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LAST BUT NOT LEAST

Odours grab his hand but not hers

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Abstract. Gender is important for the determination of olfactory abilities. Previous reports on gender differences in human odour perception claimed that the sensitivity and discrimination ability of females for odours is superior to that of males. Evolutionary theories, however, open up the possibility of an interesting dissociation between females and males in terms of odour processing: there is an advantage for women for the perceptual aspects of olfactory stimuli and an advantage for men when translating perceptual olfactory information into action. In line with this hypothesis our observations suggest that encoding odours has the ability to guide the movement of males but not that of females.

The observation of gender differences in relation to olfactory abilities dates back to the end of the nineteenth century when Toulouse and Vaschide (1899) claimed that females' sensitivity and discrimination ability for odours is superior to those of males. Their claim was based on the results of a study in which camphor and floral odours were administered to 237 subjects of both sexes and all ages. The notion of female superiority in olfactory perception also appears to be a universal belief, as demonstrated by the outcome of a large survey involving 1.5 million people performed by Wysocki and Gilbert (1989) in collaboration with the National Geographic Society. They found that women had a higher opinion of their olfactory abilities than men independently of their age. In recent years the question of gender differences in chemosensory perception has received increased attention with a variety of psychophysical studies demonstrating that odour perception differs between sexes and this difference still appears to be always in favour of women (Brand and Millot 2001).

Further support for a female advantage in odour perception comes from the documentation of sexual differences concerning both physiology and morphology of the main olfactory cerebral regions. When odours are presented to subjects as stimulants for functional magnetic resonance imaging, the volume of activated foci in females is eight times bigger than in males (Yousem et al 1999). Similarly, women express larger amplitudes of event-related potentials on the left hemisphere than men during odorant delivery (Lundström and Hummel 2006), and concentration of grey matter within specific olfactory areas appears to be higher for females than males (Garcia-Falgueas et al 2006).

Among the theories offered to explain how a female advantage in olfactory perception might have arisen, those relying on an evolutionary perspective are particularly gripping (eg Velle 1997). It has been proposed that sex differences have been selected to compensate for the weaker physical strength of women. In this perspective women might have shown less effective defensive aptitudes than men. This might have brought to an early division of labour with the main task for women to gather food supply which were essentially of plant origin. Therefore, women might have developed superiority in olfaction and taste to distinguish toxic from non-toxic plants and possibly for the evaluation of their nutritional value (eg Velle 1987).

Evolutionary theories, however, also reported sex differences in sensory processing which speak in favour of men and might have implications for olfactory processing. According to the 'Man – Hunter' and the 'Man – Sexual Competitor' models, the males' participation in archaic activities, such as those subserving plundering and sexual-competing behaviour, has produced an actual advantage in managing the geometry and dynamics for acting on 3-D visual objects (Ecuyer-Dab and Robert 2004). We found the assumptions behind these theories interesting, because, if men had extended the action-tailored functioning of perception from visual to olfactory domain, then these assumptions would allow us to predict the possibility of gender dissociation in terms of task-related olfactory processing. Whereas female advantage in extracting relevant properties of olfactory stimuli might be confined to purely perceptual aspects, men might be better than women when the situation implies the translation of olfactory information into action. Recent developments in the investigation of olfactory processing for the control of action make this a timely and tractable issue.

We have demonstrated that human subjects are sensitive to the nature of olfactory information presented during the planning and the execution of a prehensile movement (Castiello et al 2006; Tubaldi et al 2008). Participants were requested to reach towards and grasp a fruit which could be either small (almond, strawberry) or large (apple, orange) after smelling an odour associated with either a large or a small fruit (figure 1).

