Is There a Normal Phase of Synaesthesia in Development? <1>

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ABSTRACT: Synaesthesia (one sense triggering another) has recently become amenable to scientific investigation. Recent findings are reviewed. Maurer's developmental theory of synaesthesia is then discussed. The theory states that all human neonates have synaesthesia, but that by about 4 months of age the senses have become modularized to the extent that we no longer have synaesthesia. Possible ways of testing this important theory are described, and the distinction between this account and cross-modal matching (Meltzoff) is clarified.

1. Introduction

Synaesthesia, the mixing of two (or more) senses, is reviewed by both Harrison and Cytowic (this issue). For an adult, it is clearly unusual to experience a sensation in one modality triggered purely by a sensation in another. For example, to see a colour every time you hear a sound. Our research group have become convinced that such unusual cases are genuine, and it is several lines of evidence that have persuaded us: (1) the impressive test-retest reliability in the consistency of colours triggered by different words (in the case of "coloured hearing"); the similarity of reports from different cultures and different times across the century; the sex ratio (it is overwhelmingly a female condition); the familial pattern to the condition; and the neuroimaging data (using PET) showing different cortical blood flow patterns in women with synaesthesia in comparison to women without the condition. These findings are reported elsewhere (Baron-Cohen, Wyke, and Binnie, 1987; Baron-Cohen, Harrison, Goldstein, & Wyke, 1993; Paulesu, Harrison, Baron-Cohen, Frith, Frakowiac, & Goldstein, 1995).

The question addressed in this article is whether synaesthesia is unusual only in adulthood. Could it be the case that such cases of adult synaesthesia represent a failure to develop beyond a normal phase of infancy, in terms of the differentiation of the perceptual system? On the face of it, such a proposal seems hard to credit: that all babies might be synaesthetic at some point in their lives. Yet this is precisely the proposal formulated by Maurer (1993), and I think we have to take it seriously. In this article, I briefly summarize and evaluate the evidence for this radical proposal, and end by suggesting some lines of research for the future, to help answer this interesting question.

2. The Neonatal Synaesthesia Hypothesis

To understand the Neonatal Synaesthesia (NS) hypothesis, it is important to distinguish it from a close (but less radical) relation, the Cross-Modal Transfer (CMT) hypothesis. Here is the nub of it. The NS hypothesis argues that early in infancy, probably up to about 4 months of age, all babies experience sensory input in an undifferentiated way. Sounds trigger both auditory and visual and tactile experiences. A truly psychedelic state, and all natural - no illegal substances play a role. In contrast, the CMT hypothesis argues that objects can be recognized in more than one modality, as a result of infants being able to represent objects in an abstract form (Meltzoff & Borton, 1979). This implies, for example, that babies can recognize one object versus another from their appearance, even if they have previously only touched them without seeing them.

There is considerable evidence for the CMT hypothesis. For example, Rose, Gottfried, and Bridger (1978) found that 12 month olds look longer at an object they had just explored orally. Meltzoff and Borton (1979) found a similar result for 1 month olds. Lewkowicz and Turkewitz (1980) found that 1 month olds show least heart rate change when a patch of white light is followed by a burst of white noise at an intensity that adults rate as 'matched in intensity', but they showed significant heart rate change when the light was followed by a sound of very high or very low intensity. This suggests infants match intensity of stimulation between vision and hearing, and "respond to changes in the intensity of stimulation impinging anywhere on the nervous system" (Maurer, 1993, p. 109; this is also the authors' interpretation) .

In sum, whilst the CMT hypothesis was radical when it was first proposed, it is now widely accepted. It refutes Piaget's (1952) idea that the different sensory systems are independent at birth and only gradually become integrated with one another. Instead, it offers some support for the view proposed by E. Gibson (1969), Bower (1974), and Werner (1973) that detection of intersensory equivalence is present from birth, and that perceptual development is characterized by gradual differentiation. (These theories are reviewed in Lewkowicz, 1992). In contrast to the consensus surrounding the CMT hypothesis, the NS hypothesis is very new and controversial. It builds on the CMT evidence, but suggests that this results in a sensory confusion for the infant. It suggests there is a plausible anatomical basis for neonatal synaesthesia, if one looks at the transient connections between neural structures in neonates of other species. Thus, the neonatal hamster has transient connections between the retina and the main

somatosensory and auditory nuclei of the thalamus, and the kitten has similar transient connections between visual, auditory, somatosensory, and motor cortex (e.g., Dehay, Bullier, and Kennedy, 1984; and reviewed by Maurer, 1993). Maurer suggests the same could be true of human neonates. Some evidence suggests this may be true:

"During early infancy - and only during early infancy - ... evoked responses to spoken language (are recorded) not just over the temporal cortex, where one would expect to find them, but over the occipital cortex as well. There are similar reports of wide-spread cortical responses to visual stimuli during the first 2 months of life (e.g., Hoffman, 1978). Results such as these suggest that primary sensory cortex is not so specialized in the young infant as in the adult" (ibid, p. 111).

These data are provocative and certainly consistent with the NS hypothesis. However, currently we must conclude with a verdict of "not-proven" until more evidence has been collected. But what would count as relevant evidence with which to prove the hypothesis? Here, I suggest one critical test, in the hope that when this is done, this will help move the field forward.

