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The Development and Neural Basis of Face Recognition: Comment and Speculation

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In this commentary, I will focus on two critical questions that must be addressed by any constructivist or experience-expectant account of the development of face processing. These can be thought of as the 'what' and 'where' questions. The 'what' question concerns why infants' brains specialize more for faces than for other dynamic multi-modal objects in their environment. The 'where' question addresses why it is that some specific regions of cortex, such as the 'fusiform face area' (FFA), become specialized for faces and not, usually, other regions. Together, these issues result in what I have termed the 'paradox of plasticity' (Johnson *et al.*, 1998). While I agree completely with Nelson's conclusion that, overall, the available data better fit a constructivist than a nativist account of the neurodevelopment of face processing, we have to acknowledge that, from a nativist perspective, the what and where questions are answered in an attractively simple way: the brain is specialized for faces because particular genes combine to 'code' for specific neural wiring in a specific part of the brain. This specific part of the brain is assumed to be active early, and matures over the first months with, perhaps, a little fine tuning from experience.

Nelson's alternative answer to the 'what' question is simply that, in their natural early environment, babies are exposed to faces more frequently than to other objects, and so this class of visual stimuli shapes neural wiring from the earliest minutes. Specifically, Nelson criticizes evidence for a 'Conspec' (Johnson and Morton, 1991) on the grounds that (a) 'faces are far from the only stimulus that moves . . . in the periphery, and thus it is not clear why Conspec would be positively biased toward faces', (b) there is no evidence that (subcortical) visual motor pathways respond to patterned stimuli such as faces, and (c) while face preferences have been tested as early as the first half an hour of life (e.g. Johnson *et al.*, 1991), they have never been tested at the actual point of birth, leaving open the possibility of very rapid experience-driven effects. Point (a) seems to be an unfortunate misunderstanding of the notion of a Conspec. Information about the approximate spatial arrangement of high-contrast elements that compose a face is necessary for Conspec precisely because there are many non-face objects in the infant's early environment. Thus, this is an argument for, not against, a Conspec mechanism. With regard to point (b), it has recently been suggested that the pulvinar may be an important substrate for the

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Conspec mechanism. This structure has strong input from the superior colliculus, is sensitive to form (and, in the adult, colour), and has been described as particularly important for saccades toward 'high salience' stimuli (see Grieve *et al.*, 2000, for review). It is also the case that faces seem to have special status relative to other objects when adult patients with cortical damage are required to orient and detect stimuli (e.g. Vuilleumier, 2000). Turning to point (c), it is, of course, correct that a few minutes of experience may have some effect on plastic circuits. However, in other species in which early exposure can be more carefully controlled, such as domestic chicks, there is evidence for a mechanism with similar properties to Conspec present from the very first exposure to patterned light (Johnson and Horn, 1988). Thus, according to Johnson and Morton (1991), the answer to the 'what' question is that there is a primitive kick-start mechanism which is only expressed when faces are present in the early environment. This bias is sufficient to ensure that developing cortical circuits are preferentially exposed to faces. In other words, it serves to guide subsequent learning.

Turning to the 'where' question, why is it that the FFA (and one or two others) become specialized for faces and not other regions? If there is no cortical region-specific gene expression and maturation of pre-wired circuits, why do faces usually end up being processed in the FFA? As Nelson acknowledges, this question must be addressed by any alternative to the nativist account. I have recently begun developing an 'interactive specialization' framework for understanding functional brain development which attempts to address this issue (Johnson, 2000). Briefly stated, this framework brings together two phenomena associated with functional brain development in human infants: changes in specialization, and changes in localization. By *specialization*, I refer to the 'tuning properties' of regions of cortex (or other parts of the brain). For example, a region of cortex may start off being broadly tuned and responsive to a wide range of objects and faces. With experience, however, its response properties may become narrowed to faces, or even just to upright human faces. By *localization*, I refer to changes in the extent of cortical regions and pathways activated following presentation of an object or task context. The 'interactive specialization' framework brings these two phenomena together by arguing that changes in specialization (owing to experience) result in changes in localization, in that the more finely tuned to a particular type of stimulus an area becomes, the less it will be activated by the presentation of other objects or task situations. Consequently, cortical activation patterns will become more focal with experience. With regard to faces, I hypothesize that in the first months of life, multiple pathways are activated by seeing faces, but these are all, as yet, broadly tuned and underspecialized. With increasing experience, different pathways and structures become specialized for different types of stimuli and, therefore, most of them are less responsive to faces than they once were. Initial biases associated with overall patterns of connectivity (such as being on the ventral visual pathway with good interconnectivity to the hippocampus) are likely to ensure that, commonly (but not always), face processing migrates to the FFA and related regions. Whatever the validity of this account, the 'what' and the 'where' issues will have to be addressed in any future accounts of the neurodevelopment of face processing.

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