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A Primal Reaction to Fetid Feet? A Brief Report

Marissa A. Harrison[1]; Ashley J. McFalls[2]

[1]*Penn State Harrisburg*
[2]*Penn State Hershey College of Medicine*

The prevalence of illness- and odor-causing bacteria on human feet may be responsible for an evolved disgust response to feet. Foot aversion was evident in a sample of 110 students, with almost all reporting that feet have a foul odor. Further, most participants perceived feet as "gross," would mind touching someone else's feet, and said that they would purposefully avoid a romance with someone with malodorous feet. The adaptive significance of aversion to feet is discussed.

Keywords: feet aversion; foot odor; disgust; toes; digit research

Introduction

People do seem to offer harsh olfactory and overall assessments of human feet. Evidence suggests this reaction is not unwarranted, as several studies investigating malodorous feet have identified disease-related bacteria as components thereof (e.g., Marshall, Holland, & Gribbon, 1988). For example, Ara and colleagues (2006) sampled human foot surfaces from Canadian adult women and documented the presence of many bacteria, including (a) *Propionibacterium acnes*, related to skin acne but also associated with loss of vision (Rogers, Fox, Noble, Kerr, & Inglis, 1994) and life-threatening infections such as endocarditis (i.e. inflammation of the lining of the heart) and sarcoidosis (i.e. a multiple organ inflammatory disease) (Bruggemann, et al., 2004), (b) *Corynebacterium minutissimum*, which causes skin disease, and (c) *Staphylococcus aureus* (a cause of Staph infections), a pathogen that can cause a host of diseases including meningitis, pneumonia, and sepsis (methicillin-resistant *S. aureus*, or MRSA, is a "superbug" especially threatening to those with compromised immune systems) (Enright, Robinson, Randle, Feil, Grundmann, & Spratt, 2002). In addition, Noble et al. (1986) swabbed the toe webs of British college students and detected the presence of numerous bacilli, including (a) *Pseudomonas putrefaciens*, which can cause sepsis and cellulitis (Chen, Lawerence, Packham, & Sorrell, 1991; Marne, Palleres, & Sitges-Serra, 1983), (b) *Enterobacter cloacae*, related to gangrene, respiratory tract and urinary tract infections (Doblecki-Lewis, Palaios, Bejarano, Tzakis, Selvaggi, & Morris, 2008; Hall, Poon, Yaghsczian, & Boechat, 1992; Rivera-Sanchez et al., 2010), (c) *Escherichia coli*, which causes diarrhea (Fischer Walker, Sack, & Black, 2010); *Proteus vulgaris*, a putrefying organism found in feces and soil and related to urinary tract infections (Orrett & Davis, 2006), and (d) *Flavobacterium meningosepticum*, a cause of meningitis (Rios, Klimek, Maderazo, & Quintiliani, 1978).

In addition, lingering, foul foot odor, such as that observed in the bacterial infection pitted keratolysis (Takama, Tamada, Yokochi, & Ikeya, 1998), is caused by isovaleric acid (Kanda, Yagi, Fukuda, Nakajimi, Ohta, & Nakata, 1990). A buildup of isovaleric acid has been linked to neurological deficits and metabolic and digestion anomalies (Dodelson de Kremer, Depetris de Boldini, Paschini de Capra, Hliba, & Corbella, 1992; Gerdes, Gregersen, Guttler, Ludvigsson, Dinesen, & Holm, 1989).

In summary, ample evidence shows that human feet can offer a veritable smorgasbord of illness-causing bacteria. Therefore, a disgust reaction to feet may be an evolved safety precaution, protecting the olfactorily offended from contact with disease-causing agents. Organisms causing infection posed a consistent threat to survival in the human ancestral environment (Tybur, Lieberman, & Griskevicius, 2009). Pinker (1997) and other theorists (e.g., Curtis & Biran, 2001; Curtis, de Barra, & Aunger, 2011; Haidt, McCauley, & Rozin, 1993; Rozin, Millman, & Nemeroff, 1986; Tybur, Lieberman, & Griskevicius, 2009) have contended that disgust evolved to motivate humans to avoid disease-causing agents. Many researchers have documented modern human revulsion to threatening stimuli, such as rotting flesh, vomit, feces, body envelope violations, and other people with marked cues of disease (Haidt et al., 1993; see Oaten, Stevenson, & Case, 2009, for review).

In consideration of the convincing evidence for the causes and function of disgust, and because the prevalence of a trait or behavior in contemporary men and women suggests it was adaptive to our hominid ancestors, we attempted to establish the prevalence of a disgust response to feet. We know of only one other study that addressed repulsion to human feet. In their investigation of perceptions of and reactins to self- versus other-generated odors, Stevenson and Repacholi (2005) presented college students with a series of vignettes to rate how much they would like or dislike a series of smells, including feet, feces, flatulence, sweat, garbage, and perfume, and to what extent would they express disgust versus delight if exposed to such. They found that the people rated their own foot odor as less unpleasant compared to the foot odor of others. They attributed this effect to disease avoidance. The present study extends such, focusing on feet alone and introducing additional perceptual and behavioral items.

Methods

All procedures were approved by the local Institutional Review Board. Participants were recruited from a Psychology participant pool of a college in the northeast United States. All gave informed consent to participate. Embedded in an online questionnaire regarding a different research topic ("Your Perceptions of Romance") were five items asking participants about foot aversion and disgust (see Table 1). A total of 125 people began the questionnaire, but 15 provided no information after login. The final sample (N = 110) consisted of 62 women (56.4%) and 48 men (43.6%). Their mean age was 22.72 (*SD* = 7.97), with a range from 18 to 59.

