Sensory Memory

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June 5, 2026

During every moment of an organism's life, sensory information is being taken in by sensory receptors and processed by the nervous system. Humans have five main senses: sight, hearing, taste, smell, and touch. Sensory memory(SM) allows individuals to retain impressions of sensory information after the original stimulus has ceased. A common demonstration of SM is a child's ability to write letters and make circles by twirling a sparkler at night. When the sparkler is spun fast enough, it appears to leave a trail which forms a continuous image. This "light trail" is the image that is represented in the visual sensory store know as iconic memory. The other two types of SM that have been most extensively studied are echoic memory, and haptic memory; however, it is reasonable to assume that each psysiological sense has a corresponding memory store. Children for example have been shown to remember specific "sweet" tastes during incidental learning trials but the nature of this gustatory store is still unclear.

Characteristics

SM is considered to be outside of cognitive control and is instead an automatic response. The information represented in SM is the "raw data" which provides a snapshot of a person's overall sensory experience. Common features between each sensory modality have been identified; however, as experimental techniques advance, exceptions and additions to these general characteristics will surely evolve. The auditory store, echoic memory, for example, has been shown to have a temporal characteristic in which the timing and tempo of a presented stimulus affects transfer into more stable forms of memory. Four common features have been identified for all forms of SM:

The formation of a SM trace is independent of attention to the stimulus.
The information stored in SM is modality specific. This means for example, that echoic memory is for the exclusive storage of auditory information, and haptic memory is for the exclusive storage of tactile information.
Each SM store represents an immense amount of detail resulting in very high resolution of information.
Each SM store is very brief and lasts a very short period of time. Once the SM trace has decayed or is replaced by a new memory, the information stored is no longer accessible and is ultimately lost. All SM stores have slightly different durations which is discussed in more detail on their respective pages.

It is widely accepted that all forms of SM are very brief in duration; however, the approximated duration of each memory store is not static. Iconic memory for example has an average duration of 500 ms which tends to decrease with age. Genetics also play a role in SM capacity; mutations to the brain-derived neurotrophic factor (BDNF), a nerve growth factor, and N-methyl-D-aspartate (NMDA) receptors, responsible for synaptic plasticity, decrease iconic and echoic memory capacities respectively.

Types

Iconic memory

Iconic memory represents SM for the visual sense of visual perception/sight. Visual information is detected by photoreceptor cells in the eyes which is then sent to the occipital lobe in the brain. Iconic memory was the first sensory store to be investigated with experiments dating back as far as 1740. One of the earliest investigations into this phenomenon was by Johann Andreas Segner (1704 - 1777) a German physicist and mathematician. In his experiment, Segner attached a glowing coal to a cartwheel and rotated the wheel at increasing speed until an unbroken circle of light was perceived by the observer. He calculated that the glowing coal needed to make a complete circle in under 100ms to achieve this effect which he determined was the duration of this visual memory store. Segner's estimate of the duration of iconic memory is not far off of what George Sperling found over 100 years later using his famous partial report paradigm.

Echoic memory

Echoic memory represents SM for the auditory sense of hearing. Auditory information travels as sound waves which are sensed by hair cells in the ears. Information is sent to and processed in the temporal lobe. The first studies of echoic memory came shortly after Sperling investigated iconic memory using an adapted partial report paradigm. Today, characteristics of echoic memory have been found mainly using a Mismatch Negativity (MMN) paradigm which utilizes EEG and MEG recordings. MMN has been used to identify some of the key roles of echoic memory such as change detection and language acquisition. Change detection, or the ability to detect an unusual or possibly dangerous change in the environment independent of attention, is key to the survival of an organism. With regards to language, a characteristic of children who begin speaking late in development is reduced duration of echoic memory.

Haptic memory

Haptic memory represents SM for the tactile sense of touch. Sensory receptors all over the body detect sensations such as pressure, itching, and pain. Information from receptors travel through afferent neurons in the spinal cord to the postcentral gyrus of the parietal lobe in the brain. This pathway comprises the somatosensory system. Evidence for haptic memory has only recently been identified resulting in a small body of research regarding its role, capacity, and duration. Already however, fMRI studies have revealed that specific neurons in the prefrontal cortex are involved in both SM, and motor preparation which provides a crucial link to haptic memory and its role in motor responses.

Relationship with other memory systems

SM is not involved in higher cognitive functions such as consolidation of memory traces or comparison of information. Likewise, the capacity and duration of SM cannot be influenced by top-down control; a person cannot consciously think or choose what information is stored in SM, or how long it will be stored for. The role of SM is to provide a detailed representation of our entire sensory experience for which relevant pieces of information can be extracted by short-term memory (STM) and processed by working memory (WM). STM is capable of storing information for 10-15 seconds without rehearsal while working memory actively processes, manipulates, and controls the information. Information from STM can then be consolidated into long-term memory where memories can last a lifetime. The transfer of SM to STM is the first step in the Atkinson-Shiffrin memory model which proposes a structure of memory.