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Saliency and context play a role in infants' texture segmentation

Ruxandra Sireteanu [a,b,c,*], Irmgard Encke [b], Iris Bachert [b]

[a] Department of Biological Psychology, Institute of Psychology, Johann-Wolfgang-Goethe-University, 60054 Frankfurt/Main, Germany
[b] Department of Neurophysiology, Max-Planck-Institute for Brain Research, Deutschordenstr. 46, 60528 Frankfurt/Main, Germany
[c] Department of Biomedical Engineering, College of Engineering, Boston University, Boston, MA 02215, USA

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Abstract

We investigated whether young infants orient reliably towards more salient vs. less salient objects in a visual scene. Subjects were tested with stimuli presented on textured fields, one side showing a target stimulus (a 'more salient' or 'less salient' texture patch) and the other a background stimulus. Infants typically preferred the more salient, but not the less salient target. Their behaviour depended on the configuration of the background stimulus. In contrast, 3–4 year-old children always showed a preference for the target stimulus, regardless of the configuration of the background. We conclude that both saliency of a target stimulus and its context play a role in early texture segmentation.

Keywords: Infants; Texture segmentation; Saliency; Context

1. Introduction

In everyday life we extract figures without effort from a cluttered visual scene. This ability of the human brain, called *segmentation*, may be based on the coherence of the features which define a given object or by the contrast of their features with those of surrounding objects. Natural objects are usually defined by both, coherence of their features and contrast with the surrounding objects.

One aspect of visual segmentation is the *segmentation of textures* (cf. Beck, 1966, 1982; Bergen & Julesz, 1983; Julesz, 1981, 1984). Textures consist of arrays of micropatterns containing a group of items differing from the items of the background by a single feature. Sharp discontinuities between the different regions of the visual texture can often be perceived, while sometimes such discontinuities require careful scrutiny in order to be identified. The segmentation type depends on the kinds of elements within the target region and the relationship between these elements. If the group of discrepant elements can be detected immediately, its extraction is termed 'preattentive'. Elements supporting preattentive segmentation are known as *textons* (Bergen & Julesz, 1983; Julesz, 1981, 1984; but see Nothdurft, 1990, 1991, 1992).

In a related experimental paradigm, called *visual search*, a single odd item has to be located within an array of distracting elements. If the time needed to locate the discrepant element is independent of the number of distracting elements, the search is said to be *parallel*. The target item is said to *pop out* from the background of distracting items. If the search time increases with the numbers of distractors, the search is deemed to be *serial*, and is assumed to proceed by an element-by-element scrutiny of the experimental array. Elements for which the search is parallel, called *features*, are considered to form the elementary building blocks of visual perception

* Corresponding author. Address: Max-Planck-Institute for Brain Research, Department of Neurophysiology, Deutschordenstr. 46, 60528 Frankfurt/M., Germany. Tel.: +49 69 96769 277; fax: +49 69 96769 742.
E-mail address: sireteanu@mpih-frankfurt.mpg.de (R. Sireteanu).

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(Treisman & Gelade, 1980; Treisman & Gormican, 1988; Treisman & Souther, 1985). The features identified by a visual search process are not identical with the textons extracted by texture segmentation (Wolfe, 1992).

Effortless visual search and preattentive texture segmentation are considered to proceed in parallel across the visual field, as opposed to a serial, element-by-element scrutiny, thought to involve sequential shifts of attention (for a discussion of the limitations of this dichotomy and of the distinctions between visual search and texture segmentation, see Leonards, Rettenbach, & Sireteanu, 1998; Wolfe, 1992).

In this study, we investigated the segmentation of textures by infants and children. Previous findings made us suspect that infants' early segmentation abilities, reflected by their visual preferences, might be qualitatively different from those of adult observers.

In 1975, Salapatek reviewed a series of experiments conducted in his laboratory, which investigated the development of preferences for visual stimuli presented as matrices containing either a single discrepant element or groups of discrepant elements. Monitoring the side of first fixation in a 30-s presentation period, he found that 2-month-old infants show visual preferences fundamentally different from those of adults. Infants did not show a preference for discrepant objects; this preference emerged somewhere between 2 months and 3 years of age. In some instances, 2-month-old infants even showed an intriguing *negative* preference, i.e. they oriented *away* from a discrepant stimulus (for instance, a group of parallel line segments embedded in a matrix of squares). The infants preferred the side of the display containing *more squares*, regardless of whether the pattern elements were darker or brighter than the surround. Salapatek (1975) concluded that infants' visual orienting behaviour might be governed by factors like contour density, local brightness, or shape, instead of the preference for discrepant targets, shown by adult observers.

Infants' segmentation of oriented textures was later investigated independently and concomitantly by Atkinson and Braddick (1992) and Sireteanu and Rieth (1992).

Atkinson and Braddick presented infants with textures of obliquely oriented lines containing either a discrepant group of orthogonally oriented lines or a group with an increased density of lines, thus containing a luminance difference between target and surround. They found that segmentation of oriented textures emerges between 10 and 16 weeks of age and is slower to develop than segmentation based on luminance differences.

Sireteanu and Rieth (1992) used textures containing either obliquely oriented line segments or dark blobs on a bright background. The target could be a texture of an orthogonal orientation or a group of larger blobs. They found that infants started to segment oriented textures toward the end of the first year of life. This ability does not become adult-like before school age, while segmentation of textures based on differences in blob size is accomplished by infants as young as 2 months of age. Thus, although the two studies agree that the segmentation of textures containing luminance differences occurs very early in life, and the segmentation of oriented textures requires a more protracted developmental period, they differed on the age of onset of the latter function. This difference might be due to differences in the stimulus parameters used in the two studies (Rieth & Sireteanu, 1994a, 1994b).

The neural substrate of the late development of segmentation of oriented textures was proposed to reside in the long-range, tangential connections in the primary visual cortex (Atkinson & Braddick, 1992; Sireteanu, 2000, 2001; Sireteanu & Rieth, 1992), which are known to emerge after birth and take several years to reach maturity (Burkhalter, Bernardo, & Charles, 1993). This hypothesis was reinforced by Kovacs (2000), who found that the binding of individual oriented Gabor patches into a coherent figure, as well as the perception of some well-known visual illusions known to require tangential connections (e.g., the Ebbinghaus illusion) take several years to reach maturity (see also Kovacs, Kozma, Feher, & Benedek, 1999).

Two further aspects govern visual preferences in adult observers, namely *saliency* and *context*. Previous studies have shown that items displaying more, respectively less of a certain visual attribute (local luminance, size, colour saturation) than the surrounding items are processed differently in a visual search task (Treisman & Gormican, 1988; Treisman & Souther, 1985). Braun (1994) investigated the role of attention on the processing of target stimuli displaying more or less of a given quality than the surrounding items (he called these targets 'most salient', respectively 'least salient'). He found that withdrawal of attention selectively compromises perfomance for the less salient targets, while leaving performance for the more salient objects relatively unaffected. These results suggest that processing of perceptual objects of differing saliency might represent functionally different tasks, with probably different functional mechanisms underlying their execution.

Studies on visual preferences in early infancy have capitalized on the innate tendency of preverbal subjects to orient towards the *most salient* object in a visual scene: the only patterned patch on an otherwise uniformly gray background, the larger, colored, moving, or stereoscopically conspicuous object over a gray, stationary, or flat surround. But in real life, visual objects might be defined by being *less salient* (smaller, grayer, paler, quieter, flatter etc.) than their surrounding objects. While a large body of evidence is accumulating