Texture segmentation and 'pop-out' in infants and children: The effect of test field size

CHRISTIANE RIETH and RUXANDRA SIRETEANU
Max-Planck-Institute for Brain Research, Department of Neurophysiology, Deutschordenstrasse 46, 60528 Frankfurt am Main, Germany

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Abstract—The ability of infants and children to segment textures based on differences in line orientation and blob size was investigated, using a forced-choice preferential looking method. In the first experiment, a stimulus pair (a homogeneous texture and a texture containing either a group of sixteen elements or a single element of an orthogonal orientation or a larger blob size) was presented on two separate test fields. Preference for the figure defined by differences in blob size was seen already in 2-month-old infants. In contrast, preference for a figure defined by differences in orientation emerged at 9-12 months of age and became adult-like around school age (see also Sireteanu and Rieth, Behavioural Brain Res., 49, 133-139, 1992). Preference for the single discrepant element was always lower than preference for the discrepant group. In the second experiment, segmentation of oriented textures presented on a single, rather than two separate surfaces was tested. A significant preference for the embedded discrepant group, but not for the single discrepant element, was seen already at 3 months of age. These results show that infants as young as 3 months of age are able to detect a boundary defined by differences in line orientation (see also Atkinson and Braddick, Behavioural Brain Res., 49, 123-131, 1992). However, this ability does not appear to lead to the 'pop-out' phenomenon, as seen in adult observers, until much later.

INTRODUCTION

In everyday life, figures are automatically and effortlessly extracted from a visual scene. The ability of the brain to complete this remarkable feat is called 'segmentation'. Segmentation may be based on the coherence of features, like luminance, colour, motion, or depth, that define a given object. Alternatively, objects may be defined by the contrast of features along their borders.

One aspect of visual segmentation that has received considerable interest in recent years is the segmentation of textures (c.f. Beck, 1966, 1982; Julesz, 1981, 1991; Julesz and Bergen, 1983). Textures consist of arrays of micropatterns, or elements, often containing a group of elements differing from the rest by a single feature. Depending on the kind of elements placed in the different regions of the array and on the relationships between these elements, a sharp discontinuity between these regions can often be perceived, while sometimes such discontinuities require careful scrutiny in order to be identified. If the group of discrepant elements can be immediately detected, its extraction is termed 'preattentive'. This group is said to 'pop out' from the rest. Elements supporting preattentive segmentation were called 'textons' (Julesz, 1981). Effortless visual search or preattentive texture segmentation were considered to be equivalent and to proceed in parallel across the visual field (but see Wolfe, 1992), as opposed to a serial, element-by-element scrutiny by the 'searchlight' of focal attention.
Similar ideas were independently put forward by Treisman and colleagues (Treisman and Gelade, 1980; Treisman and Gormican, 1988). Treisman suggested that only certain critical features (such as colour, brightness or orientation) are detected in parallel; all the other features, including the conjunctions of two critical features, must be detected in a serial search by focused attention. The catalogue of ‘features’ suggested by Treisman is similar to the list of ‘textons’ proposed by Julesz, thus suggesting that these features might function as the primitive building blocks of visual perception (for an updated list of ‘textons’, see Nothdurft, 1990).

If the features described by Julesz and Treisman were indeed the fundamental perceptual units of vision, one might expect to see them very early in development. There is recent evidence that 3-month-old infants are sensitive to some of the conspicuously local features, or textons, that Julesz (1981) and Julesz and Bergen (1983) identified in research on texture segregation with adults (Rovee-Collier et al., 1992). The authors tested the retention performance of the infants, using a method of operant conditioning and an array of a few disparate items. Since the infants’ behaviour was reinforced, it is not clear whether the described performance was preattentive, or whether it required the allocation of attentional resources.

In a previous study, we investigated the development of texture segmentation in infants and children, using a method of forced-choice preferential looking (FPL). We reasoned that, if subjects are able to detect a figure defined by textural differences, this should lead to a preferential orienting of attention (and hence to eye and head movements) towards the figure. We used textures defined by differences in the orientation of their elements or by differences in blob size. Both textures have been suggested to consist of elementary features (‘textons’), and both are preattentively segmented by normal adult observers (Julesz and Bergen, 1983; Nothdurft, 1990). The line stimulus does not contain global luminance differences, while the blob stimulus shows such differences. We found that segmentation of textures based on line orientation emerges only at 9–12 months of age and becomes adult-like around school age; segmentation of textures based on blob size was accomplished by infants as young as 2 months of age (Sireteanu and Rieth, 1992a).

At the same time, Atkinson and Braddick (1992) published a study showing that segmentation of oriented textures occurs at 14–18 weeks, but not at 8–12 weeks of age; segmentation of textures containing luminance differences is seen at both ages. There are several methodological differences between the two studies: in our study, the stimuli were presented on two separate surfaces; the textures consisted of oblique lines jittered in position; and one of the test surfaces contained a square of sixteen line elements oriented perpendicularly to the lines of the background. Atkinson and Braddick presented the infants with textures composed of oblique lines jittered in length as well as in position; their stimulus consisted of a single large test surface; their discrepant patch was rectangular, rather than square-like, and consisted of thirty-eight, instead of sixteen single elements.

These differences suggest that the stimulus parameters, like the size of the test surface or of the discrepant patch, might play a critical role in texture segmentation. The main aim of the present study was to disentangle the importance of the