

# The knowing nose

Laura J. Speed on how olfactory studies can inform theories of language and perception

We live in a loud and colourful world, with our visual and auditory systems bombarded with information. But what of the lower sense of smell? Can we learn anything by studying olfaction?

Think about your experience with vision. Viewing a beautiful scene we can pick out various features, identify colours, we can describe the scene in detail, and later recall the scene vividly in memory. We can even create an image of a comparable scene easily by using visual imagery. These feats seem easy and have been thoroughly researched and theorised in the psychological literature. But here I would like to argue that by focusing on the dominant sense of vision, our picture of language and perception might be skewed.

Finding relevant literature on 'language and perception' doesn't take long, with Google Scholar retrieving almost three million articles. But what proportion of these papers discuss senses other than the dominant vision? I expect very few. 'Perception' is often conflated with 'vision'. Even in the first pages of the influential book *Language and Perception*, the authors, George Miller and

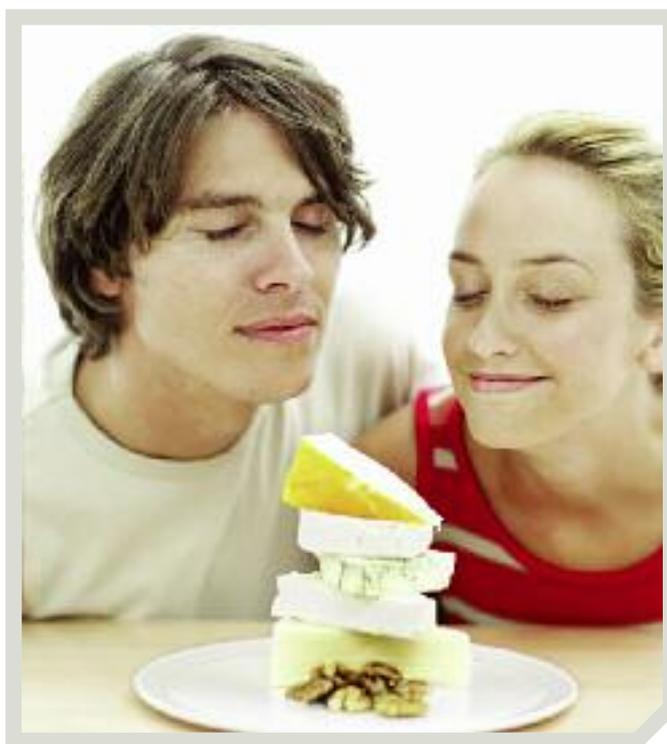
Philip Johnson-Laird (1976), make the slip of referring to perception as 'what is seen'. Of course, vision is our most reliable sense for orienting in the world, providing fine-grained spatial information. Similarly, audition is extremely important for temporal

information. Further, both perceptual modalities are integral to communication – speaking, listening, reading and writing – making their salience in the conception of 'perception' obvious. However, we don't experience the world in only the visual and auditory modalities, so understanding how we perceive, conceptualise and talk about the other senses is important. Any differences to vision and audition could reveal interesting facts about human cognition. Here I focus on the olfactory modality, which could be considered most distinct from the dominant senses for a number of reasons, as we shall see.

## Talking about odours

We find it pretty easy to describe a painting to someone, the outfit your colleague wore yesterday or your new favourite song. It would appear that our language system works very effectively with our perceptual systems. Early psycholinguists proposed that knowledge acquired through vision and knowledge acquired through linguistic input were represented similarly, making talking about vision easy. Consistent with this idea, spatial representations acquired from vision and spatial representations acquired from language have been shown to be comparable. Avraamides et al. (2004) had participants learn spatial layouts through visual perception or spatial descriptions and later make direction and distance judgements about the spatial representations. Results showed that participants performed similarly in both visual and linguistic conditions.

Evidence for the strong link between language and



Odour perceptions and judgements can easily be shaped by verbal labels and visual information

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vision has also been demonstrated using eye tracking and what is known as the 'visual-world paradigm'. Here, eye movements around visual scenes are closely time-locked to linguistic input, and fixations to objects in a scene can provide a fine-grained measure of lexical access (Allopenna et al., 1998). For example, upon hearing a sentence such as 'Pick up the beaker...' eye movements towards a visually present beaker, and to a phonological competitor beetle, begin to increase from the onset of 'beaker' showing that both 'beaker' and 'beetle' are lexically retrieved.

For odours however, the connection between language and perception is much weaker. In Western societies people seldom talk about odours. But when they do, they are often incorrect in their descriptions. People can correctly name an odour (in terms of the source object of the odour) only around 50 per cent of the time (e.g. Cain, 1979), even common everyday odours like coffee and peanut butter. This deficiency in naming is quite shocking when compared with the ease of naming visual objects. Imagine only being able to name half of the colours of the rainbow! Naming odours becomes much easier when a list of label alternatives is given (de Wijk & Cain, 1994). Research suggests that words with strong olfactory associations (such as cinnamon) can activate primary olfactory cortex (Gonzalez et al., 2006), implying that an odour word could provide an olfactory template to which the odour can be matched. It seems possible then that the weak link between odour and language is unidirectional: we find it difficult to retrieve words when given an odour, but words are reliable cues for odour information.

