Senses special: Doors of perception

- 29 January 2005 by **Bruce Durie**
- Magazine issue 2484. **Subscribe** and get 4 free issues.

TRY something for me, will you? Close your eyes. Now stretch out your arms. How do you know where they are? Now wiggle your fingers. How do you know they are moving? Now do it all again, standing on one leg (eyes still closed, remember). Did you fall over, and if so, did it hurt?

It won't come as any surprise that you have your senses to thank for managing this feat at all. But which ones? It certainly wasn't sight, sound, taste, smell or touch.

While schools still teach us that there are five senses - an idea that came courtesy of Aristotle and permeates popular culture - the count is at odds with science. Try grabbing an ice cube with one hand and a red-hot poker with the other, and tell me that what you feel can be encompassed by the favourite five. Go on a white-knuckle ride at any theme park and convince me that everything you experienced was down to sight, sound and touch. You probably had your eyes closed anyway. There is clearly more to sensation than these five categories. So how many senses do we have?

In some ways the answer depends on how we divide our sensory systems up. For example, we could classify senses by the nature of the stimulus. In this sense (as it were) there are just three types, not five - chemical (sensed as tastes, smells or "internally", as with blood glucose), mechanical (touch and hearing) and light (vision). Some animals also have electroreception or a magnetic sense. All these groups of sensation require quite different sensory systems. Something dissolving on the tongue and producing an odour which permeates up into the nose and fits into a receptor is quite different from the mechanical movement of a hair cell in the inner ear, or a photon hitting the retina.

But we could as easily subdivide these further, and define a "sense" as a system consisting of a specialised cell type responding to a specific signal and reporting to a particular part of the brain. For instance, taste could be seen not as one sense but five - sweet, salt, sour, bitter and "umami", a Japanese word for the taste of glutamate, which gives us our sense of meaty flavours. Vision could be viewed as one sense (light), two (light and colour) or four (light, red, green and blue). In some animals there are retinal cells which respond only to movement. Some people might consider that to be yet another sense. Neurologists classify pain as cutaneous, somatic or visceral depending on where it is felt - but does this mean they are different sensory systems or are they simply a matter of geography on and in the body?

Many people would agree that they can sense temperature, pressure, touch, joint position (proprioception), body movement (kinaesthesis), balance and feelings associated with a full bladder, an empty stomach or thirst. But there are other monitoring systems in the body that

we can never be even dimly "aware of" - sensing the pH of the cerebrospinal fluid would be an example.

And take hearing. Is this one sense, or many hundreds, one per cochlear hair cell? That is probably taking things a bit too far, but it is interesting to note that we can lose high-frequency hearing without losing low-frequency acuity, and vice versa. So maybe they should be thought of separately. The more we study the structure of our sense organs, the more senses we appear to have.

But, intriguing as all this is, sensation alone isn't really all that important. When we talk of senses, what we really mean are feelings or perceptions. Otherwise we'd be operating not much above the level of an amoeba or a plant. The majority of the natural world gets by with just one or two senses - typically light and touch. A plant that grows to follow the apparent motion of the sun or the Venus fly-trap closing over an insect is merely reacting mechanically to a stimulus.

Vision could be viewed as one sense, or four, or more. The more we study our sense organs, the more senses we appear to have

We, on the other hand, see light and shade but perceive objects, spaces and people, and their positions. We hear sounds, but we perceive voices or music or approaching traffic. We taste and smell a complex mixture of chemical signals, but we perceive the mix as ice cream or an orange or a steak. Perception is the "added value" that the organised brain gives to raw sensory data. Perception goes way beyond the palette of sensations and involves memory, early experiences and higher-level processing.

What you hear, for example, is not just a simple sum of the sounds collected by each ear, but a bigger picture. Various processes come into play, some of which allow the brain to tell the direction of the noise. Even more complex processes enable us to screen out one sound when attending to another. In the well-known "cocktail party phenomenon", for example, we ignore all extraneous sounds while taking part in a conversation, but can quickly switch focus if someone else mentions our name. The implication is that we were always "listening" to ambient sound but not always "hearing" it, except when it suddenly becomes meaningful. Our perception goes far beyond the bare sensation.

