International Journal of Psychophysiology 71 (2009) 64–69

Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

Episodic memory decay along the adult lifespan: A review of behavioral and neurophysiological evidence

Selene Cansino *

Laboratorio de NeuroCognición, Facultad de Psicología, Universidad Nacional Autónoma de México, Mexico City, Mexico

ARTICLE INFO

Available online 23 July 2008

Keywords:
Episodic memory
Source memory
Recognition
Aging
Encoding
Event-related potentials
ERP

ABSTRACT

The ability to learn and remember new information declines along life. Empirical evidence reveals that this deficit occurs unevenly with different types of memory. Episodic memory, which is referred to as the ability to remember our own experiences in a determined temporal and spatial context, is especially vulnerable to aging. Episodic information can be retrieved with or without the context information that took place when the episodic event was encoded. There is agreement that, with advancing age, the source information related to an episodic event is more susceptible to be forgotten than the event; however, there is no consensus regarding the age at which this decline begins, the speed of source-memory decline along life or the possible changes, due to aging, in neurophysiological activity during encoding of source information that is subsequently correctly retrieved. In an attempt to answer the first two issues, a behavioral study with 552 subjects from 20 to 80 years of age was conducted, which provided evidence of the exact age at which source memory starts to decline and of the speed of this memory loss along life. To address the last question, event-related potentials were recorded while young and old adults encoded source information, to investigate whether older adults generate memory traces different from young adults during encoding.

1. Introduction

One of the most significant problems that people have to deal with as they get older is the loss of their memory abilities. Although the amount of memory deficit varies among individuals, it can be considered a universal phenomenon, since all humans will sooner or later experience some degree of memory difficulties. However, this deficit does not occur in all kinds of memories, some of them resist the passage of time better than others. Evidence has revealed that the elderly perform adequately in memory tasks that require less effort, as in implicit memory tasks, in which previously experienced stimuli affect subsequent behavior with or without the subject being aware of the previous presentation of these stimuli (Light et al., 1992), or in primary memory tasks in which subjects are required to repeat a set of stimuli in the same order (Puckett and Stockburger, 1988) and in recognition tasks in which subjects have to indicate if a stimulus has been previously presented or not (Craik and McDowd, 1987). Performance diminishes in tasks that demand a strong effort, as in working memory tasks in which subjects have to transform the information retained in their mind for a few seconds (Dobbs and Rule, 1989), in free recall tasks in which no clues are given to the subject to retrieve information (Schonfield and Robertson, 1966), and in prospective memory tasks in which subjects have to carry out some action without reminders (Einstein et al., 1995). Thus, when elderly people are required to retrieve or manipulate information employing their own resources without external help, performance tends to decline.

Episodic memory, which is referred to as the ability to remember our own experiences in a determined temporal and spatial context (Tulving, 1972), is especially vulnerable as a function of normal aging when it is evaluated by means of free recall tasks but not when it is evaluated by recognition tasks (Craik and McDowd, 1987). In view of the fact that episodic memory comprises information about the event itself and about the context related to that event, it has been possible to establish that, with advancing age, the source information related to an episodic event is more susceptible to being forgotten than the event (McIntyre and Craik, 1987).

Older adults perform poorer than young adults in episodic tasks in which subjects are required to retrieve the context or the source related to a specific event as has been shown by numerous studies (Spencer and Raz, 1995). However, there is no consensus regarding the following: At what age does source memory start to decline? How fast does this deficit occur along life? Is this deficit related to differences in the electrophysiological activity of young and old adults at the time of encoding source information that is subsequently correctly retrieved or forgotten? The following pages contain a review of the studies that have investigated these issues and describe some of the experimental evidence obtained at our laboratory. Firstly, a description is made of

* Laboratorio de NeuroCognición, Facultad de Psicología, Universidad Nacional Autónoma de México, Avenida Universidad 3004, edificio D, 2 piso, no. 12, Cd. Universitaria, Col. Copilco Universidad, México D. F., 04510, Mexico. Tel.: +52 55 56 22 23 39; fax: +52 55 56 16 07 78.
E-mail address: selene@servidor.unam.mx.