Talking about what we see, we have at our disposal 'a stable world of objects, regions, motions, distances, gradients, directions, events' (Miller & Johnson-Laird, 1976), but on what dimensions do we conceptualise our olfactory world? What are the contents of our subjective perceptual experiences of odour?

Compared to vision, olfaction is more 'ineffable' (Levinson & Majid, 2014) – olfactory experiences are more difficult to put into words. In English, and other languages spoken in the West, there are very few words that exist to talk only about odours. We can say something is 'stinky' or 'fragrant', but it's hard to find specific odour words that give you any more information about an odour other than its pleasantness. This is of course important, and it is thought that pleasantness is the main dimension by which odours are perceived (Yeshurun & Sobel, 2010), but it really limits the number of ways in which we can talk about odours. Many people instead resort to talking about the odour source, for example 'it smells like banana', 'it smells fruity', which consequently activates other conceptual associations with that object, like shape and colour. It seems then that in language, odours rarely enjoy the spotlight alone.

### Perceiving and judging odours

It has been suggested that because of the limitations in thinking and talking about odours, odour perceptions and judgements can easily be shaped by verbal labels and visual information. Herz (2003) argues that olfaction should be influenced by language more than other perceptual modalities are because we cannot see odours, we cannot easily spatially locate them, nor can we easily identify them. So, instead we search for any other information in the environment (such as language) to inform odour perception. Giving an odour a name (de Wijk & Cain, 1994) has been shown to aid in odour discrimination (determining

whether two odours are the same or different). Language can also change the perceptual interpretation of an odour. Simply labelling the same odour as 'cheese' versus 'body odour' can lead to differences in pleasantness judgements (de Araujo et al., 2005). Similarly, Zellner et al. (2008) found explicitly labelling unisex fragrances as male (or female) made participants perceive the fragrance as more masculine (or feminine). These effects have been described as 'olfactory illusions' (Herz, 2003).

How does this compare with the effect of language on vision? A wealth of research has provided evidence that language can affect visual perception. For

## Meet the author

'For many years I have been fascinated in "embodied cognition", specifically how the body and the senses can be involved in language understanding. Research assessing the relationship between language and vision in this area has been abundant, and includes exciting findings about how language can affect visual perception and vice versa. But the area of language and olfaction has been relatively ignored. Yet odour is a powerful and emotional sense. The single sniff of a fragrance can transport you to a distant but vivid memory. A smell can be enough for you to decide to stay or leave a room, eat a meal or not, or whether or not to go on a second date. Because of the strength of odours, and the ways in which olfaction differs from the dominant senses, a theory of language and perception without olfaction is incomplete. My journey with olfaction has been extremely exciting so far, challenging my previous views and informing me about the capabilities of language and perception.'



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example, we are faster to discriminate between colours or shapes when they have different names. Gilbert et al. (2006) found that discriminating a colour target from distractors was easier when the distractors had a different colour name (e.g. blue target with green distractors) than when they were the same (e.g. green target with green distractors), even though the colour distance between target and distractor was fixed (i.e. the two conditions were perceptually matched). Similarly, Lupyan and Spivey (2008) found that visual search for a target among distractors was easier when the objects were labelled as '2s' and '5s', compared to having no verbal labels.

Thus language appears able to facilitate visual processing. But can language actually change the perceived identity of a visual object as it can for odours? We all know the visual illusion Rubin's vase, in which at one moment two faces are visually perceived, the next moment a vase. In this illusion we can control which interpretation we see by thinking of each particular concept. There are also more recent demonstrations of 'changing what we see', such as Lupyan and Ward (2013), who showed that language can bring object perception into conscious awareness. Participants' visual awareness of familiar objects was suppressed by using a method called continuous flash suppression. In this method, an image of an object is presented to one eye while a visual masking pattern is sent to the other, leading to overall perception of visual noise. When a verbal label was given matching the 'suppressed' object, participants were more likely to detect the object (Lupyan & Ward, 2013). Thus language effectively changed the perception of visual noise to the perception of an object.

Although, on the surface, effects of language on visual perception and effects of language on odour perception appear comparable, there are differences. In the odour studies described above (e.g. Zellner et al., 2008), the odours used



It could be argued that odours themselves are generally more ambiguous at the outset

were not perceptually manipulated, but presented in their standard form. For vision however, the effect of a label on visual identity occurs specifically when the visual object was designed to be ambiguous or distorted – language affects visual interpretation when perception is most difficult. The threshold for an effect of language on perception therefore may be lower for olfaction. However, it could be argued that odours themselves are generally more ambiguous at the outset.

### Odour and the brain

The visual cortex has been extensively mapped, with more than a dozen putative

visual areas identified with brain imaging (e.g. Tootell et al., 1996). Many visual areas are mapped retinotopically, with cortical organisation reflecting real-world spatial information. Moving from the primary visual cortex V1 up to visual motion processing MT, visual areas have been characterised with specific functions that determine features of visual input at various grains of information, gradually increasing in complexity (see Grill-Spector & Malach (2004) for a review).

