MEMORY

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Q551
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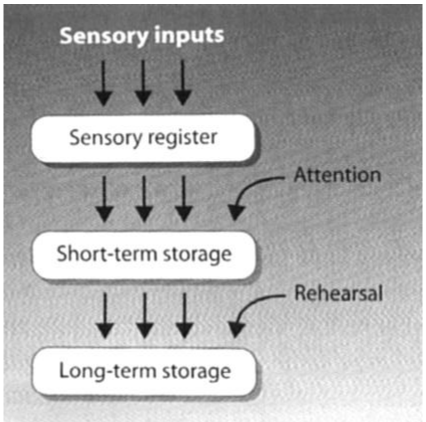
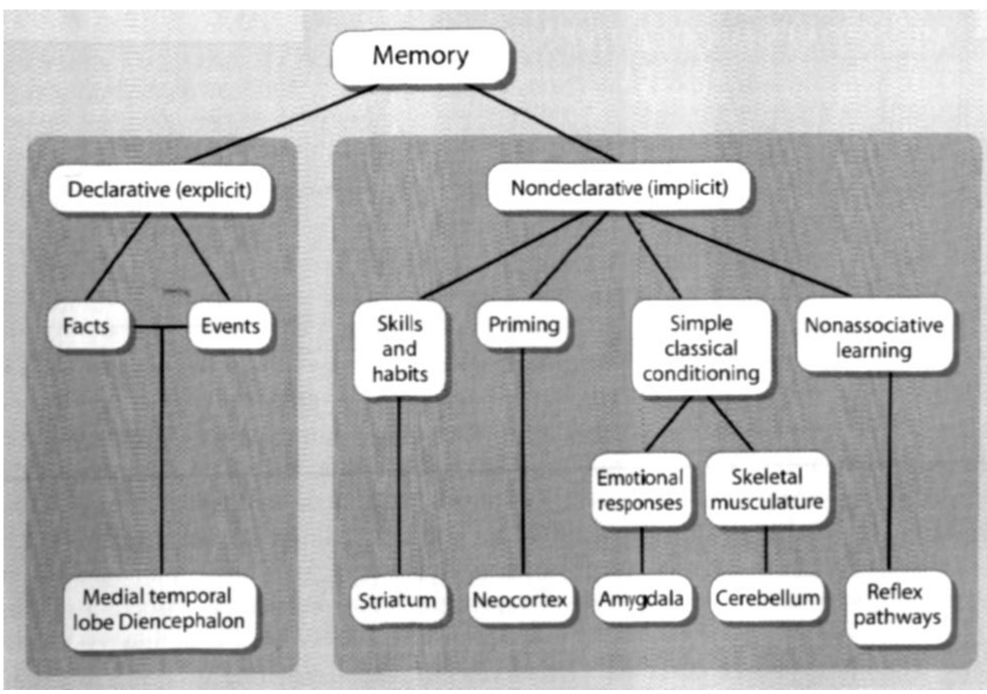
0 - Introduction



1. Atkinson & Shiffrin box model

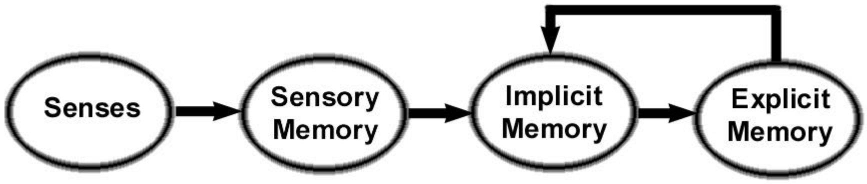
Figure 1. at left (Gazzaniga et al., 1998: 255) is a typical conception of the flow of memory from sensory input to long-term storage. In other models, the “boxes” may vary slightly — for example, “Short-term storage” may instead be “Working memory” with its own internal structure — but the essential idea remains the same. There is sensory input, input is stored in short-term memory, and depending on various factors (rehearsal, emotional state, etc) that information is stored in a “long-term memory”. Long-term memory, in turn, is typically divided into “explicit” and “implicit” memory (figure 2., Gazzinga et al, 1998: 273) and then further divided based supposed types of explicit and implicit memory.

