocks ignorant wealthy people, and “wine and meat stink behind vermilion gates” uses “stink” as a status symbol for the exploiting class. Olfaction originally was human sensation of natural odors, gradually evolving to describe the quality of living environments, and finally developing to symbolize moral levels.

Second, embodied cognition influences decision-making judgment. Embodied cognition means physiological experiences activate psychological sensations that affect social decisions. Holland et al. (2005) and Liljenquist et al. (2010) found that olfactory cues from citrus cleaning scents could increase moral behavior because citrus fruits have strong antibacterial and cleaning properties with a fresh scent. This cleaning scent embodiedly activated individuals’ metaphor of “clean,” potentially making them hold themselves to the standard of “being a clean person” and unconsciously increasing moral behaviors in decision-making. Lee et al. (2015) found that fishy smells induced suspicion and distrust, leading to higher vigilance toward provided information and more cautious responses. Fishy smells metaphorically represent suspicious or unreliable phenomena, possibly because in English contexts, “suspicion” is highly associated with organic, perishable value products (like fish and meat) that develop foul odors when rotten. Through olfactory experience, people can detect problematic food (Lee et al., 2012), and over time, the metaphorical connection between odor and suspicion formed.

In summary, the embodied cognition hypothesis follows the logic “olfaction → embodied cognition and metaphor → social judgment and decision-making.” When individuals are in different odor contexts, olfaction activates corresponding metaphorical mechanisms, potentially changing views of real events and influencing social judgment and decision-making. For example, in warm odor (cinnamon) conditions, individuals have higher power desire, and their luxury purchasing behavior increases (Madzharov et al., 2015). Hunger and cold, satiety and warmth are often linked. Eating in warm odor conditions leads individuals to choose low-calorie foods because the odor creates a psychological satiety suggestion (Lefebvre & Biswas, 2019). Individuals’ odor perception activates odor-related semantic and behavioral representations, which automatically guide and modify judgment and decision-making in specific situations.

2.5 Social Construction Hypothesis

The social construction hypothesis, from an interpersonal and social perspective, posits that after odor stimuli trigger olfaction, the language and socio-cultural norms of individuals' environments potentially change their emotional experiences and cognitive meanings of olfaction, influencing social judgment and decision-making without awareness.

First, olfaction activates environmental language and sociocultural norms. Coppin et al. (2016) found that the famous Swiss chocolate odor activated Swiss individuals' national identity, but popcorn odor did not, and this chocolate odor did not prime non-Swiss individuals' identity. Wnuk et al. (2017) found that culture plays an important role in odor-temperature associations. For example, Thais associate banana odor with cold and cheese and garlic odors with heat, while Dutch associate wine and sand ginger odors with cold. As mentioned earlier, temperature perception affects purchasing desire and eating choices (Madzharov et al., 2015), with culture playing a moderating role. Additionally, odor identification is highly related to language, memory, and general cognitive function. A regression analysis showed that language is an important predictor of olfactory performance (Westervelt et al., 2005). Majid et al. (2018) matched 30 Malaysian indigenous people with 30 Dutch individuals, finding that emotional reactions to odors were the same, but Dutch described odors with concrete language (e.g., lemon scent) while Malaysian indigenous people used abstract language (e.g., musty smell), possibly because Malaysian indigenous people, as hunters who frequently discuss odors, find odor naming easier. Different national cultures, lifestyles (Olofsson et al., 2018), and family environments affect odor expression, and linguistic differences in odor description affect individuals' views of odors, giving them emotional coloring (Majid, 2021). Human odor perception has long transcended pure sensory experience. Individuals' olfaction triggers related language and cultural norms, thereby changing their emotional experiences and cognitive meanings of olfaction.

Second, social culture influences social judgment and decision-making. For example, cultural differences between collectivism and individualism affect financial risk preferences. Chinese show slightly stronger risk preferences than Americans in financial decisions because Chinese collectivist culture is more likely to provide help to decision-makers, reducing negative impacts from wrong decisions and buffering consequences (Weber & Hsee, 1998). Individualistic societies show more willingness to donate than collectivistic societies because individualism promotes capitalism, increases social wealth disparity, creates expectations for the wealthy to support those in need, and thereby promotes prosocial donation decisions (Luria et al., 2014).

