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Commentary

Synthetic synaesthesia and sensory substitution ☆

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ABSTRACT

Visual information can be provided to blind users through sensory substitution devices that convert images into sound. Through extensive use to develop expertise, some blind users have reported visual experiences when using such a device. These blind expert users have also reported visual phenomenology to other sounds even when not using the device. The blind users acquired synthetic synaesthesia, with visual experience evoked by sounds only after gaining such expertise. Sensorimotor learning may facilitate and perhaps even be required to develop expertise in the use of multimodal information. Furthermore, other areas where expertise is acquired in dividing attention amongst cross-modal information or integrating such information might also give rise to synthetic synaesthesia.

Vision appears to be a simple experience: one simply opens one's eyes and quickly identifies what is where. The rapidity and seeming ease of the act of seeing belies the computational challenge of recognizing and localizing objects in a cluttered world. One reason for this deception is that adult sighted humans are experts at vision. Although the world might be a "blooming, buzzing confusion" to a human infant (James, 1950/1890, p. 488), the visual skills necessary to provide such immediate perception in adulthood is discovered rapidly during development (for reviews, see Colombo (2001) and Quinn and Bhatt (2009)).

Consider a case of somehow providing vision to a blind person. The visual world might indeed be confusing until a certain degree of expertise is acquired. For example, when a patient, MM, received a successful corneal transplant, he reported closing his eyes while skiing early on (he was already an avid skier) and keeping his eyes open only after experiencing vision for 2 years (Fine et al., 2003). Vision can be acquired in blind persons by other means as well. For example, sensory substitution devices for the blind provide the missing visual input by providing information that another sensory modality, such as the tactile or auditory system, can process (e.g., Bach-y-Rita & Kercel, 2003).

In a recent article, Ward and Meijer (2010) examined the visual experiences of blind, expert users of a sensory substitution system called The vOICe (Meijer, 2010). The vOICe converts images into sounds, and previous research has found that users of the device can localize and identify objects on the basis of the sound output (e.g., Auvray, Hanneton, & O'Regan, 2007; Proulx, Stoerig, Ludowig, & Knoll, 2008). Although previous studies have described the experience of the participants in visual terms (e.g., Bach-y-Rita, Collins, Saunders, White, & Scadden, 1969), Block (2003) questioned whether this was truly a case of visual perception in the blind, and argued in favor of spatial perception instead.

The most tractable definition of vision might focus on its function, of which spatial perception is one part. As famously noted by Marr, the simple idea of vision is to know what is where (Marr, 1982). Ward and Meijer (2010) made a clear case that the experience of the two expert users of The vOICe went beyond simple spatial processing (information about 'where') in that feature information was experienced in a phenomenological manner by the users and contributes to their process of

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object identification (information about 'what'). For example, Ward and Meijer report the perception of contrast by the two users, and the suggestion of texture in identifying objects such as faces supports the notion that visual, rather than solely spatial, perception is experienced. Thus, sensory substitution provides a fascinating opportunity to study the phenomenology of vision in the absence of purely visual input (Ward & Meijer, 2010). Further tests of other visual features would provide an excellent test of their claim that this truly is a visual, rather than spatial, experience.

The impact of expertise on acquired synaesthesia can also be studied experimentally with sensory substitution. Synaesthesia is the condition where sensory stimulation of one sort elicits not only the expected sensation but an additional sensation in the same or another sensory modality (Ward & Mattingley, 2006). Acquired or synthetic synaesthesia (Proulx & Stoerig, 2006) would arise in sensory substitution when one's expertise has advanced enough for immediate (and perhaps involuntary) perception to occur in vision after auditory or tactile stimulation. Ward and Meijer (2010) reported instances of such experiences occurring in the users not only when using the device, but even in response to other sounds within the range of what might be produced by the device, even when the device is not worn. For example, one user reported visual experience when hearing some music, and was able to report visual experiences evoked by tones played by the experimenters. This provides a provoking hypothesis for research in other realms of expertise.

Might synthetic synaesthesia serve as a marker of cross-modal expertise? Although synthetic synaesthesia has been described as a goal to provide veridical, phenomenological sight to blind persons via visual qualia induced by sensory substitution (Proulx & Stoerig, 2006), perhaps the concept could be extended. Many forms of expertise depend on cross-modal contingencies. Visual to auditory sensory substitution, in devices like The vOICe, provides an abstract contingency learning system as a function of the conversion of images into sound. This provides a controlled study of the acquisition of cross-modal expertise, with synthetic synaesthesia and its automaticity as outputs of such expertise. However, this can be extended to applied expertise as well. For example, expert operators, such as airline pilots, must learn to integrate multisensory information from visual, auditory, and tactile perception. As one trains to become a pilot, are automatic associations created between the senses? Certainly automaticity arises as one learns to associate auditory signals with visual cues and the feedback pressure of the control yoke, and this automaticity is in part a synthetic form of synaesthesia (cf., Marks, 1987). Whether the acquisition of multisensory expertise, such as would be expected in pilots, results in similar synthetic synaesthesia experiences as those blind user experts described by Ward and Meijer (2010) would be a fascinating course of research into the cross-modal nature of perceptual experience.

The demands of dividing attention amongst the different senses must be lessened as expertise is acquired; certainly this would be a requirement to make sensory substitution useful (Proulx & Harder, 2008). Recasting Marr's definition of vision might provide one way to resolve theoretically the challenge of learning to integrate multisensory information. Rather than knowing what and where, perhaps the real content of vision is what and how (cf. Goodale & Milner, 1992). Goodale and Milner emphasized the importance of perception for action rather than for spatial information because much of our perceptual learning to resolve, and perhaps even integrate, the "blooming, buzzing confusion" that James described comes about through sensorimotor learning. This results in a reclassification of Block's (2003) critique of visual awareness in sensory substitution. Block questioned whether sensory substitution users have spatial perception rather than visual perception. In light of Goodale and Milner's hypothesized division of the visual system into what and how processing, it might be worth considering whether the users have acquired action perception. If the users indeed developed action perception rather than spatial perception, then sensorimotor accounts of visual experience would also predict that acquiring expertise with sensorimotor contingencies would result in a qualitative change in visual consciousness (see, e.g., Auvray, Hanneton, & O'Regan, 2007; O'Regan and Noë, 2001).

In summary, the study by Ward and Meijer (2010) provides convincing evidence of visual experience in expert blind users of a sensory substitution device. Further studies examining the perception of non-spatial features would provide important tests of their claims. In addition, Ward and Meijer also report that the expert blind users of The vOICe acquired synthetic synaesthesia, with an experience of the cross-modal auditory evoked visual experience even when not wearing the device. Other areas where expertise is acquired in dividing attention amongst cross-modal information might also give rise to such synthetic synaesthesia. Sensorimotor learning may facilitate and perhaps even be required to develop expertise in the use of multimodal information, and sensory substitution provides an opportunity to explore this contingency and any resultant effects on conscious experience.

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