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A RELATIONSHIP BETWEEN SMELL IDENTIFICATION AND EMPATHY

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Olfaction is a sense that has close relationships with the limbic system and emotion. Empathy is a vicarious feeling of others' emotional states. The two functions are known to be subserved by common neuroanatomical structures, including orbitofrontal cortex, mediodorsal thalamus, and the amygdala. This study demonstrates a correlation between smell identification and empathy, using the Mehrabian and Epstein Empathy Questionnaire and Alberta Smell Test. Right nostril smell identification correlated with empathy, whereas the left nostril did not. Given the predominantly ipsilateral representation in the olfactory system, this is in accordance with right hemisphere dominance for emotional functions and empathy. Further, the emotional component of empathy (feeling another's emotions) correlated with smell, whereas a cognitive component (comprehending another's emotions) did not. This study is the first to demonstrate a relationship between empathy and smell in normal subjects, suggesting common neural substrates.

Olfaction is a chemical sense that has powerful relationships with emotion (Zald & Pardo, 1997; Herz, McCall, & Cahill, 1999). The central olfactory system has projections to limbic and paralimbic structures, including pyriform cortex, mediodorsal thalamus, the basolateral amygdala, lateral hypothalamus, and orbitofrontal cortex (Scalia & Winans, 1975; Barbas, 1993). Orbitofrontal cortex is activated

during olfactory identification tasks, and smell tests are used to demonstrate anosmia in people with orbitofrontal dysfunction (Savic, Bookheimer, Fried, & Engel, 1997). Although there is some bilateral activation produced by certain odors, orbitofrontal cortex may be more strongly activated ipsilaterally, depending on the nostril presented and hedonic value of the odor (Savic & Gulyas, 2000; Zald & Pardo, 1997). Given this extensive limbic representation of olfaction, it is not surprising that olfaction relates to mood and some personality characteristics (Pause, Ferstl, & Fehm-Wolfsdorf, 1998; Postolache et al., 1999).

Empathy is defined as a vicarious feeling of others' emotional states (Davis, 1980; Mehrabian & Epstein, 1972). It serves as a strong motivator for prosocial behavior and is seen as a important component for appropriate moral development (Eisenberg, 2000; Litvack-Miller et al., 1997). Empathy has been differentiated into cognitive and emotional components (Davis, 1980). The cognitive component entails the ability to take another person's mental perspective, or *comprehending* another's emotions. This is more akin to the "theory of mind," or the ability to form accurate mental representations of another's thoughts, perceptions, and emotions (Adolphs, 2001). The emotional component of empathy, on the other hand, involves emotional and visceral experience in response to another's state, or *feeling* another's emotions.

A neurobiological basis for empathy has been suggested by several lines of evidence. Lesions of prefrontal cortex during development and adulthood have been associated with a reduced capacity for empathy (Grattan & Eslinger, 1992; Eslinger, 1998). Within prefrontal cortex, medial orbitofrontal cortex (ventromedial prefrontal cortex, vmPFC) seems especially relevant to empathy (Barrash et al., 2000; Tranel, 1994; Blair & Cipolotti, 2000). Lesions of vmPFC produce a behavioral syndrome termed "acquired sociopathy," consisting of dampened experience of aversive emotions, emotional lability, impaired social judgment and goal-directed behavior, and a profound lack of insight. Although these individuals retain a knowledge of social rules and conventions, they appear unable or unwilling to adhere to them. Similarly, psychopaths show dysosmia and cognitive deficits that are suggestive of orbitofrontal dysfunction (Lapierre, Braun, & Hodgins, 1995).

Although orbitofrontal cortex has been the focus of the neuroana-tomical substrate of empathy, it has neuroanatomical connections and close functional relationships with other limbic structures such as basolateral amygdala and mediodorsal thalamus (Porrino, Crane, & Goldman-Rakic, 1981). Thus, it is likely that these structures play some role in empathy as well. For example, an analysis of cases of frontotemporal dementia suggests that dysfunction of right anterior temporal cortex causes a decrease in empathy (Perry et al., 2001).

Given the common neuroanatomical regions subserving olfaction, emotion, and empathy (particularly orbitofrontal cortex, amygdala, and mediodorsal thalamus; Figure 1), it was hypothesized that there is a relationship between performance on smell tests and ratings of empathy.

METHODS

Subjects

The subjects were a convenience sample who were recruited vol-untarily, and did not receive any financial compensation for their
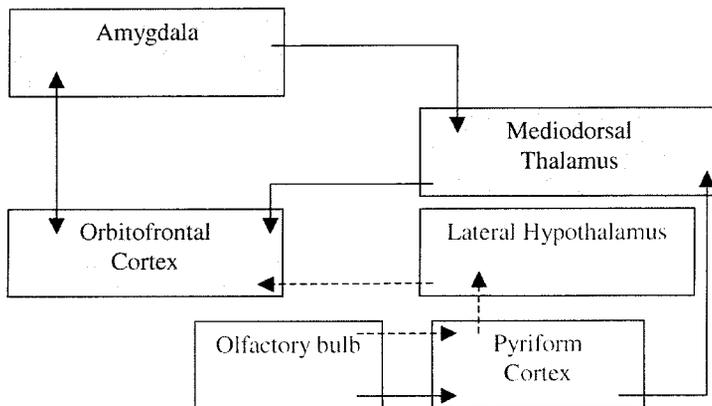
FIGURE 1. Common neuroanatomical basis of empathy and smell. The olfactory system includes the olfactory bulb, pyriform cortex, and lateral hypothalamus. Olfactory structures which overlap with structures important to empathy (darkened boxes) include orbitofrontal cortex, mediodorsal thalamus, and amygdala. (Derived from Paxinos, 1990.)

participation. A large proportion were college students who received a minuscule amount of course credit for participating. The study was approved by an institutional review board and all subjects read and signed an appropriate informed consent. Twenty-eight subjects participated (20 female, 8 male), ranging in age from 19 to 70 (mean 29.18 ± 2.80) years of age. There was a mean of 14.32 ± 0.92 years of education.