0167-8760/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijpsycho.2008.07.005

the most frequently employed tasks used to study source memory, and details of the source-memory paradigm employed in our experiments are provided. Then, an answer to the first two questions mentioned above is attempted by examining previous behavioral studies and our own experiments. The final part seeks to answer the third question posed. Only neurophysiological studies employing the event-related potential (ERP) technique are discussed, because a satisfactory report of research with other techniques is beyond the scope of this document.

2. Methods for studying source memory

The distinction between the event and the context in episodic memory has motivated the development of tasks that allow a separate evaluation of each. One of the first tasks employed to study item and source information was the so-called 'remember/know' procedure (Tulving, 1985). In this task, during the test session, subjects are instructed to provide a 'remember' answer if they are able to retrieve any contextual information related to the item that was presented for the first time in the study session, or to endorse a 'know' response if the item seems familiar to them but they are unable to retrieve contextual information from the study session. This task relies on the subject's introspection, since it is not possible to verify the actual information retrieved by the subject at each trial, or to identify the nature of this contextual information. Despite this shortcoming, this procedure has been extensively employed to test episodic memory. A more objective method to determine whether recognition memory was or was not accompanied by retrieval of contextual information consists of presenting each item in a specific context during a study session, followed by a test session in which subjects are required to retrieve the context of each item presented in the previous session. This task will be referred to hereafter as a source-memory paradigm. This procedure permits measurement of the subject's ability either to retrieve or not to retrieve the specific source under evaluation.

In the studies described here a source-memory paradigm previously used in a functional magnetic resonance imaging (fMRI) study was employed (Cansino et al., 2002). Fig. 1 illustrates the stimuli used to produce a high level of item memory by employing perceptually rich and distinctive pictorial color images of common objects as stimuli. A total set of 108 images was used for the behavioral experiments (72 items for the encoding session and the total set for the retrieval session), while for the ERP experiments a total set of 180 images was employed (120 items for the encoding session and the total set for the retrieval session). The images for the encoding session of each subject were randomly selected from the total set of images.

During the encoding session, the screen was continuously divided into quadrants by a cross. The center of the cross was located in the middle of the screen and served as the eyesight fixing-point in the behavioral experiments. In the ERP recordings, an additional small cross appeared inside the quadrant just previous to the stimulus, with the purpose of preventing eye movements once the trial had begun. The stimuli were displayed for 1000 and 500 ms in the behavioral and ERP experiments, respectively. The interval between the onset of successive stimuli was 3000 and 4500 ms for the behavioral and ERP experiments, respectively. The ERP experiments consisted of longer trials to allow subjects to blink between trials. Subjects were allowed to respond from the beginning of the stimulus presentation until the end of the trial. This time setting was used for both, encoding and retrieval sessions.

During encoding, the stimuli were presented randomly within one of the quadrants of the screen; each quadrant had the same probability of being selected. The task was to indicate whether the image represented a natural or an artificial object. In the retrieval session, a five push-button response panel was employed with four buttons arranged in two rows of two keys each. The left keys of each row were accessed by the index finger while the right keys were pressed by the middle finger. These four keys represented each of the screen quadrants. The fifth key was located in the lower part of the panel to be pressed by the thumb. During retrieval, the images were presented in the center of the screen and subjects were instructed to judge whether the image was new or old (previously presented in the encoding session). If the image was new, subjects pressed the lower key of the response panel and if it was old, subjects indicated at which position on the screen the stimulus was presented during the encoding session, by pressing one of the four keys. Subjects were instructed to guess and to randomly select one of the four keys if they were unable to remember the position of the stimulus at encoding.

This source-memory paradigm has proved to be especially useful to study brain activity related to the successful and unsuccessful encoding and retrieval of source memory (Cansino et al., 2002). The reason for this is that typical source-memory experiments have employed two-choice tasks, such that subjects are instructed to select between two different contexts, namely, the context in which each item was presented during the study (e.g., visual vs. auditory, female voice vs. male voice, first list vs. second list). With this procedure, the probability to provide a correct source judgment by chance is of $P=0.5$, thus, performance is expected to be high in order to consider a correct source response truly correct and not based on a 'lucky guess'. The consequence of this high performance is that few incorrect source judgments are usually available to be compared with correct performance. In contrast, the four-choice task employed in the present experiments reduced the probability of providing a correct source judgment by chance ($P=0.25$) and thus increased the proportion of source judgments, both correct and

Fig. 1. Two examples of the stimuli employed in the source-memory task, representing an artificial and a natural object.