

Implicit and explicit memory effects in haptic perception

Soledad Ballesteros

Introduction

There is considerable evidence in the literature showing that memory is not a unitary entity. Old neuropsychological findings from different groups of patients and more recent laboratory studies are in agreement about the major memory systems in the human brain. A distinction is made between *declarative* or *explicit memory* and *nondeclarative* or *implicit memory*. Of special interest is the distinction in declarative memory between *episodic* and *semantic* memory [1]. *Episodic memory* includes personal experiences and conscious recollection of events in our past. This type of memory is defined by the capacity to retrieve voluntarily facts and events in the spatial-temporal context. On the other hand, *semantic memory* refers to our general knowledge, including the meaning of words and concepts.

Two decades ago, Graf and Schacter [2] used the terms *implicit* and *explicit* memory to refer to two different forms of memory as well as two ways of accessing previously encoded information. Explicit memory refers to conscious recollection of previous experience with stimuli (words, pictures, objects, etc.) while implicit memory is inferred when previous experiences with the stimuli do not require intentional or conscious recovery of previously perceived information. Most research on implicit and/or explicit memory has focused on verbal stimuli or pictures presented visually while the number of studies that have presented the stimuli tactually has been very limited.

Researchers on touch have called our attention to the historical lack of interest in the study

of touch [3, 4]. For example, Heller [3] pointed out that psychologists had emphasised the study of visual shape perception. As he recognised, touch did not function as efficiently as vision in detecting outlines of shapes, because the touch modality is slower than vision and scans the stimulus sequentially. These different methods of operation made researchers think that touch is less important than vision. However, this situation has changed lately. During the last decade a number of laboratories around the world have dedicated a great deal of effort and research resources to studying how touch works [5]. It is true that human vision is an outstanding perceptual modality that allows sighted people to rapidly gather highly precise information from objects in space and their spatial relations. However, when human perceivers actively explore objects with their hands, a large number of sensory inputs and high quality of sensory information are extracted for further processing [6].

Active touch is a complex modality that extracts and encodes a wealth of information from cutaneous and kinaesthetic receptors. Haptic perception (the combination of the information gather by cutaneous and kinaesthetic receptors) is very efficient in object identification [7]. In conjunction with findings from behavioural studies, the cognitive neuroscience approach has incorporated new neuroimaging techniques that are causing great expectations in the field. They have been able to explore the activation of different parts of the cerebral cortex while performing different cognitive tasks. The study of the cerebral cortical areas involved in tactile and haptic perception and memory is an area of research that has rapidly grown during the last few years [8–12].

This chapter is organised into three major parts. The first part reviews empirical results from studies conducted with young adults who used raised-line shapes and three-dimensional (3-D) objects to investigate the possible dissociations between implicit and explicit forms of accessing previously encoded, tactually explored stimuli, without vision. The interest is in the recovery of the previously encoded information under implicit (unconscious) and explicit (conscious) retrieval. The second section is focused on whether the perceptual representations of visual and haptic objects that mediate perceptual priming as a measure of implicit memory are modality specific, and whether there are dissociations between implicit and explicit memory measures. A summary of the main behavioural and neuroimaging findings will be followed by a discussion of their theoretical implications. The final section considers a number of recent findings that indicate that haptic as well as cross-modal visual/haptic implicit facilitation is preserved with ageing. These behavioural results, in conjunction with other recent brain imaging findings, allow us to speculate on brain areas involved in haptic as well as cross-modal implicit and explicit memory in ageing. These findings are changing the understanding of visual and haptic memory in normal and pathological ageing.

Implicit and explicit memory for stimuli explored by touch

Despite the large number of studies conducted in memory, the literature is dominated by the use of verbal stimuli presented in the visual and the auditory modalities, while touch has been largely neglected. Although this section is devoted to long-term haptic memory, I will briefly mention a few findings on haptic short-term memory. Millar [4] reviewed a substantial body of research from blind and sighted children under the general framework of the information processing and memory-systems approach. She presented evidence showing the existence of short-term

memory in the tactual modality. However, spans for touch are shorter than for vision and limited to two or three tactual items. According to Millar, the small memory spans (two to three items) for unfamiliar patterns explored by touch can be explained by the paucity of reference information for coding inputs spatially.

The small memory spans for haptically explored stimuli have also been observed in young adults. Moreover, the small haptic memory span (see Heller [13]) deteriorates in normal ageing and is very poor in the elderly with mild cognitive impairment (MCI). In our laboratory, we [14] investigated the interference caused by a secondary task (visual or haptic) in the performance of a primary (visual or haptic) task. In the study, we used a dual-task paradigm with two primary tasks (Visual Matrices and Haptic Corsi Blocks) combined with two secondary tasks (one visual and the other haptic) to assess the visual and the spatial (haptic) component spans in young adults, older healthy adults, and mild cognitive impairment (MCI) adults. A Corsi Haptic device was constructed to avoid the use of vision while performing the haptic tasks. The MCI group obtained the smallest span measures on both modalities, and their poorer performance was on the haptic tasks. The shortest spans obtained by the three groups occurred when the primary and the secondary tasks were conducted in touch (Haptic Corsi Blocks and Moving a Cube – to turn a cube once counter-clockwise around inside a box). The mean spans were 3.5, 2.5, and 1 for young adults, healthy older adults, and MCI, respectively. In contrast, when the primary and the secondary tasks were conducted in vision (Visual Matrices and the Arrows task – to press a key when two arrows pointed to the same direction and another one when the arrows pointed to opposite directions), the spans were larger 5.5, 3.5, and 3, for young adults, healthy older adults, and MCI, respectively. The largest spans were obtained when the primary task was visual and the secondary task was tactual. In this condition of less interference, spans were 6.5, 4.5, and 3.5 for young adults, older adults, and MCI, respectively).