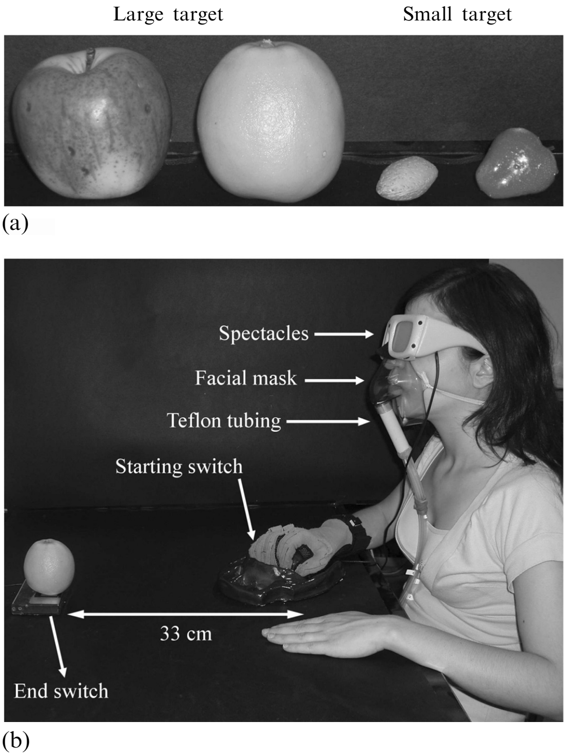

Figure 1. (a) The visual targets. (b) The parts composing the experimental set up. The experimental procedures were as follows: (i) vision was occluded by means of spectacles before the target was positioned on the working surface; (ii) an auditory tone indicated odour delivery by means of Teflon tubing connected to an olfactometer; (iii) after 3 s, a similar tone indicated the offset of odour delivery; (iv) following a 500 ms interval a different tone was presented; and (v) upon hearing the tone, participants were instructed to reach towards, grasp, and lift the target. Movement duration was measured as the time interval between the moment at which a starting switch embedded within a glove was released at hand movement onset and the moment at which the end switch was released at object lifting.

When the size of the visual target and the size of the olfactory stimulus did not match (incongruent odour condition), movement duration increased over that when the two 'sizes' did match (congruent odour condition). Such manifestations of interference were taken as evidence that olfactory representations of objects contain detailed 'motoric' information able to compete with the representation evoked by the visual targets.

Here we used similar procedures to compare the performance of males and females participants in a reach-to-grasp task by manipulating the nature of olfactory information. If males are more sensitive than women when processing olfactory information within an 'action' context, then interference effects should be more pronounced for males than females. We found that this was the case. For males ($N = 10$; mean age: 22 years), reach duration was longer for the incongruent than for the congruent odour condition (figure 2). For females ($N = 10$; mean age: 21 years), reach duration was not affected by the mismatch between the 'size' of the odour and the size of the visual target (figure 2).

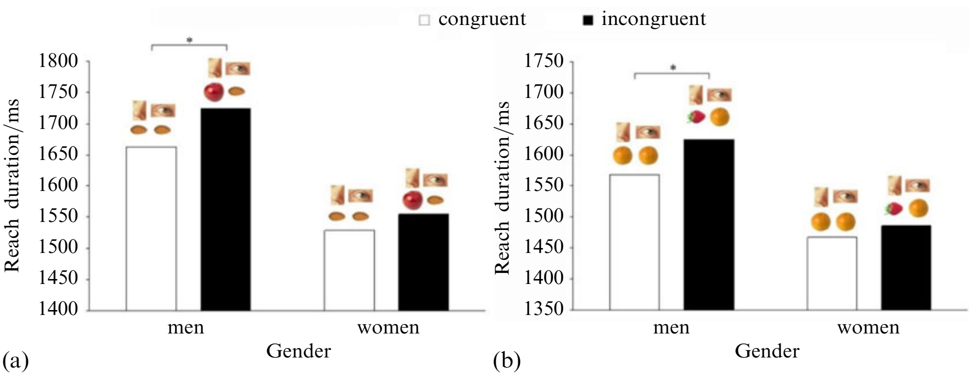

Figure 2. [In colour online, see http://dx.doi.org/10.1068/p6286] Graphical representation of the results obtained for reach duration ($F_{1,18} = 4.538$, $\eta_p^2 = 0.201$, $p < 0.05$). Results in (a) refer to the condition in which either males or females grasped a small target in the presence of an odour associated with an object either larger or of the same size as the target. Results in (b) refer to a large object. Note that an increase in movement duration for the incongruent conditions (black bars) was only found for males. Asterisks indicate significant differences. The 'nose' and the 'eye' represent the olfactory and the visual stimulus, respectively.

This observation opens up a novel perspective on sex-differentiated olfactory abilities. Whereas previous literature suggests that women 'know' odours better than men, the present results suggest that men may 'act' on odours better than women. In other words, female sense of smell would be perception-oriented, ie optimised to detect, discriminate, identify, recognise, and categorise odours. Conversely, male sense of smell would appear to be action-oriented, ie tailored to elicit specific and selective motor commands for interacting with 'smelled-objects'. In this view, gender differences should not be considered in terms of irrevocable, pervasive differences in the brain of two sexes, but as the flip of a switch between male and female behavioural repertoires for which plays a fundamental role the to-be-accomplished environmental requirements.

Our hope in presenting these observations to the *Perception* community is that the investigation of gender differences may provide interesting insights into the mechanisms underlying sensory processing. For instance, exploring such differences might be useful in revealing the possibility that the perception and perception-for-action dissociation previously described for other modalities (eg vision; Goodale and Milner 1991) might be extended to olfaction.

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