Results

The survey results, analyzed with a Chi-square goodness-of-fit test, are presented in Table 1.

All five significant results remain statistically significant using a modified Bonferroni correction to alpha for multiple comparisons. Fleiss's Kappa (.27) showed fair agreement (Viera & Garret, 2005), consistent with a pervasive aversion towards feet. Considering all items together, raters expressed an aversion towards feet at an overall rate of 73.5%.

Tab. 1: Responses to Items Regarding Foot Aversion

Item	More frequent response:	%	$\chi 2$	*p*
Do you mind touching someone else's toes/feet?	Yes	76.4	30.58	.000*
Do you think toes/feet are "gross?"	Yes	76.1	29.81	.000*
Do you think toes/feet have a foul odor?	Yes	94.5	87.31	.000*
Would you avoid a romance with someone just because they had foul-smelling feet?	Yes	75	27.00	.000*
Do you think toes/feet can be sexually attractive?	No	65.5	10.51	.001*
Would you ever want to conduct research with feet?	No	57	2.10	.147

Discussion

Consistent with prediction, the majority of participants in this study attributed a global "grossness" to feet and reported a negative evaluation of foot odor and of coming into contact with others' feet. Additionally, three-quarters of the sample said they would avoid a romance with someone solely due to a noisome foot odor, and most dismissed the notion of feet and/or toes being a sexual attractant as observed in some fetishes. Although one may hear frequent anecdotal accounts of repulsion to fetid feet, we know of only one other study (Stevenson & Repacholi, 2005) to-date that empirically documented, among a relatively large group, people's aversion to feet. However, these researchers did not discuss prevalence or elaborate upon behavioral consequences.

Although the majority of participants, all students of Psychology and therefore ostensibly interested in behavioral science, said they would *not* want to conduct feet research, the result was not statistically significant. Moreover, since we did not ask about willingness to conduct research with hands or other body parts, we have no way of assessing whether the expressed interest in feet research is high or low. In any case, behavioral scientists have devoted a considerable amount of effort to examining the relationship between finger lengths (particularly the 2D:4D ratio) and behavior (e.g., Manning et al., 2000; Manning, 2002; Manning, Stewart, Bundred, & Trivers, 2004; Puts, Gaulin, Sporter, & McBurney, 2004; Vermeersch, T'Sjoen, Kaufman, & Vincke, 2008), but only a couple of studies have investigated relationships between toe lengths and finger lengths or toe lengths and behavior (e.g., Harrison, 2010; McFadden & Shubel, 2002) in spite of the common morphogenesis of fingers and toes (Garn, Burdi, Babler, & Stinson, 1975; Kondo, Zakany, Innis, & Duboule, 1997; Manning, Callow, & Bundred, 2003). Admittedly, there are noted measurement issues with obtaining toe length measurements (see McFadden & Shubel, 2002). Nonetheless, since three out of four individuals in our study reported they would mind if they had to touch someone else's feet, it is possible that aversion is another limiting factor in the pursuit of this line of inquiry.

Repulsion to feet may confer an advantage to the repulsed. Considering the potential for contact with disease-causing bacteria, it is certainly beneficial to have a noxious deterrent motivate an avoidance of such a potentially dangerous surface. Throughout the animal kingdom the olfactory sense is employed to avoid that which threatens the survival of the organism, be it predators or infection. In social species especially, where there is an increased interaction and therefore an increased likelihood of contact with foreign organisms, many non-human animals are able to distinguish between their healthy and diseased or parasitic conspecifics (Kavaliers, Choleris & Pfaff, 2005; Kavaliers, Colwell, Braun, & Choleris, 2003). On the other hand (or foot), possession of disease-causing, malodorous feet could have afforded a survival advantage in the ancestral environment; as G.G. Gallup, Jr., (personal communication) contends, predators

may have evaluated ancestral humans as unpalatable due to noisome odors left behind in their footprints.

Following the contention that disease avoidance is an evolved mechanism for survival and promotion of a species, previous studies have found a small, yet significant decline in the repulsion to disease-causing stimuli as age increases and fertility wanes (Curtis, Aunger, & Rabie, 2004; Fessler & Navarette, 2003). As 80% of our sample fell between 18-23 years, we were not able to examine this age effect; however, it would be interesting to see if the study of foot avoidance in a more age-diverse group would reveal such a trend.

Of course, the bacteriological studies cited herein were conducted with modern humans who are presumably used to wearing shoes. The human foot is biologically adapted for walking barefoot on natural terrain (D'Aout, Pataky, De Clercq, & Aerts, 2009), and early humans did not don constricting footwear (e.g., socks, sneakers) in the ancestral environment. Since trapping sweat inside one's shoes is a likely reason for increased bacterial growth and thus odor (see Ramsey, 1996) in the "habitually shod" (D'Aout et al., p. 81), our ancestors may not have produced the same foul foot odor as we do. Future researchers may endeavor to examine foot odor, repulsion thereto, and bacterial profiles of those who are perpetual barefoot walkers both within Western culture or cross-culturally (e.g., some South Indian peoples, cf. D'Aout et al., 2009). Regardless, the origins of disgust are likely rooted in disease avoidance, and therefore repulsion to feet, old or new in evolutionary terms, promotes human survival.

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