In summary, the social construction perspective follows the logic “olfaction → social-cultural construction → social judgment and decision-making,” where olfaction activates individuals' inherent cultural backgrounds, influencing decision-making and judgment about related things or events through culture. As Vy-

gotsky believed, everything civilized is social, and odor maps human internal historical experiences and cultural connotations. For example, most people dislike the stench of pickled herring, but Swedes have a special fondness for it. When Swedes are exposed to this odor, the cultural background embedded in pickled herring's stench evokes different cognition that influences social decision-making.

3.1 Existing Problems

Chemical signals emitted by odors contain rich information. Human olfaction is extremely sensitive, and substantial evidence proves that both non-social and social odors can influence social judgment and decision-making at conscious and subconscious levels. Against the backdrop of rising embodied cognition research in psychology, this is a promising emerging field, but several problems remain.

First, individual differences exist in odor perception. Human thoughts and intentions are hidden, making social cognition inherently uncertain (Feldman-Hall & Shenhav, 2019). Across different cultural backgrounds and situations, and even among different individuals in the same situation, expressions of disgust, fear, happiness, sadness, and other emotions vary greatly (Barrett et al., 2019). Individuals' unique experiences and preferences with odors top-down affect their cognition, judgment, and decision-making about odors. For example, Allen et al. (2016) found that women pay more attention to olfactory information than men, while Sandell (2019) found no gender effect, suggesting that olfaction's influence on decision-making is mainly constrained by individual cognitive decision-making styles.

Second, different studies manipulate odor dosage and exposure time differently, and no unified research paradigm has emerged in olfactory psychology. On one hand, odor dosage and instruction wording affect results. For example, Bradley et al. (2009) used 0.2ml of lavender odor as an experimental condition, finding that this concentration could alleviate anxiety in individuals watching neutral videos but could not effectively alleviate anxiety in those watching anxiety-inducing videos, possibly because the odor concentration was insufficient to regulate high anxiety levels. Additionally, Schnall (2008) found that unpleasant olfactory stimuli caused harsher moral judgments, but Barnett et al. (2022) did not find consistent conclusions. The reason may be that the former's instructions did not remind individuals to pay attention to room odors, while the latter explicitly asked individuals to notice and rate odors. On the other hand, odor effects vary with exposure duration. Damjanovic et al. (2018) and Syrjänen et al. (2019) both found that pleasant odors enabled faster identification of happy faces early on, but identification speed gradually decreased later, while unpleasant odors slowed early identification of happy faces but speed gradually increased later. This suggests that olfactory adaptation may significantly affect experimental results, and ignoring exposure duration may produce contradictory results.

Third, olfaction is a richly cross-modal sensory domain. For example, in “smell-hearing” research, odor flow in one nostril only affected sound localization when the trigeminal nerve was activated (Liang et al., 2022). In “smell-vision” research, when different concentrations of rose or vanilla odor were released to each nostril (without trigeminal activation), although individuals could not objectively determine which nostril smelled stronger, inter-nostril odor concentration differences caused perceptual shifts in visual optic flow stimuli (simulating movement toward a light point cluster at 5 m/s with precisely controlled expansion patterns), subconsciously making individuals feel they were moving toward the side with higher odor concentration, with olfaction guiding forward direction (Wu et al., 2020). Therefore, compared to other sensory channels like vision and hearing, different olfactory stimuli can affect social cognition not only at the conscious level but also be processed subconsciously. When odors operate at the subconscious level, their behavioral impact may be greater than at the conscious level (Cecchetto et al., 2017), and the natural connection between olfaction and emotion is stronger than other senses (Zhou & Feng, 2012). Even when another sensory channel’s emotional signal is ambiguous (such as blurred faces), olfaction can mediate emotional perception (Zhou & Chen, 2009). However, because olfaction lacks obvious spatiotemporal features, physical properties, and perceptibility like vision and hearing, its causal effects are difficult to isolate independently, and existing research rarely fully considers cross-modal information integration in olfaction.

