Going round in circles: shape effects in the Ebbinghaus illusion

DAVID ROSE* and PAOLA BRESSAN

1 Department of Psychology, University of Surrey, Guildford, Surrey GU2 7XH, UK
2 Dipartimento di Psicologia Generale, Università di Padova, 35131 Padova, Italy

Received 25 January 2001; revised 10 June 2001; accepted 13 June 2001

Abstract—The Ebbinghaus illusion has traditionally been considered as either a sensory or a cognitive illusion, or some combination of these two. Cognitive contrast explanations take support from the way the illusion varies with the degree of shape similarity between the test and inducing elements; we show, however, that contour interaction explanations may account for this result too. We therefore tested these alternative theories by measuring the illusion with different test shapes as well as different inducer shapes, in all combinations. We found that for angular or hexagonal test shapes there is no similarity effect, and for some shape combinations there is no significant illusion, in contradiction to both of the traditional hypotheses. Instead, we suggest that an integrated model of visual processing is needed to account for the illusion.

Keywords: Ebbinghaus illusion; visual illusions; cognitive contrast.

1. INTRODUCTION

The Ebbinghaus illusion (also known as the Titchener circles) consists of a change in the perceived size of a circle in the presence of nearby nonconcentric circles of larger or smaller area. Demonstration of the effect is usually given by surrounding one of two identical circles with large elements and the other with small elements, and by showing that the first now appears smaller than the second. This phenomenon illustrates a very general finding: perception of an object is at least partially based on its relations with the stimuli that form its context. Unfortunately, however, no single hypothesis has been shown sufficient to explain the Ebbinghaus phenomenon.

*To whom correspondence should be addressed. E-mail: d.rose@surrey.ac.uk
1.1. Cognitive size contrast

Massaro and Anderson (1971) accounted for the Ebbinghaus anomaly in terms of a cognitive mechanism of size contrast, which alters the apparent size of the test circle, exaggerating its relative smallness or largeness relative to the figures surrounding it.

Support for such a judgmental mechanism comes from an ingenious experiment by Coren and Miller (1974). These authors surrounded a test circle with a ring of four larger or smaller identical figures that differed in degree of similarity to the centre circle. (The degree of similarity was measured by asking subjects to rate it.) The surrounding figures were circles, hexagons, triangles, or angular shapes, which were chosen to form a sequence along an ordinal scale of shape similarity. The Ebbinghaus effect was found to vary as an increasing function of the similarity between test and inducing elements. On the assumption that it is more likely for the visual system to make comparisons among similar targets than dissimilar ones, Coren and Miller considered their results as supportive of a judgmental process of comparison (see also Coren and Enns, 1993).

Choplin and Medin (1999) have recently qualified this conclusion, claiming that Coren and Miller’s notion of ‘similarity’ was insufficiently well characterized. Choplin and Medin instead found that only the similarity of the figure perimeters affected the magnitude of the illusion; the degree of similarity in internal structure between the test and inducing figures was of no consequence. They suggested that the perimeters or silhouettes of objects are crucial because they contain sufficient information to categorize the objects. This permits an efficient estimation of the relative sizes of several objects from the same category, without having to commit computational resources and time for a full semantic categorization of the whole object.

Certain problems remain however with cognitive judgement theories, such as why the illusion strength varies with the brightness of the lines (Cooper and Weintraub, 1970; Jaeger and Pollack, 1977; Jaeger and Grasso, 1993), with the number of inducing elements and with their separation from the central test figure (Massaro and Anderson, 1971; Girgus et al., 1972; Jaeger, 1978; Weintraub, 1979; Jaeger and Grasso, 1993). Additional hypotheses have to be invoked, such as (ad hoc) changes in the weighted averaging of the element sizes (Massaro and Anderson, 1971; Pressey and Murray, 1976) or processing only within a focal aperture of (ad hoc) variable size (reviewed by Shulman, 1992).

1.2. Contour interaction

The alternative tradition posits that the Ebbinghaus effect is due to a more fundamental, sensory process which causes perceived displacement of visual contours via a mechanism operating on a spatiotopic encoding of the stimulus, as opposed to an object file or a semantic level of encoding. According to this tradition, if contour attraction is an increasing function of proximity and length of inducing contour,