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Salivary secretion and disgust: A pilot study

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A B S T R A C T

Although a direct link has been established between self-experienced disgust and salivary secretion, it is unclear whether this physiological index is modulated by the social experience of disgust (i.e., exposure to the facial expression of disgust). We tested this issue in a pilot study by collecting salivary samples in a group of 20 healthy humans watching pictures of faces expressing disgust. Moreover, we tried to replicate previous evidence by testing saliva secretion in response to pictures of unpalatable (i.e., rotten) food and non-gustatory disgusting stimuli (i.e., disgusting insects). Overall, our analysis shows a general reduction of saliva secretion in response to disgust stimuli, compared to their positive counterparts, although further analyses for specific stimulus categories indicated that this difference was statistically significant only for food pictures. The non-significance of the face and insect categories might be due to insufficient power of our small sample. Overall, a general reduction of saliva secretion for different disgust-related stimuli suggests a shared mechanism of encoding, in line with theories of neural reuse.

1. Introduction

The study of salivary secretion as investigative tool to probe animal and human psychology has enjoyed some popularity thanks to the research of physiologists such as Ivan Pavlov (1927) and psychologists such as Burrhus F. Skinner (1935). The interest in studying salivary secretion dates back at least to the second half of the nineteenth century when Claude Bernard (1853) investigated salivary secretion in a horse, when some movement of the experimenter indicated to the horse that it was about to be fed.

Studies such as those above are the foundation of an intriguing research line investigating the effects of endogenous and exogenous/environmental variables on salivary production. Given the role of saliva in digestive functions, most of this research has focused on the influence of rewarding food stimuli on salivary secretion, that is, the anticipatory phase of digestion (Lashley, 1916; Pavlov, 1927). Several investigations have documented an increase of salivary secretion in response to rewarding food stimuli. This phenomenon was mainly linked to the likelihood and/or the motivation to acquire the presented food, as suggested in the studies by Hayashi and Ararie (1963) and Powley (1977), where saliva secretion was measured in response to the presentation of dishes of palatable foods. In line with this evidence, the study by Christensen and Navazesh (1984) has reported the greatest salivary flow increase in response to pictures of slices of pizza. This effect was reported even without expecting to acquire the presented food. However, this study suggests that the salivary responses were not related to the anticipated palability of the test foods, but rather to their physical and chemical properties. In fact, no significant salivary increase was documented for other food-related stimuli. By contrast, Pangborn, Witherly, and Jones (1979) reported no significant change in parotid salivary flow when participants simply viewed pictures of lemons, as well as appetizing food, even though subjects knew they could eat them (see also Birnbaum, Steiner, Karmeli, & Ilsar, 1974 for similar results). Moreover, an early study by Wooley and Wooley (1973) reported that salivary responses to food stimuli were attenuated if participants did not expect to eat the food, compared to a condition where consumption was expected. Interestingly, in a subsequent study including a bigger sample, the same authors (Wooley, Wooley, & Dunham, 1976) found that exposure to food stimuli can be associated to reduced saliva secretion, compared to a no-food exposure, if (healthy) participants are not expecting to consume the food. The literature mentioned above provides an inconsistent picture about the effects of food exposure to saliva secretion. This might be due to the underpowered nature of all these investigations. Therefore, any conclusion about these results should be drawn with great caution.

Salivary secretion can be stimulated also by exposure to non-food reward cues. For instance, Gal (2012) documented higher salivary secretion in response to the exposure to money and sports cars, but only

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when participants experienced a low power state and were in the presence of mating goals. These findings suggest that material reward cues stimulate salivation similarly to food reward stimuli. Moreover, salivary flow can be modulated by factors such as changes in ambient illumination or eye closure (Shannon & Suddick, 1973; Pangborn & Berggren, 1971; Pangborn, Lundgren, Drake, & Nilsson, 1978), hunger (e.g., Wooley & Wooley, 1973; Mattes, 2000), chocolate craving (Meule & Hormes, 2015), background sounds (Pangborn et al., 1978), and other cognitive factors such as attention, mental imagery, and labelling (see Spence, 2011, for a review).

Surprisingly, very little research has been done about the effect of disgust on salivary secretion, despite its central relevance in social and health psychology. The early study by Brunacci (1917) reported diminished salivary secretion in response to unpleasant odors (asafetida). In contrast, Pangborn and Berggren (1973) documented increases of saliva flow in the presence of the unpleasant odour of butyric acid. Moreover, a recent study has reported increased salivary secretion in response to guided imagery of disgust (van Overveld, de Jong, & Peters, 2009). This result has been indirectly confirmed by research examining EMG activity of the digastricus muscle – considered an indirect measure of saliva production (Nederkoorn, Smulders, & Jansen, 1999) – during exposure to core disgust video clips (de Jong, van Overveld, & Peters, 2011).

The literature suggests that disgust and salivary production are linked also at the neural level. Converging results from neuroimaging (e.g., Jabbi, Bastiaansen, & Keysers, 2008) and clinical research (Vicario et al., 2017a, for a review) support the hypothesis that the insular cortex represents a *hub* region mediating the experience of several forms of disgust such as self-disgust (Vicario, 2013; Overton, Markland, Taggart, Bagshaw, & Simpson, 2008), moral disgust (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003) and the recognition of disgust in others (Wicker et al., 2003). Penfield and Faulk (1955) demonstrated that in vivo electrical stimulation of the human insula modulates salivary secretion. Moreover, there is evidence of hypersalivation in patients with insular-opercular seizures (Proserpio et al., 2011).