3.2 Future Directions

Psychology has accumulated substantial empirical research on olfaction’s influence on social decision-making. Overall, these studies follow the embodied cognition research logic of “bodily sensations affect psychology after environmental stimulation,” belonging to basic psychological research. Future research can continue to expand such basic research through improvement and innovation, exploring mechanisms and constructing theoretical models.

First, as mentioned earlier, olfaction is a sensory domain with rich cross-modal experiences. Future research can adapt and unify experimental paradigms to deeply explore cross-modal mechanisms through which olfaction interacts with vision, hearing, taste, and other senses to influence decision-making. For example, Syrjänen et al. (2017) observed that compared to static face images, odors had less influence on emotional evaluation of dynamic face images, possibly because attention was more focused on dynamic images. So in dynamic real-life interactions, to what extent must olfactory cues integrate with visual cues to produce significant effects? How does “olfactory navigation” coordinate with visual and auditory senses? Is it appropriate for most current experiments to study judgment and decision-making effects by manipulating only olfaction? In summary, questions about how olfaction integrates and interacts with other sensory channels and the weight of each sense in task processing urgently need further exploration.

Second, actively explore localized and cross-cultural mechanisms of olfaction. Individuals' familiarity with odors affects the universality of odor perception (intensity, pungency, and hedonics) or semantics (nameability, familiarity) (Nehmé et al., 2016). Currently, domestic research on olfaction's influence on social life and decision-making is limited. Olfactory experiences are culturally specific. Examining olfaction's role in decision-making and social interaction under Chinese cultural backgrounds while expanding cross-cultural olfactory research can better grasp the characteristics and patterns of olfaction's influence on decision-making, avoid misinterpreting information, and promote cross-cultural communication. Furthermore, can empirical research on odor and face evaluation, mostly conducted in laboratories, be extended to more realistic social behaviors? Besides the olfactory navigation example mentioned earlier, can other olfactory processes like odor identification, discrimination ability, and their relationship with spatial memory be explored? Additionally, while most literature shows that olfactory impairment negatively affects social interaction, how do different degrees of impairment affect decision-making processes? In love psychology, how does olfaction influence perception and behavior related to different mating strategies? For example, although olfactory processes may inhibit short-term mating strategies, might they play important roles in forming and maintaining long-term romantic relationships?

Finally, develop applied research on olfaction in social life, such as consumer psychology. As mentioned earlier, using appropriate scents in retail environments can induce pleasant shopping experiences, and warm odors make individuals more willing to purchase luxury goods. Therefore, businesses can use scents to promote potential consumption. Hotels, restaurants, and cafes can use odor metaphors and psychological suggestions to create unique olfactory atmospheres consistent with brand image, enhancing brand recognition, comfort, and pleasure, building brand characteristics, and cultivating customer loyalty (Errajaa et al., 2021). In business negotiations, parties' body odors and negotiation environment odors may also become factors influencing negotiation atmosphere—warm or cold, friendly cooperation or suspicion and guard. In school moral education, fresh scents like orange might enhance students' moral awareness and promote moral and prosocial decision-making.

References

- Chen, W., Chen, K., Zhou, B., & Zhou, W. (2017). Olfaction and sensory information integration. *Science and Technology Review*, 35(18), 29–36.
- Zhou, W., & Feng, G. (2012). Olfactory perception and its interaction with the emotional system. *Advances in Psychological Science*, 20(01), 2–9.
- Allen, C., Cobey, K. D., Havlíček, J., & Roberts, S. C. (2016). The impact of artificial fragrances on the assessment of mate quality cues in body odor. *Evolution & Human Behavior*, 37(6), 481–489.