Mehrabian and Epstein Empathy Questionnaire

The Mehrabian and Epstein Empathy Questionnaire (MEEQ) is a 30-item, self-rating Likert scale that measures various aspects of empathy (Mehrabian & Epstein, 1972). It covers both emotional and cognitive aspects of empathy, and has been experimentally validated. Empathy is a multidimensional phenomenon, involving both cognitive and emotional processes (Davis, 1980). Although Mehrabian and Epstein's instrument yields a unitary score, items were selected out for this study on an a priori basis that represent cognitive aspects of empathy, based on factor analytic studies of similar instruments (Davis, 1980; Davis, Hull, Young, & Warren, 1987), Scores were tallied based on the total, cognitive, and emotional items (Em-T, Em-C, Em-E, respectively).

Alberta Smell Test

The Alberta Smell Test (AST) is a measure of olfactory identification (Green & Iverson, 2001). It employs eight scented markers as stimuli, presented monorhinally and blind to the subject. Subjects are presented with a list of the eight possible scents from which to choose. The markers are capped between uses and retain their scent well across multiple uses. However, to prevent diminishing the potency of smell, the markers were changed after 10 uses. Scores were obtained for the left and right nostrils (S-L and S-R, respectively), as well as a smell laterality index (SLat) represented by (Right – Left)/(Right + Left) (Postolache et al., 1999). Further, smell improvement indices were obtained by computing the slope of the cumulative frequencies for the total, left, and right side scores (SII-T, SII-L, and SII-R, respectively).

Data Analysis

Pearson correlations were obtained for the variables assessed. A correlation matrix was computed relating empathy and smell variables (Table 1). Twenty-five percent of the sample were tobacco smokers, smoking an average of 0.15 ± 0.33 packs of cigarettes per day. Neither smoking status nor packs smoked per day had a significant relationship with mean smell performance ($p = .17$, nonsignificant, and $p = -.07$, nonsignificant; respectively). Age also did not play a significant role in mean smell performance ($p = -16$, nonsignificant).

DISCUSSION

This study demonstrates a relationship between human olfactory performance and self-ratings of empathy. There is convergent evidence suggesting common neuroanatomical pathways for these two functions involving orbitofrontal cortex, the amygdala, and mediodorsal thalamus. A correlation between these seemingly disparate functions supports at least a partial functional localization.

Olfactory function in the frontal lobe is usually associated with lateral orbitofrontal cortex (Rolls, 1996). However, gyrus rectus (medial orbitofrontal cortex) does receive projections from entorhinal cortex and mediodorsal thalamus, and human neuroimaging studies show gyrus rectus activation during olfactory stimulation (Morecraft, Geula, & Mesulam, 1992; Di Nardo et al., 2000; Irle, Markowitsch, &

TABLE 1. Correlation matrix of empathy and smell measures

	S-L	S-R	Mean	SLat	SII-T	SII-L	SII-R	Em-C
Em-T	0.11	0.44‡	0.41†	0.37*	0.35*	0.26	0.40†	
Em-C	0.02	0.23	0.19	0.22	0.16	0.16	0.22	
Em-E	0.12	0.46‡	0.42†	0.37*	0.35*	0.27	0.40†	0.57‡

*Significant at the .05 level.
†Significant at the .025 level.
‡Significant at the .01 level.
Abbreviations: Em-T = total empathy score; Em-C = cognitive empathy score: Em-E = emotional empathy score; S-L = left nostril smell; S-R = right nostril smell; Mean = mean smell; SLat = smell laterality index; SII-T = smell improvement index—total; SII-L = smell improvement index—left; SII-R = smell improvement index—right.

Streicher, 1984; Markowitsch, Pritzel, & Divac, 1978). Orbitofrontal-basolateral amygdala interactions have been demonstrated with other olfactory processes, such as olfactory-cued reward learning (Schoenbaum, Chiba, & Gallagher, 1998).

The results also indicate that right-sided smell identification and smell improvement correlate with empathy measures better than left-sided smell measures. Several lines of evidence, including brain injury studies, indicate a right-hemisphere dominance for emotional processing (Borod, 1992; Cummings, 1997). This is also consistent with the critical role of right anterior temporal structures in empathy found in cases of frontotemporal dementia (Perry et al., 2001).

Another finding in this study is the correlation between the emotional aspect of empathy with smell measures, but not the cognitive aspect. The cognitive component of empathy concerns comprehending another's emotional state, more so than "feeling" their emotional state. In this respect, it is more akin to "theory of mind" ability than empathy proper, although it may be a necessary prerequisite to understand another's emotions before being able to empathize. Indeed, the correlation between emotional and cognitive components of empathy suggests that they are closely related but not identical functions.

However, there is a neuroanatomical basis for the discrepant correlation between emotional versus cognitive empathy with smell. Although evidence suggests that empathy is mediated in part by orbitofrontal/ventromedial prefrontal cortex and associated structures, human neuroimaging studies suggest medial prefrontal involvement for theory of mind (Adolphs, 2001). Given the different neuroanatomical connections and functional heterogeneity of these areas, the differential correlation of emotional versus cognitive empathy with smell provides behavioral support for this distinction.

This study is the first to demonstrate a relationship between empathy and smell in normal subjects. It is suggested that the reason for the relationship between these two seemingly disparate functions is a consequence of their common neuroanatomical substrates.

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