The origins of ability and automaticity in tactile spatial perception

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Röder and colleagues, in their commentary, propose that *an ability per se* to perceive touches in external coordinates develops in infancy, whereas *automatic* coding of touch in external space continues to develop well into childhood. This account neatly resolves conflicting reports of the development of external spatial coding of touch (Bremner et al., 2008; Pagel et al., 2009). Röder et al. argue that Pagel et al.'s tactile Temporal Order Judgment (TOJ) task, which did not show the influence of an external frame of reference (via a crossed-hands effect) in children younger than 5.5 years, tested *automatic* external coding of touch, whereas Begum Ali et al. (this volume) and Bremner et al. (2008) tested *the ability per se* to locate touch in external coordinates. Drawing on evidence from individuals with visual impairments (Röder et al., 2004), they further argue that the development of automatic external coding of touch is contingent upon early visual experience.

Röder et al.'s argument is appealing because it makes sense, in terms of perceptual (and sensorimotor) learning, for automatic external coding of touch to emerge following a period in which it is achievable but non-obligatory (see, e.g., Cleeremans & Jiménez, 2002), but it also rests on some assumptions. First, the interpretation of Pagel et al.'s (2009) study as demonstrating *automatic* coding assumes that children would adopt the more efficient somatotopic reference frame if it were not for automatic external processing intervening. Perhaps this is a reasonable supposition to make with adults but, we would argue, not with young children. Developmental psychology is replete with examples of young children (5.5-year-olds no exception) using esoteric interpretations of task demands (e.g., Donaldson, 1978).

We also question the suggestion that automatic remapping processes have *not* been shown in early development. Bremner et al. (2008) showed a crossed-hands effect in 6.5-month-old infants' manual responses to tactile stimuli, indicating a tendency to respond to

the external side of the body where a touch to their hand would normally be even when it was not there..Given that a somatotopic spatial code would lead to accurate orienting across arm postures, this tendency seems a little perverse unless there is some element of automaticity, or at least bias, towards external spatial reference. The emergence of automatic external coding of touch in infancy is also consistent with a recent and fascinating case study (Ley et al., 2013) demonstrating that visual deprivation up until 2 years of age leads to an absence, even in adulthood, of the crossed-hands effect in a tactile TOJ task similar to that reported by Pagel et al. (2009).

In sum, although we are sympathetic to Roder et al.'s proposal that the automaticity of tactile spatial remapping increases into early childhood, we feel that more research is needed to test this. One hallmark of automatic processes is immunity to secondary task demands (e.g., Poldrack et al., 2005). If crossed-hands effects in infants and/or children persist when a secondary task or a distractor is applied, then this would present stronger evidence of automaticity in these age-groups.

The newborn infant has to determine how the proximal tactile environment experienced in the womb relates to the external spatial environment newly offered up by vision. In typical development the visual aspect of tactile localization is particularly challenging for infants, who initially do not show much visual orienting to touches (Bremner et al., 2008), and also children who in some circumstances become more errorful when they can see their hands (Begum Ali et al., this volume). Studies of both behavioural development and the effects of visual deprivation indicate that interactions between vision and touch change dramatically in early life with effects lasting into adulthood. We eagerly await the next advances in our understanding of the developmental processes which underlie the ability to perceive a coherent and embodied multisensory world.

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