- Barnett, M. D., Mokhtari, B. K., & Moore, J. M. (2022). Smelling death, loving life: The impact of olfactory chemosignals on life satisfaction. *Chemosensory Perception*, 15, 95–103.
- Barrett, L. F., Adolphs, R., Marsella, S., Martinez, A. M., & Pollak, S. D. (2019). Emotional expressions reconsidered: Challenges to inferring emotion from human facial movements. *Psychological Science in the Public Interest*, 20(1), 1–68.
- Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex*, 10(3), 295–307.
- Bialek, M., Muda, R., Fugelsang, J., & Friedman, O. (2021). Disgust and moral judgment: Distinguishing between elicitors and feelings matters. *Social Psychological and Personality Science*, 12(3), 304–313.
- Boesveldt, S., & Parma, V. (2021). The importance of the olfactory system in human well-being, through nutrition and social behavior. *Cell and Tissue Research*, 383(1), 559–567.
- Bradley, B. F., Brown, S. L., Chu, S., & Lea, R. W. (2009). Effects of orally administered lavender essential oil on responses to anxiety-provoking film clips. *Human Psychopharmacology*, 24(4), 319–330.
- Cecchetto, C., Lancini, E., Rumiati, R. I., & Parma, V. (2019). Women smelling men's masked body odors show enhanced harm aversion in moral dilemmas. *Physiology & Behavior*, 201, 212–220.
- Cecchetto, C., Rumiati, R. I., & Parma, V. (2017). Relative contribution of odour intensity and valence to moral decisions. *Perception*, 46(3-4), 447–474.
- Chen, B., Klarman, R., Israel, M., Ning, Y., Colle, R., & Hummel, T. (2019). Difference of olfactory deficit in patients with acute episode of schizophrenia and major depressive episode. *Schizophrenia Research*, 212, 99–103.
- Choi, N., Wu, Y., & Park, S. (2022). Effects of olfactory stimulation with aroma oils on psychophysiological responses of female adults. *International Journal of Environmental Research and Public Health*, 19(9), 5196.
- Cook, S., Fallon, N., Wright, H., Thomas, A., Giesbrecht, T., Field, M., & Stancak, A. (2015). Pleasant and unpleasant odors influence hedonic evaluations of human faces: An event-related potential study. *Frontiers in Human Neuroscience*, 9, 661.
- Coppin, G., Pool, E., Delplanque, S., Oud, B., Margot, C., Sander, D., & Van Bavel, J. J. (2016). Swiss identity smells like chocolate: Social identity shapes olfactory judgments. *Scientific Reports*, 6, 34979.
- Croijmans, I., Beetsma, D., Aarts, H., Gortemaker, I., & Smeets, M. (2021). The role of fragrance and self-esteem in perception of body odors and impressions of others. *Plos One*, 16(11), e0258773.

- Croy, I., Bojanowski, V., & Hummel, T. (2013). Men without a sense of smell exhibit a strongly reduced number of sexual relationships, women exhibit reduced partnership security—A reanalysis of previously published data. *Biological Psychology*, 92(2), 292–294.
- Cunningham, E., Forestell, C. A., & Dickter, C. L. (2013). Induced disgust affects implicit and explicit responses toward gay men and lesbians. *European Journal of Social Psychology*, 43(5), 362–369.
- Damjanovic, L., Wilkinson, H., & Lloyd, J. (2018). Sweet emotion: The role of odor-induced context in the search advantage for happy facial expressions. *Chemical Senses*, 43(3), 139–150.
- Davis, E. A., Magnini, V. P., Weaver, P. A., & McGehee, N. G. (2013). The influences of verbal smell references in radio advertisements. *Journal of Hospitality & Tourism Research*, 37(2), 281–299.
- De Groot, J. H. B., Smeets, M. A. M., Rowson, M. J., Bulsing, P. J., Blonk, C. G., Wilkinson, J. E., & Semin, G. R. (2015). A sniff of happiness. *Psychological Science*, 26(6), 684–700.
- De Groot, J., van Houtum, L., Gortemaker, I., Ye, Y., Chen, W., Zhou, W., & Smeets, M. (2018). Beyond the west: Chemosignaling of emotions transcends ethno-cultural boundaries. *Psychoneuroendocrinology*, 98, 177–185.
- De Lange, M. A., Debets, L. W., Ruitenburg, K., & Holland, R. W. (2012). Making less of a mess: Scent exposure as a tool for behavioral change. *Social Influence*, 7(2), 90–97.
- De Luca, R., & Botelho, D. (2020). Olfactory priming on consumer categorization, recall, and choice. *Psychology & Marketing*, 37(8), 1101–1117.
- Endevelt-Shapira, Y., Djalovski, A., Dumas, G., & Feldman, R. (2021). Maternal chemosignals enhance infant-adult brain-to-brain synchrony. *Science Advances*, 7(50), eabg6867.
- Endevelt-Shapira, Y., Perl, O., Ravia, A., Amir, D., Eisen, A., Bezalel, V., Rozenkrantz, L., Mishor, E., Pinchover, L., Soroka, T., Honigstein, D., & Sobel, N. (2018). Altered responses to social chemosignals in autism spectrum disorder. *Nature Neuroscience*, 21(1), 111–119.
- Errajaa, K., Legohérel, P., Daucé, B., & Bilgihan, A. (2021). Scent marketing: Linking the scent congruence with brand image. *International Journal of Contemporary Hospitality Management*, 33(2), 402–427.
- FeldmanHall, O., & Shenhav, A. (2019). Resolving uncertainty in a social world. *Nature Human Behaviour*, 3(5), 426–435.
- Ferdenzi, C., Delplanque, S., Atanassova, R., & Sander, D. (2016). Androstenone's influence on the perception of facial and vocal attractiveness is not sex specific. *Psychoneuroendocrinology*, 66, 166–175.