The currently known facts about the olfactory cortex are less enlightening. There is indication that the primary olfactory cortex has subregions responding differentially to odour

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hedonics (i.e. pleasant versus unpleasant odours) (Zald & Pardo, 1997) and that different regions process odour quality (identity) versus odour structure (Gottfried et al., 2006), but the organisation of the olfactory cortex has not been mapped in a topographical manner comparable to vision. In fact, it has been suggested that odours may be processed holistically rather than by individual components (Engen & Ross, 1973). Mapping the organisation of the primary olfactory cortex becomes more problematic because structurally related odours may smell different but structurally distinct odours may smell similar (Cain & Polak, 1992). This suggests that the relationship between odour sensation and odour perception is unpredictable (Gottfried et al., 2006).

There are further characteristics that differentiate olfactory perception and language from vision. First, the location of the olfactory cortex is significant. The olfactory cortex is located very close to the limbic system, being well connected with emotion and memory systems (Soudry et al., 2011). This proximity to emotion and memory can lead individuals to have strong emotional reactions to odours (e.g. Weber & Heuberger, 2008), and odours can be powerful triggers of autobiographical memories (e.g. Chu & Downes, 2002), with memories more emotional (Arshamian et al., 2013) than autobiographical memories cued by other modalities. Whereas visual objects are easily

integrated with semantic information, information integral to word meaning (Olofsson & Gottfried, 2015), odour objects are instead endowed with emotion and memories.

Another important fact about the organisation of the olfactory system concerns its connections with the brain's language system. Odour and language are said to be 'poorly connected' (Olofsson & Gottfried, 2015). At a neural level, the olfactory cortex is more 'directly' connected with language regions of the brain: the integration of linguistic and olfactory information occurs at only the third synapse from the receptor neuron. But this means that, in comparison to visual information that has been processed at multiple cortical and subcortical levels, odour information is less processed and more coarse by the time it reaches linguistic information (Olofsson & Gottfried, 2015). It is therefore much less elaborated than visual information, which subsequently makes word finding more difficult. Since olfactory information is received at a coarse grain, it is more likely that broad categories are activated for naming (e.g. fruit) rather than a specific odour quality or source term (e.g. lemon).

### Odour across cultures

Recent work has highlighted the importance of cross-cultural investigations of the language–perception relationship (Majid, 2015). The discrepancy between visual language and perception and olfactory language and perception may be just a Western problem.

In the West, smell is neglected. We rarely talk about odours and go to great lengths to try to eliminate odours from our environment. San

Roque et al. (2015) found that across 13 different languages and cultures, vision verbs were most dominant in talking about the senses but smell verbs were least frequent in all but one language. Yet in some non-Western cultures in the world, talking about smell is common, and the languages of such cultures actually provide sufficient means to talk about smells accurately. Speakers of Jahai in the Malay Peninsula, for example, are just as good talking about smells as they are talking about colours (Majid & Burenhult, 2014). In a free-naming task, Jahai speakers could name odours just as easily as colours. In contrast English speakers had difficulty naming odours but not colours (Majid & Burenhult, 2014). The Jahai language

contains a number of specific abstract smell terms, comparable to colour terms (e.g. red, blue) in that they don't refer to specific odour sources (e.g. lemon, cinnamon) but abstract across a number of odours (see also Wnuk and Majid, 2014, for similar findings in the Maniq language). The term *ɲɛs*, for example, is used for odours with a 'stinging' smell, such as petrol, smoke and bat droppings. Thus, speakers of the language are better equipped to talk about smell than speakers of Western languages, who have few terms to specifically describe an odour. For people in the Jahai culture, odour is an integral part of their daily lives, featuring in their cultural practices and ideals. This raises the question to what extent experience and cultural practices can affect language and perception. In line with this, evidence from experts (e.g. vinologists) suggests that odour naming can be shaped with relevant experience (Croijmans & Majid, 2016).

### Why study olfaction?

So what can olfaction tell us about language and perception overall? Since olfaction is a less dominant modality in everyday interactions, it can reveal how language and perceptual processes differ for a more neglected modality. Is the frequency of use and utility of olfaction and vision reflected in the way these modalities are talked about and their vulnerability to linguistic influence? Perhaps olfactory language and perception is merely 'good enough' for what olfaction is needed for. By integrating findings from the olfactory domain into theories of language and perception we can reveal overall mechanisms. Further, predictions can be made between language–perception effects and depth of cortical analysis – vision may be more easily talked about and more resilient to linguistic influence because it is processed at a more fine-grained featural level. Cortical and subcortical connections may also play significant roles in language and perception, with odours more amenable to memories or emotional information, and vision instead to semantic associations. Finally, looking at cross-linguistic differences and differences in cultural practices can further elucidate the experiential factors that can shape olfactory and visual cognition. Overall, finding similarities and differences across perceptual modalities can 'tell us something fundamental about constraints on how consciousness and reasoning can patrol our inner lives' (Levinson & Majid, 2014).

"Jahai speakers could name odours just as easily as colours"

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