3. A Thought Experiment

If newborn babies, when assessed using functional neuroimaging techniques, show blood flow changes across both visual and auditory cortex when presented with pure auditory tones, and if after a critical point in development (say, 4 months old) a different (adult-like) pattern is seen, such that pure auditory tones activate auditory cortex alone, this would be strong evidence for neonatal synaesthesia. Furthermore, if premature infants showed the same shift in terms of the pattern of blood flow during scanning, relative to their age from conception (rather than their age from birth), this would be strong convergent evidence for a critical phase in development when synaesthesia is normal.

The notion would be that following an early initial phase of normal synaesthesia, the different sensory modalities become increasing modular (Fodor, 1983), presumably because modularity leads to more rapid and efficient information processing, and is therefore highly adaptive.

Adult synaesthesia, as we suggested earlier (Baron-Cohen et al, 1993) might therefore represent a breakdown in the process of modularization, such that during infancy the modularization process was not completed. Current functional neuroimaging methods (PET, SPECT) mostly entail radiation, which makes them ethically unsuitable for such infancy research, but the new development of functional MRI makes this thought experiment a real possibility in the medium-term future.

4. Coloured Hearing, Literacy, and Neonatal Synaesthesia

One possibility is that coloured hearing - and particularly coloured speech perception - is simply the consequence of coloured visual imagery of the orthography of words. As it turns out, many synaesthetes with coloured speech perception do indeed report that words with the same initial sound but different initial letter (like fish and photo) trigger different colours, whilst words with a different initial sound but the same initial letter (like psychology and photo) trigger the same colour (Baron-Cohen et al, 1993). This looks strongly like letters rather than sounds are determining the colours triggered. In our earlier terminology we called this chromatic-graphemic (CG) synaesthesia.

However, when one asks such subjects "Are the colours of words always determined by an initial or dominant letter?", the answer for some of these subjects is "No". That is, they readily report that in other cases the colour is triggered by phonemic features of the word (so that sex and psychology have the same colour); and in other instances, there is no connection between the word and its colour at all (e.g., Jane and July, despite sharing both the initial sound and letter, trigger different colours). This is true, for example of our subject Rose Young (henceforth RY), who was one of the subjects tested in the Baron-Cohen et al (1993) and Paulesu et al (1995) studies. Her case was featured in the BBC2 Horizon documentary "Orange sherbet kisses" (12th December 1994). It is also true of Elizabeth Pulford (henceforth EP), who was described in the Baron-Cohen et al (1987) study. Her case was featured in the BBC Tomorrow's World documentary (June, 1994). This tells us that some individuals with synaesthesia can be simultaneously chromatic-graphemic (CG) and chromatic-phonemic (CP) and chromatic-lexical (CL) synaesthetes. This should not come as any surprise, since word-processing occurs at several levels, and presumably colours can be triggered by any of these levels. However, it does mean that synaesthesia is not likely to be simply a product of literacy, and therefore an acquired phenomenon at the age of 4 or 5 years old; rather it is likely to be a product of connections between speech perception and colour vision, and therefore in principle present at birth (Eimas, et al, 1977).

5. Dysmodularity and Maladaptiveness

As mentioned earlier, one way of viewing synaesthesia is in terms of a breakdown in modularity (Baron-Cohen et al, 1993). If this view is correct, it forces us to ask why in the normal case the senses would be modular. If synaesthesia is genetic, and if normal modularization of the senses is under similar genetic control, then we have to approach this question by thinking about natural selection and adaptation. In an evolutionary framework, one must assume that modularity of the senses makes for adaptive neural and psychological functioning. This does not seem to be an unreasonable assumption: recall Fodor's (1983) argument is in terms of modularity producing rapid, automatic, efficient processing, in an informationally encapsulated way. But this should also mean that there was some cost to the reproductive fitness of individuals whose senses were 'dysmodular': one sense leaking into another. Curiously enough, most individuals with coloured hearing synaesthesia do not complain of their condition. For them, it is their normal perception of the world, and they are not aware of it causing an disadvantages or interference. This is true both of RY and EP, who have coloured hearing (sounds triggering colours, but not

vice-versa). This leads to the paradoxical conclusion that dysmodularity is not maladaptive. This is paradoxical because it is by no means obvious why modularity should have evolved if dysmodularity is just as good.

We have however recently solved this riddle, by studying a different type of synaesthesia: Julie Roxburgh (herewith subject JR) not only sees colours when she hears sounds, but suffers from the reverse: she hears sounds whenever she sees colours. Here, the word "suffers" is used advisedly, as this form of synaesthesia leads to massive interference, stress, dizziness, a feeling of information overload, and a need to avoid those situations that are either too noisy or too colourful. We have studied JR in detail, and can confirm the genuineness of her synaesthesia in terms of its consistency over time. JR's case was also featured in the BBC2 Horizon documentary mentioned earlier. Here then, we have a clear case of synaesthesia leading to social withdrawal, and interference with ordinary life.

From this single case, we can advance the following tentative conclusion. Some forms of synaesthesia (but not all) are clearly maladaptive, and this is in line with the evolutionary arguments outlined earlier, in which natural selection favoured individuals whose senses were modular. Evolutionary arguments are frequently criticized for being "Just So" stories, but in this instance the evolutionary approach led to a prediction (that there should be cases of synaesthesia which are maladaptive). JR is just one case that supports this prediction. It remains for future studies to test this prediction in relation to other types of synaesthesia.

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Notes

<1> Due to an editorial error an earlier draft of this article was uploaded to the PSYCHE www site in March 1996. As soon as this error was detected it was removed and replaced with the current version. All citations should refer to the article in its current form and not to its earlier incarnation.

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