These models are fundamentally lacking in their account of human perception and processing and ignore some obvious and some not-so obvious facts. Section 2. proposes an alternative model and provides justifications for the preceding claim concerning the efficacy of (1) and (2).



2. Generalization of typical divisions within long term memory

2 - Something a Little Different



Clearly the above model is dramatically simpler than the previously shown model. Explanations of the divisions and their justifications follow below in sections 2.1 - 2.4 with the exception of “Senses” which merely refers to the method of input into the system.

2.1 - Sensory Memory

The notion of sensory memory here is not different than in (1). Evidence observed in Sperling’s (1960) experiments involving “partial report” and subsequent physiological evidence of decay of sensory memory seem quite conclusive.

Basically what these studies show is that subjects are capable of perceiving more information that they can report. The information, which decays very rapidly (within a second for vision), is present within a sensory trace and only a limited amount of that information can be processed before it is gone.

2.2 - Implicit Memory

There is a danger of getting hopelessly lost in vague definitions and overuse of highly-suggestive terminology; however, such is the curse of working in a poorly understood field. By “implicit memory” in *this* model, I mean learned knowledge. This subsumes all of “Nondeclarative” in (2) as well as all of “Declarative”. In short, it suggests that the distinctions that have been described between “procedural memory”, “factual, world-knowledge memory”, and “episodic memory” are all part of the same memory system. The bubble in the diagram may well have been labeled “Long Term Memory”, since it includes everything that would normally be considered long-term memory, however, along the lines of Tulving (1995), I choose “implicit” to reflect something about its representation / retrieval. For the most part, the arguments for this collapse of previously distinguished memory types, appear below in 2.3; a definition of “explicit” memory is required before the justifications for this classification can be adequately supplied.

2.3 - Explicit Memory

I adopt Tulving’s (1995:pg 842) definition of “explicit memory”:

“Explicit memory ... refers to the expression of what the person is consciously aware of as personal experience."

However, I take a stronger, more literal sense of the definition. It seems to me that the only memory division or system that has been so far proposed that conforms to this definition is "short term" or "working memory". We are not (*cannot*) be consciously aware of all our episodic memories all the time — only during recall. Thus, by "explicit memory", I mean the range of phenomena that is related to short-term and working memory.

The placement of explicit memory ("short term memory" in (1)) *after* implicit memory (long term memory in (1)) is a radical departure from the norm. However, the major oversight that all studies in short-term / working memory seem to have made is that complex recalls from long-term memory *have already been made* by the time any information is "chunked" into short-term memory. Every experiment from Petersen and Petersen's (1959) study of interference to Miller's (1994) review of capacity to Sperling's (1960) sensory memory study use lists of digits, letters, and words *all* of which are recognized based on long-term memory of experience. If we tried to account for this in (1) we would be left with placing word recognition in "sensory register". Despite evidence that there are cells in the visual cortex that respond to images as complicated as a hand, there remains a qualitative difference between a hand and a letter (related to its symbolic power) that prevents me from accepting such a characterization.

This being said, Sperling's (1960) study in which individuals could not transfer all presented information from "sensory memory" to "short term memory" is compelling evidence that explicit, conscious processing is not occurring. This is a large motivation for collapsing a lot of symbolic memory recall (such as might be used in language) that would otherwise be characterized as declarative, into implicit memory with other procedural tasks. Indeed, learning to read is analogous to learning to play the piano, despite the differences in the kinds of information being processed.

Experimental evidence certainly demonstrates phenomena that support the distinctions in (2) but I feel that the examinations of that phenomena are too narrow in scope. They make no reference to developmental or linguistic theory and it is a relatively simple task to produce anecdotal evidence that cannot be accounted for.

