Sensory Learning

▶ Visual Perceptual Learning

Sensory Learning Styles

A categorization of learning styles according to the sensory modalities that are applied for learning information. Generally, four modalities are distinguished: Visual, Aural (sound), Read/write, and Kinesthetic (touch). Learners usually have a preference for a certain sensory style of learning.

Sensory Memory

Zhong-Lin Lu
Departments of Psychology, University of Southern California, Los Angeles, CA, USA

Synonyms

Sensory registers

Definition

Stimulation of human sense organs is initially represented in sensory memory for a brief period by a literal, labile, and modality-specific neural copy. The term iconic memory stands for the initial representation of visual stimuli, and echoic memory is its counterpart for auditory stimulation (Neisser 1967). Sensory memory is often contrasted with short-term memory and working memory which are assumed to be less modality specific, and all of these are distinct from long-term memory. In functional terms, sensory memory is comparable to a register in a computer. In a human, if you want to know what the last sensory input was, you examine the sensory register. The prevailing view of human memory systems is that there are one or more modality-specific sensory registers in each sensory modality, plus a register or registers for short-term and/or working memory, plus functionally distinct long-term memory systems for episodic, semantic, procedural, and perhaps others form of long-term memory.

Theoretical Background

Visual sensory memory, i.e., iconic memory, was first demonstrated by George Sperling using the partial-report paradigm (Sperling 1960): After a brief presentation of a 3×3 or 3×4 array of letters, observers often can report all the letters in any cued row if the cue occurs immediately after the visual presentation ("partial-report"), even though they can only report four to five letters when asked to recall all the items in the display ("whole-report"). Because all rows are cued with equal probability, reporting all the items in a randomly cued row implies that observer has access to all the items in the array at the termination of the display. The partial-report superiority effect – performance advantage of partial-report over whole-report – suggests that there exists a fast-decaying iconic memory that can initially hold at least 9–12 items. Numerous studies have established that iconic memory has a large capacity, decays rapidly, and is destroyed by post-stimulus masking (Coltheart 1980; Gegenfurtner and Sperling 1993; Neisser 1967; Sperling 1960). The duration of iconic memory has been estimated to be about 300–500 ms for young adult observers.

Auditory sensory memory, also called "echoic memory" (Neisser 1967), is essential for integrating acoustic information presented sequentially over an appreciable period of time (Crowder 1976; Glanzer and Cunitz 1966; Treisman 1964; Wickelgren 1969). Psychophysical experiments suggest that echoic memory resides at a central rather than a peripheral site (Massaro 1975). Electrophysiological investigations of auditory memory functions in animals provide evidence that similar short-term memory functions are served by sensory areas of cerebral cortex (Weinberger et al. 1990).

In biological sensory processing, there is a considerable amount of memory – perhaps more aptly called retention – that is inherent in the processing itself. So, in a broad sense, sensory memory exists and may differ for different stimuli in every stage of sensory processing. For example, visual sensory memory exists in the receptors and bipolar cells of the retina as an afterimage. These cells do not constitute a register in the usual meaning of the word, but they can retain a representation of the input image long after it has been removed. The afterimage is a negative of the original stimulus that is perceived upon subsequent stimulation. The original stimulus can itself persist in the retina as "persistence of sensation."

A complete understanding of a sensory memory system requires specification of (1) its brain location, (2) the time constant for which it retains information, and (3) the format (or encoding) of the information it retains. The magnetoencephalography (MEG) habituation paradigm developed by Lu, Williamson, and Kaufman (Lu et al. 1992a) offers a means to specify the first two components of a sensory memory (location and time constant) and perhaps the third (encoding) as well. In this paradigm, the same stimulus is presented repetitively with different repetition rates. The recovery of the MEG response with increasing inter-stimulus interval (ISI) serves as a measure of the decay of the initial activation. In its first application, Lu et al. (1992a) used auditory stimulation with various repetition rates to characterize the temporal dynamics of neural activation in the primary and secondary auditory cortices of human observers in terms of simple exponential decay functions. They later found that the lifetime of a cortical activation trace in primary auditory cortex predicts the lifetimes of behaviorally determined auditory sensory memory of the loudness of a tone for each individual subject (Lu et al. 1992b). Using the same paradigm with flickering checkerboard stimuli, Uusitalo, Williamson, and Seppa (Uusitalo et al. 1996) were able to detect 10 brain locations with different recovery time constants in the visual system. Each one of these brain locations represents a process with an inherent retention time, a process that could become a component of the overall retention time observed in a psychophysical sensory memory experiment.

Important Scientific Research and Open Questions

Vision and audition each have several levels of sensory memory, and constructing experiments to selectively measure one or another of these memories has been an elusive goal. There have been many attempts in the literature to distinguish different forms of visual sensory memory (for review, see Coltheart 1980, Long 1980). One well-recognized distinction is between eye-specific visual persistence and non-eye-specific iconic memory. Many have debated interpretations of results from information-based assessments (e.g., the partial-report procedure) and some more direct sensory measures of visual sensory memory. Coltheart (1980) concluded that the partial-report procedure mostly reflects retinal nonspecific iconic memory

(but see Massaro and Loftus 1996). Beyond visual sensory (iconic) and visual short-term memory, deriving the taxonomy of visual memory systems has not been possible by means of psychophysical tasks alone.