- Gaby, J. M., & Zayas, V. (2017). Smelling is telling: Human olfactory cues influence social judgments in semi-realistic interactions. *Chemical Senses*, 42(5), 405–418.
- Gambetti, E., & Giusberti, F. (2012). The effect of anger and anxiety traits on investment decisions. *Journal of Economic Psychology*, 33(6), 1059–1069.
- Glachet, O., & El Haj, M. (2022). Smell your self: Olfactory stimulation improves self-concept in Alzheimer's disease. *Neuropsychological Rehabilitation*, 32(3), 464–480.
- Granqvist, P., Vestbrant, K., Döllinger, L., Liuzza, M. T., Olsson, M. J., Blomkvist, A., & Lundström, J. N. (2019). The scent of security: Odor of romantic partner alters subjective discomfort and autonomic stress responses in an adult attachment-dependent manner. *Physiology & Behavior*, 198, 144–150.
- Guéguen, N. (2012a). The sweet smell of ... implicit helping: Effects of pleasant ambient fragrance on spontaneous help in shopping malls. *The Journal of Social Psychology*, 152(4), 397–400.
- Guéguen, N. (2012b). The sweet smell of ... courtship: Effects of pleasant ambient fragrance on women's receptivity to a man's courtship request. *Journal of Environmental Psychology*, 32(2), 123–125.
- Haegler, K., Zerneck, R., Kleemann, A. M., Albrecht, J., Pollatos, O., Brückmann, H., & Wiesmann, M. (2010). No fear no risk! Human risk behavior is affected by chemosensory anxiety signals. *Neuropsychologia*, 48(13), 3901–3908.
- Han, P., Hummel, T., Raue, C., & Croy, I. (2019). Olfactory loss is associated with reduced hippocampal activation in response to emotional pictures. *Neuroimage*, 188, 84–91.
- Haze, S., Sakai, K., & Gozu, Y. (2002). Effects of fragrance inhalation on sympathetic activity in normal adults. *Japanese Journal of Pharmacology*, 90(3), 247–253.
- Helversen, B., Coppin, G., & Scheibehenne, B. (2020). Money does not stink: Using unpleasant odors as stimulus material changes risky decision making. *Journal of Behavioral Decision Making*, 33(5), 593–605.
- Herz, R. S. (2009). Aromatherapy facts and fictions: A scientific analysis of olfactory effects on mood, physiology and behavior. *International Journal of Neuroscience*, 119(2), 263–290.
- Hirsch, A. R. (1995). Effects of ambient odors on slot-machine usage in a las vegas casino. *Psychology & Marketing*, 12(7), 585–594.
- Hofer, M. K., Collins, H. K., Whillans, A. V., & Chen, F. S. (2018). Olfactory cues from romantic partners and strangers influence women's responses to stress. *Journal of Personality and Social Psychology*, 114(1), 1–9.