In the present pilot study we aimed to provide further evidence on the effect of disgust on saliva secretion addressing two goals: i) expanding the extremely limited literature in the field of disgust and saliva secretion – hitherto confined to odors and imagery (Pangborn & Berggren, 1973; van Overveld et al., 2009) – to the domain of visual stimuli; and ii) extending our current knowledge about the link between disgust and saliva secretion to the – as yet unexplored – social domain (i.e., pictures of faces expressing disgust).

According to the study by van Overveld et al. (2009), it is plausible to expect an increase of salivary secretion in response to pictures associated with gustatory disgust (i.e., unpalatable food) and pictures associated to non-oral-related disgusting stimuli (i.e., insects). Moreover, according to the evidence (e.g., Vicario & Newman, 2013; Wicker et al., 2003) in support of the *sensory motor resonance* hypothesis, perceiving facial expressions of others may evoke a similar sensory and motor representation and, therefore, a similar physiological response in the observer (see Hess, Blairy, & Philippot, 1999 for a review, but also Adolphs, 2002). Therefore, we expected a similar pattern of results while perceiving faces expressing disgust as when viewing pictures of disgusting stimuli.

2. Methods

2.1. Participants

According to suggestions provided for pilot research (e.g., Isaac & Michael, 1995; Hill, 1998; Julious, 2005; van Belle, 2002) we tested 20 participants (5 males; mean age = 28.7 years, $SD = 11.75$) recruited at the Bangor University, who completed this study in return for £6 or course credits. Because Treece and Treece (1982) and Connelly (2008) suggested that the sample size for a pilot study should be about 10% of the sample intended for the larger study, 20 participants fairly well reflect this percentage, if we assume that 194 is the suggested sample for a regular study (i.e., this sample size has been estimated on the basis of the number of potentially recruiting students at the School of Psychology via SONA system - about 390 -, a confidence interval of 95% and a margin error of 5%). This estimation has been performed via online platform (https://www.surveymonkey.com/mp/sample-size-calculator/#).

One participant was not able to complete all experimental conditions; hence analyses are based on 19 participants. All participants had normal or corrected-to-normal visual acuity, gave written informed consent prior to their inclusion in the study, and were naive as to its purpose. Specific information concerning the study was provided only after completion of all experimental sessions. The study was approved by the ethics board of the School of Psychology and conducted in agreement with the principles of the 1964 Helsinki declaration.

2.2. Materials

2.2.1. Visual stimuli

To test the effect of disgust on salivary secretion, participants were asked to observe, in separate blocks within one session, disgusting pictures and positive control stimuli. These stimuli belonged to three different categories: food pictures (12 pictures of rotten food and 12 pictures of fresh food); pictures of insects (12 pictures of disgusting insects such as cockroaches and 12 pictures of attractive insects such as butterflies); pictures of facial expressions (12 pictures of faces expressing disgust and 12 pictures of faces expressing happiness). Stimuli belonging to the food and insect categories were created by our research team. They were pre-selected by an independent group of participants ($N = 12$) from an initial sample of 80 pictures (i.e., 20 × 2 categories × 2 types). Participants rated each picture for disgust and arousal by using visual analogue scales (ranging from not disgusting to very disgusting - 0 to 10 - and from not arousing to very arousing - 0 to 10 - respectively). Experimental stimuli were selected by including the most disgusting (food: $M = 7.54$, $SD = 1.57$; insects: $M = 4.97$, $SD = 3.44$) pictures (i.e., 12 per type), with the lowest arousal rating (food: $M = 4.09$, $SD = 3.12$; insects: $M = 3.68$, $SD = 2.88$). As control stimuli, we decided to use positive pictures ($N = 12$ per block) of the same categories mentioned above (disgust rating: food: $M = 0.43$, $SD = 0.38$; insects: $M = 0.83$, $SD = 1.02$; Arousing rating: food: $M = 3.67$, $SD = 4.70$; insects: $M = 4.70$, $SD = 2.84$), to compare the salivary responses to opposing stimuli belonging to the same category. This was done to control for any potential influence of attention changes on salivary secretion that might take place when comparing the presentation of a visual stimulus condition with respect to a no-stimulus condition (see Spence, 2011, for a discussion) or a neutral stimulus. The ANOVA of the disgust ratings showed a significant main effect of stimulus category [$F(1, 11) = 13.35$, $p = 0.003$, $\eta^2 = 0.548$], documenting higher disgust ratings for food ($M = 3.97 \pm 0.255$), compared to insects ($M = 2.90 \pm 0.458$). We also detected a significant stimulus type effect [$F(1, 11) = 78.45$, $p < 0.001$, $\eta^2 = 0.877$] documenting higher disgust ratings for disgust-related stimuli ($M = 6.26 \pm 0.642$) compared to positive stimuli ($M = 0.60 \pm 1.55$). Finally, we detected a significant stimulus category × stimulus type interaction term [$F(1, 11) = 16.78$, $p = 0.001$, $\eta^2 = 0.604$]. Post hoc comparisons documented a significant difference between disgust and positive stimuli for both food ($p < 0.001$) and insects ($p < 0.001$). On the other hand, the arousal ratings provided by the independent group of participants were not different, as indicated by the absence of a significant main effect of stimulus category [$F(1, 11) = 0.08$, $p < 0.776$, $\eta^2 = 0.007$] and stimulus type [$F(1, 11) = 0.484$, $p < 0.500$, $\eta^2 = 0.042$] as well as by the absence of a significant stimulus category x stimulus type interaction term [$F(1, 11) = 0.125$, $p < 0.729$, $\eta^2 = 0.011$]. For the face category, we choose pictures of faces expressing disgust and happiness from *The*