The taxonomy of auditory sensory memory systems is probably even more complicated because auditory signals are subjected to much more complicated processing prior to reaching auditory temporal cortex area A1 than are visual signals before reaching occipital cortex area V1. Cowan's reviews conclude that there are at least two forms of auditory sensory memory: a very short-lived memory such as the memory for tonal loudness described above and a second auditory sensory memory with a duration on the order of seconds (Cowan 1995). Indeed, it is not obvious that the next-higher auditory memory can be characterized by a time constant in seconds. It might be a limited capacity memory based on retroactive interference – new inputs push older material out of memory. In the absence of new auditory input (i.e., silence), periods of silence might themselves be recorded as memory events. This is a much more complex process than simple, exponential passive decay with time, although it may be difficult to distinguish from passive decay when new stimuli arrive at a constant rate.

Cross-References

► Attention and the Processing of Visual Scenes
► Habituation
► Human Information Processing
► Memory Codes
► Perceptual Learning
► Short-Term Memory and Learning
► Visual Perceptual Learning
► Working Memory

References

Coltheart, M. (1980). Iconic memory and visual persistence. *Perception and Psychophysics, 27*(3), 183–228.

Cowan, N. (1995). *Attention and memory: An integrated framework.* New York, NY: Oxford University Press.

Crowder, R. G. (1976). *Principles of learning and memory.* Hillsdale, NJ: Erlbaum.

Gegenfurtner, K. R., & Sperling, G. (1993). Information transfer in iconic memory experiments. *Journal of Experimental Psychology: Human Perception & Performance, 19*, 845–866.

Glanzer, M., & Cunitz, A. R. (1966). Two storage mechanisms in free recal. *Journal of Verbal Learning and Verbal Behavior, 5*, 351–360.

Long, G. M. (1980). Iconic memory: A review and critique of the study of short-term visual storage. *Psychological Bulletin, 88*, 785–820.

Lu, Z. L., Williamson, S. J., & Kaufman, L. (1992a). Human auditory primary and association cortex have differing lifetimes for activation traces. *Brain Res, 572*(1–2), 236–241.

Lu, Z. L., Williamson, S. J., & Kaufman, L. (1992b). Behavioral lifetime of human auditory sensory memory predicted by physiological measures. *Science, 258*(5088), 1668–1670.

Massaro, D. W. (1975). *Experimental psychology and information processing.* Chicago, IL: Rand McNally.

Massaro, D. W., & Loftus, G. R. (1996). Sensory and perceptual storage: data and theory. In E L Ba R A Bjork (Ed.), *Memory.* San Diego, CA: Academic Press.

Neisser, U. (1967). *Cognitive psychology.* East Norwalk: Appleton-Century-Crofts.

Sperling, G. (1960). The information available in brief visual presentation. *Psychological Monographs, 74*, 1–29.

Treisman, A. (1964). Monitoring and storage of irrelevant messages in selective attention. *Journal of Verbal Learning and Verbal Behavior, 3*, 449–459.

Uusitalo, M. A., Williamson, S. J., & Seppa, M. T. (1996). Dynamical organisation of the human visual system revealed by lifetimes of activation traces. *Neuroscience Letters, 213*, 149–152.

Weinberger, N. M., Ashe, J. H., Metherate, R., McKenna, T. M., Diamond, D. M., & Bakin, J. (1990). Retuning auditory cortex by learning: a preliminary model of receptive field plasticity. *Concepts in Neuroscience, 1*, 91–132.

Wickelgren, W. A. (1969). Associative strength theory of recognition memory for pitch. *Journal of Mathematical Psychology, 6*, 13–61.

Sensory Plasticity

► Visual Perceptual Learning

Sensory Preconditioning

Learning of an association between two stimuli that are not biologically significant at the time of training. To show that learning has taken place, it is usually necessary to later train one of the neutral stimuli to predict an innately significant stimulus and subsequently test the response to the other neutral stimulus.

Sensory Register

Component of the information-processing model of cognitive learning concerned with initial awareness of information through the senses (vision, hearing, touch, smell, and taste).

Sensory Registers

► Sensory Memory

Sentiment

► Attitudes – Formation and Change

Sequence Learning

► Learning and Consolidation in Autism
► Procedural Learning
► Task Sequencing and Learning

Sequence Learning Without Awareness

► Implicit Sequence Learning

Sequence Skill Consolidation in Normal Aging

Daniel Cohen[1], Nichola Rice Cohen[2], Alvaro Pascual-Leone[1], Edwin Robertson[1]
[1]Department of Neurology, Berenson-Allen Center for Non-invasive Brain Stimulation, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA
[2]Department of Psychology, Volen Center for Complex Systems, Brandeis University, Waltham, MA, USA

Synonyms

Offline learning; Procedural memory consolidation; Skill enhancement

Definition

Following practice, a new skill memory continues to be processed offline during a period of consolidation. Consolidation stabilizes a memory, making it more