- Holland, R. W., Hendriks, M., & Aarts, H. (2005). Smells like clean spirit. Nonconscious effects of scent on cognition and behavior. *Psychological Science*, 16(9), 689–693.
- Homan, P., Ely, B. A., Yuan, M., Brosch, T., Ng, J., Trope, Y., & Schiller, D. (2017). Aversive smell associations shape social judgment. *Neurobiology of Learning and Memory*, 144, 86–95.
- Ille, R., Wolf, A., Tomazic, P. V., & Schienle, A. (2016). Disgust-related personality traits in men with olfactory dysfunction. *Chemical Senses*, 41(5), 427–431.
- Jacob, S., McClintock, M. K., Zelano, B., & Ober, C. (2002). Paternally inherited HLA alleles are associated with women's choice of male odor. *Nature Genetics*, 30(2), 175–179.
- Kugler, T., Noussair, C. N., & Hatch, D. (2021). Does disgust increase unethical behavior? A replication of winterich, mittal, and morales (2014). *Social Psychological & Personality Science*, 12(6), 938–945.
- Landy, J. F., & Goodwin, G. P. (2015). Does incidental disgust amplify moral judgment? A meta-analytic review of experimental evidence. *Perspectives on Psychological Science*, 10(4), 518–536.
- Lee, D. S., Kim, E., & Schwarz, N. (2015). Something smells fishy: Olfactory suspicion cues improve performance on the Moses illusion and Wason rule discovery task. *Journal of Experimental Social Psychology*, 59, 47–50.
- Lee, S. W., & Schwarz, N. (2012). Bidirectionality, mediation, and moderation of metaphorical effects: The embodiment of social suspicion and fishy smells. *Journal of Personality and Social Psychology*, 103(5), 737–749.
- Leenders, M. A. A. M., Smidts, A., & Haji, A. E. (2019). Ambient scent as a mood inducer in supermarkets: The role of scent intensity and time-pressure of shoppers. *Journal of Retailing and Consumer Services*, 48, 270–280.
- Lefebvre, S., & Biswas, D. (2019). The influence of ambient scent temperature on food consumption behavior. *Journal of Experimental Psychology: Applied*, 25(4), 753–764.
- Li, D., Jia, J., & Wang, X. (2020). Unpleasant food odors modulate the processing of facial expressions: An event-related potential study. *Frontiers in Neuroscience*, 14, 686.
- Liang, K., Wang, W., Lei, X., Zeng, H., Gong, W., Lou, C., & Chen, L. (2022). Odor-induced sound localization bias under unilateral intranasal trigeminal stimulation. *Chemical Senses*, 47, 1–8.
- Liljenquist, K., Zhong, C. B., & Galinsky, A. D. (2010). The smell of virtue: Clean scents promote reciprocity and charity. *Psychological Science*, 21(3), 381–383.

- Lobmaier, J. S., Probst, F., Fischbacher, U., Wirthmüller, U., & Knoch, D. (2020). Pleasant body odours, but not genetic similarity, influence trustworthiness in a modified trust game. *Scientific Reports*, 10(1), 3388.
- Luria, G., Cnaan, R. A., & Boehm, A. (2014). National culture and prosocial behaviors. *Nonprofit and Voluntary Sector Quarterly*, 44(5), 1041–1065.
- Lwin, M. O., Malik, S., & Neo, J. R. J. (2021). Effects of scent and scent emission methods: Implications on workers' alertness, vigilance, and memory under fatigue conditions. *Environment and Behavior*, 53(9), 987–1010.
- Madzharov, A. V., Block, L. G., & Morrin, M. (2015). The cool scent of power: Effects of ambient scent on consumer preferences and choice behavior. *Journal of Marketing*, 79(1), 83–96.
- Majid, A. (2021). Human olfaction at the intersection of language, culture, and biology. *Trends in Cognitive Sciences*, 25(2), 111–123.
- Majid, A., Burenhult, N., Stensmyr, M., de Valk, J., & Hansson, B. S. (2018). Olfactory language and abstraction across cultures. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences*, 373(1752), 20170139.
- Meister, L., & Pause, B. M. (2021). It's trust or risk? Chemosensory anxiety signals affect bargaining in women. *Biological Psychology*, 162, 108114.
- Miller, S. L., & Maner, J. K. (2011). Ovulation as a male mating prime: Subtle signs of women's fertility influence men's mating cognition and behavior. *Journal of Personality and Social Psychology*, 100(2), 295–308.
- Moretto, G., Ladavas, E., Mattioli, F., & di Pellegrino, G. (2010). A psychophysiological investigation of moral judgment after ventromedial prefrontal damage. *Journal of Cognitive Neuroscience*, 22(8), 1888–1899.
- Nehmé, L., Barbar, R., Maric, Y., & Jacquot, M. (2016). Influence of odor function and color symbolism in odor-color associations: A French-Lebanese-Taiwanese cross-cultural study. *Food Quality and Preference*, 49, 56–61.
- Olofsson, J. K., Broman, D. A., Wulff, M., Martinkauppi, M., & Nordin, S. (2005). Olfactory and chemosomatosensory function in pregnant women assessed with event-related potentials. *Physiology & Behavior*, 86(1–2), 252–257.
- Olofsson, J. K., & Wilson, D. A. (2018). Human olfaction: It takes two villages. *Current Biology*, 28(3), R108–R110.
- Ogata, K., Ataka, K., Suzuki, H., Yagi, T., Okawa, A., Fukumoto, T., Zhang, B. Y., Nakata, M., Yada, T., & Asakawa, A. (2020). Lavender oil reduces depressive mood in healthy individuals and enhances the activity of single oxytocin neurons of the hypothalamus isolated from mice: A preliminary study. *Evidence-based Complementary and Alternative Medicine*, 2020, 5418586.

