

Haptic perceptual illusions

Edouard Gentaz and Yvette Hatwell

Perceptual illusions refer to systematically oriented errors in the perception of figures or scenes, and these errors are observed in almost all people. For centuries, they have been called 'opto-geometric illusions' because it was thought that they concerned only visual perception. Although visual errors are relatively rare, comments and questions about visual illusions are found as early as in the Greek and Roman literature. In scientific psychology, the theoretical and practical problems raised by these deformations have been intensively studied since the end of the 19th Century, and the elements of the figure inducing each error are now identified. However, there is no general theory explaining all the visual illusions. Instead, each figure must be analysed in order to determine the specific processes leading to the error.

The question as to whether analogous illusions occur in the haptic modality was asked only since the 1930s by the gestalt psychologists. According to these researchers, systematic errors result from the general functioning of the nervous system and particularly from the interactions (called 'field effects') between different parts of the figure. Therefore, because the same processing rules are at work in all perceptual modalities, illusions analogous to visual ones must be present in touch. Indeed, this was observed by Revesz [1] and Bean [2] who found haptically almost all visual illusions. However, further studies with better methodological controls produced some contradictory results, which will be discussed here.

The theoretical interest of the studies of haptic illusions is two-fold [3]. First, they confront purely visual explanations of visual illusions with non modality-specific theories. They can also

answer the question as to whether the perceptual processes implemented in tactual perception are similar or not to those implemented in visual perception (for reviews, see [4–7]). Thus, not finding a visual illusion in touch is an argument in favour of specific haptic perceptual processes. However, observing the same illusion in vision and touch does not indicate whether the error is a result of similar and/or specific perceptual processes. To do that, it is necessary to know if the factors responsible for the presence of the tactual illusion are identical to those affecting the same phenomenon in vision. An affirmative answer brings arguments in favour of similar visual and haptic processes, whereas a negative answer favours specific visual and haptic functioning. In this latter case, the problem would be to identify these modality-specific processes.

To answer these questions, blindfolded sighted, late blind and early blind people are compared. Blindfolded sighted persons may use spatial visual representations [8–11]. As visual perception and visual mental images are generally more efficient than haptic perception and non-visual images in representing space, blindfolded sighted subjects have an advantage over early blind subjects (for reviews, see [12–15]). But congenitally blind people benefit from greater tactile practice, and this gives them an advantage over the blindfolded sighted. Finally, late blind subjects benefit from both spatial visual representations and tactual practice.

If an illusion is present in the late blind but is absent in the early blind, it is assumed that visual experience is responsible for it. If the illusion is also present in the early blind, explanations based only on visual experience are invalidated and non-visual explanations must be found to

account for the existence of the same illusion in vision and touch. These explanations may be common to both modalities, but they may also be specific to each of them, as different causes can have the same effects. Finally, one should determine whether the tactual processes implemented by blindfolded sighted subjects are different from those implemented by the early and late blind. If the same results are observed in the three groups, the existence of general haptic processes independent of the visual status will be favoured. If the early blind have consistently different results as compared with the two other populations, it will suggest that they implement original haptic processes.

The analysis of literature about haptic illusions reveals that most of the above scenarios have been observed according to the type of illusion studied. The present study will show that certain special features of touch, mainly linked to manual exploratory procedures, allow at least a partial understanding of why such contradictory results have been observed. Different features of the way an object is explored and consequently the way haptic input is coded have been invoked to account for the presence or absence of geometrical haptic illusions: a) During exploration, the size of the tactual perceptual field varies depending on whether the subject uses the inside face of an index finger only, or the whole hand, or both hands. In the first case, the lines which induce the visual error might not be perceived and the haptic illusion may not appear [3]; b) The intervention of the kinaesthetic information resulting from large exploratory movements (when the arm-hand system is involved in the perception of large stimulus) may produce spatial distortions [16–19]; c) The gravitational cues generated by the anti-gravity forces allowing the arm to be kept in the air may provide reference cues not present in vision [20–23]; d) the spatial reference frame in which the figure is coded may modify the relations between the elements of the figure and the subject [24].

This chapter will be focused on intramodal haptic illusions, i.e., on systematic perceptual

errors occurring when the haptic modality is activated while the subject is deprived of vision temporarily (blindfolded sighted) or permanently (early and late totally blind). However, because the visual-haptic coordination generates too systematic errors, the second part of the study will briefly evoke some of the perceptual errors due to cross-modal interactions.

Intramodal haptic illusions

Classical geometrical illusions

Most of the literature on intramodal haptic illusions has been concentrated on three well-known visual illusions: Müller-Lyer, Vertical-Horizontal and Delboeuf. We will focus on them because of the convergent set of studies available and, as we will see further, each illusion illustrates some aspects of the theories outlined above. Other haptic illusions (Oppel-Kundt, Ponzo, Poggen-dorf,) will be discussed more briefly because the few studies available are often contradictory and they concern only blindfolded sighted people.

Müller-Lyer illusion

In the Müller-Lyer visual illusion (Fig. 1A and B), the perceived length of the horizontal segment is modified according to the orientation of the arrowheads situated at both ends. The segment with outward pointing wings is systematically overestimated as compared to the one (identical) with inward pointing wings, or as compared to an identical segment with no wings.

A number of studies showed that the illusion is present haptically in blindfolded sighted subjects as well as in early and late blind subjects [24–35]. In several of these studies, the subject was told to explore the segment and the arrowheads with the index finger of the dominant hand only. In this case, the intensity of the illusion is the same in the two modalities, the segment with the outward pointing arrowheads being judged 1.2 to 1.3 times longer than the one with the inward pointing arrowheads [33].