Higher animals only have to solve one general survival problem in life when encountering an object - should I eat it, run away from it or mate with it? In making this decision they get ample help from everything they gather from this new experience and previous similar ones. But more primitive animals, with more limited neural equipment, get easily fooled by brightly coloured flowers, or adversaries who can suddenly swell in size, have markings that look like eyes or smell of something unrelated, not to mention all the other tricks evolution has learned to play. A highly perceptive animal is not so much at the mercy of its primitive senses.

The bottom line is that we make a mistake in concentrating on senses, and even in arguing about how many there are. Perception is what matters, and sensation is what accompanies it.

For humans there are other everyday implications of all this. One is in our judgement of size. Consistency in our world view stems from the fact that objects do not usually change size over short periods of time. So for an object that we are familiar with, like a car, the larger it appears, the closer to us we perceive it to be. Though the image we sense is small, we "know" the object is big. But we can make mistakes. Clouds can be any shape and size, so their distance is hard to judge. Trains are familiar but most of us don't realise just how big they are, and so we misjudge their speed and how far away they are, which leads to around 3000 accidents annually in the US alone. We don't solve these problems by internally agonising over which senses are involved or how many senses, but by making a perceptual whole out of it. That is a higher brain function.

Take the strange case of synaesthesia, a mixing of the senses. The most commonly reported forms are experiencing sounds, letters, numbers or words as colours. Synaesthesia is highly developed in some individuals, who were until quite recently dismissed as raving fantasists and sometimes even misdiagnosed as schizophrenic. They may speak of an aroma's texture or the taste of different letters of the alphabet. It may be possible to "hear" the taste of a peach or "feel" a colour. What this tells us is that the senses are less than primary, and that perception is what we really get.

Quite possibly, the brain is set up to do exactly this sort of "sense-mixing" as part of the road to perception. There is growing evidence that crosstalk in the brain between different sensory areas mixes up things more than we might imagine. We may spot or recognise objects more easily if we hear a relevant sound at the same time. We may even believe we've heard something different if we are fooled into lip-reading something at odds with what is spoken. Ask any migraine sufferer about how a scent can trigger pain. Possibly we all have this facility to a greater or lesser extent, which is why minor chords are "sad" and blues music is "blue" (an interesting use of language in this context) and food can taste "sharp".

Of course, none of this is helped by confusion of nomenclature. Some things commonly labelled a "sense" are no such thing - a sense of loss, having a "sixth sense" - but perhaps the circadian rhythm system should be included. Or is that part of perception rather than a sense? The table on this page tries to bring together the cellular and other definitions of senses into some sort of framework. Doubtless it is flawed, and partial, and open to debate. If anything, it is incomplete. Though in the end, it may not matter at all.

And so, there are at least 21 senses and possibly more. But they could be a distraction. Would we do ourselves a favour by forgetting them, and concentrating on perceptions? As usual, science is fated to challenge everyday beliefs and appear counter-intuitive. We are acutely aware of our vision, smell, touch, so to say they don't matter initially seems daft. But senses may one day be consigned to the scientific dustbin, along with spontaneous generation, phlogiston and instantaneous events. It's just common sense, really.

Bruce Durie is a science writer based in Scotland at the University of Strathclyde in Glasgow

MAKING SENSE OF THE SENSES

There are many opinions about how many senses we have

SENSORY MODALITY	Conservative	Accepted	Radical
Vision	■		
Light		■	■
Colour		■	
Red			■
Green			■
Blue			■
Hearing	■	■	■
Smell	■	■	
2000 or more receptor types			■
Taste	■		
Sweet		■	■
Salt		■	■
Sour		■	■
Bitter		■	■
Umami			■
Touch	■	■	
Light touch			■
Pressure			■
Pain	■	■	
Cutaneous			■
Somatic			■
Visceral			■
Mechanoreception	■		
Balance	■	■	
Rotational acceleration			■
Linear acceleration			■
Proprioception – joint position		■	■
Kinaesthesis		■	
Muscle stretch – Golgi tendon organs			■
Muscle stretch – muscle spindles			■
Temperature	■		
Heat		■	■
Cold		■	■
Interoceptors			
Blood pressure	■	■	
Arterial blood pressure			■
Central venous blood pressure			■
Head blood temperature			■
Blood oxygen content		■	■
Cerebrospinal fluid pH		■	■
Plasma osmotic pressure (thirst?)		■	■
Artery-vein blood glucose difference (hunger?)		■	■
Lung inflation		■	■
Bladder stretch			■
Full stomach			■
TOTAL	10	21	33