- Overman, W. H., Boettcher, L., Watterson, L., & Walsh, K. (2011). Effects of dilemmas and aromas on performance of the Iowa Gambling Task. *Behavioural Brain Research*, 218(1), 64–72.
- Paulus, M. P., & Stein, M. B. (2006). An insular view of anxiety. *Biological Psychiatry*, 60(4), 383–387.
- Porter, R. H. (1998). Olfaction and human kin recognition. *Genetica*, 104(3), 259–263.
- Pause, B. M., Sojka, B., Krauel, K., Fehm-Wolfsdorf, G., & Ferstl, R. (1996). Olfactory information processing during the course of the menstrual cycle. *Biological Psychology*, 44(1), 31–54.
- Prokosch, M. L., Airington, Z., & Murray, D. R. (2021). Investigating the relationship between olfactory acuity, disgust, and mating strategies. *Evolution and Human Behavior*, 42(2), 113–120.
- Proserpio, C., de Graaf, C., Laureati, M., Pagliarini, E., & Boesveldt, S. (2017). Impact of ambient odors on food intake, saliva production and appetite ratings. *Physiology & Behavior*, 174, 35–41.
- Proserpio, C., Invitti, C., Boesveldt, S., Pasqualinotto, L., & Pagliarini, E. (2019). Ambient odor exposure affects food intake and sensory specific appetite in obese women. *Frontiers in Psychology*, 10, 7.
- Rainone, N. A., Watts, L. L., Mulhearn, T. J., McIntosh, T. J., & Medeiros, K. E. (2021). The impact of happy and sad affective states on biases in ethical decision making. *Ethics & Behavior*, 31(4), 284–300.
- Ravreby, I., Snitz, K., & Sobel, N. (2022). There is chemistry in social chemistry. *Science Advances*, 25(8), eabn0154.
- Richardson, M. P., Strange, B. A., & Dolan, R. J. (2004). Encoding of emotional memories depends on amygdala and hippocampus and their interactions. *Nature Neuroscience*, 7(3), 278–285.
- Royet, J., Plailly, J., Delon-Martin, C., Kareken, D. A., & Segebarth, C. (2003). fMRI of emotional responses to odors: influence of hedonic valence and judgment, handedness, and gender. *Neuroimage*, 20(2), 713–728.
- Sandell, K. (2019). Olfactory cues and purchase behavior: Consumer characteristics as moderators. *European Journal of Marketing*, 53(7), 1378–1399.
- Schaefer, M. L., Young, D. A., & Restrepo, D. (2001). Olfactory fingerprints for major histocompatibility complex-determined body odors. *The Journal of Neuroscience*, 21(7), 2481–2487.
- Schnall, S., Haidt, J., Clore, G. L., & Jordan, A. H. (2008). Disgust as embodied moral judgment. *Personality & Social Psychology Bulletin*, 34(8), 1096–1109.
- Sellaro, R., Hommel, B., Rossi Paccani, C., & Colzato, L. S. (2015). With peppermints you're not my prince: Aroma modulates self-other integration.

Attention, Perception, & Psychophysics, 77(8), 2817–2825.

Sharvit, G., Lin, E., Vuilleumier, P., & Corradi-Dell'Acqua, C. (2020). Does inappropriate behavior hurt or stink? The interplay between neural representations of somatic experiences and moral decisions. *Science Advances*, 6(42), eaat4390.

Silva, J., Sá, E. S., Escadas, M., & Carvalho, J. (2021). The influence of ambient scent on the passengers' experience, emotions and behavioral intentions: An experimental study in a Public Bus service. *Transport Policy*, 106, 88–98.

Stancak, A., Xie, Y., Fallon, N., Bulsing, P., Giesbrecht, T., Thomas, A., & Pantelous, A. A. (2015). Unpleasant odors increase aversion to monetary losses. *Biological Psychology*, 107, 1–9.

Syrjänen, E., Fischer, H., & Olofsson, J. K. (2019). Background odors affect behavior in a dot-probe task with emotionally expressive faces. *Physiology & Behavior*, 210, 112540.

Syrjänen, E., Liuzza, M. T., Fischer, H., & Olofsson, J. K. (2017). Do valenced odors and trait body odor disgust affect evaluation of emotion in dynamic faces?. *Perception*, 46(12), 1412–1426.

Tao, Y., Cai, Y., Rana, C., & Zhong, Y. (2020). The impact of the extraversion-introversion personality traits and emotions in a moral decision-making task. *Personality and Individual Differences*, 158, 109840.

Tognetti, A., Durand, V., Dubois, D., Barkat-Defradas, M., Hopfensitz, A., & Ferdenzi, C. (2022). The smell of cooperativeness: Do human body odours advertise cooperative behaviours?. *British Journal of Psychology*, 113(2), 531–546.

Van Nieuwenburg, D., de Groot, J., & Smeets, M. (2019). The subtle signaling strength of smells: A masked odor enhances interpersonal trust. *Frontiers in Psychology*, 10, 1890.

Velluzzi, F., Deledda, A., Onida, M., Loviselli, A., Crnjar, R., ... Sollai, G. (2022). Relationship between olfactory function and BMI in normal weight healthy subjects and patients with overweight or obesity. *Nutrients*, 14(6), 1156.

Weber, E. U., & Hsee, C. (1998). Cross-cultural differences in risk perception, but cross-cultural similarities in attitudes towards perceived risk. *Management Science*, 44(9), 1205–1217.

Westervelt, H. J., Ruffolo, J. S., & Tremont, G. (2005). Assessing olfaction in the neuropsychological exam: The relationship between odor identification and cognition in older adults. *Archives of Clinical Neuropsychology*, 20(6), 761–769.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review*, 9(4), 625–636.

Wnuk, E., de Valk, J. M., Huisman, J., & Majid, A. (2017). Hot and cold smells: Odor-temperature associations across cultures. *Frontiers in Psychology*, 8, 1373.

Wu, Y., Chen, K., Ye, Y., Zhang, T., & Zhou, W. (2020). Humans navigate with stereo olfaction. *Proceedings of the National Academy of Sciences of the United States of America*, 117(27), 16065–16071.

Ye, Y., Zhuang, Y., Smeets, M. A. M., & Zhou, W. (2019). Human chemosignals modulate emotional perception of biological motion in a sex-specific manner. *Psychoneuroendocrinology*, 100, 246–253.

Zakrzewska, M., Olofsson, J. K., Lindholm, T., Blomkvist, A., & Liuzza, M. T. (2019). Body odor disgust sensitivity is associated with prejudice towards a fictive group of immigrants. *Physiology & Behavior*, 201, 112–116.

Zhang, M., Gong, X., Jia, J., & Wang, X. (2021). Unpleasant odors affect alerting attention in young men: An event-related potential study using the attention network test. *Frontiers in Neuroscience*, 15, 781–997.

Zhou, W., & Chen, D. (2009). Fear-related chemosignals modulate recognition of fear in ambiguous facial expressions. *Psychological Science*, 20(2), 177–183.

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