One major problem is that it is not at all clear where language fits into (2) — clearly language acquisition is intimately tied to long term memory. "Declarative memory", by its very etymology suggests a relationship to language — memories that can be expressed in words, in a declaration as it were, are declarative. Indeed, it seems that we couldn't produce a better example of declarative memory that the production of a word. However, grammar certainly is not declarative — such can be extrapolated from the work by Abrams and Reber (1989) on artificial grammars. Natural language is acquired by children with exposure only to data and not to rules, and thus seems to be more part of "Nondeclarative Memory". And once we start looking more in depth into words themselves we find that they are not as declarative as we might have suspected. Increasingly, cognitive scientists and artificial intelligence researchers are seeing the need for "embodiment" and "grounding" to achieve meaning (Brooks, 1997), both of which can be seen as a form of nondeclarative memory. As well, increasingly, it has been shown that statistics — again nondeclarative memory — play a huge role in language acquisition (Seidenberg, 1997). This is a major reason why I would classify many “declarative” phenomena, such as world knowledge and language, as implicit. I surmise that this is also largely the motivation of Tulving for doing the same, although he does not address language in particular.

The model in (2) makes also no attempt to relate the various divisions of memory to child-development or language acquisition, despite the fact that it seems the capabilities of children would provide a great deal of insight into how the divisions are related. It is clear that children have extremely sophisticated and well developed procedural memories (Rovee-Collier, 1991) that would be classified as non-declarative in (2), but they seem to lack declarative memories. (2) would suggest that since children are not capable of declarative memory, it is a separate system acquired later through development. However, the facts of language acquisition suggest that declarative memory must be built upon nondeclarative memory through experience. There are plausible mechanism of how this could occur; one such model is proposed in McLennan (ms.) based on a dynamical model of memory and Schema Theorem (Holland, 1975). Although the details cannot be sufficiently summarized here, this model bears some resemblance to prototype models that use MDS methods. Importantly, it does not require distinct processes for learning skills and learning categorization and symbols — they are simply different levels of the same processes that act in parallel. Thus, these two seemingly disparate phenomena can be collapsed into one category — implicit memory in the proposed model.

Another short-coming of the models in (1) and (2) is that they show no capability for interaction. Introspection can convert the nondeclarative knowledge of natural grammar into declarative rules; the declarative markings of musical notation can be used to bootstrap the nondeclarative memorization of a piece of music through practice. The memory of a phone number, a rather declarative piece of information, can be tied nondeclaratively to a specific language, or turning the dial on a lock can be the cue to remembering the combination (personal experiences). Although it is easy to come up with examples of this nature, it is not easy to see how (2) can account for them as they are part of separate systems.

Additionally, (1) and (2) assume a priori discretized events, experiences, and memory. In fact, humans receive a continuous stream of sensory input and feedback through thoughts and actions Somehow salience must play a role in sorting out information that is to be remembered from that which is not. What is ignored is that one’s own speech (for example) contributes to the training of new long term memories. Indeed, the act of recall can become a memory itself and this probably plays a large role in reinforcing memories. Feedback and the coupling of information in different modalities plays an important role in acquiring the ability to preform, explicit symbolic processing (McLennan, ms.).

This sort of interaction between the memory systems unconnected in (2), in part motivated the collapse of all long term memory to implicit memory in (3). It also motivated the arrow from explicit memory to implicit memory to allow feedback into the process of long term memory. This arrow also accounts for the effects of transfer from working memory to long term memory that have been demonstrated to exist.

The characterization of “implicit” and “explicit” in (3), in fact, correspond almost identically with Tulving's retrieval types with the exception of episodic memory, which Tulving would have included in explicit. There are several reasons why I believe this is incorrect.

An important part of the model presented in McLennan (ms.) and alluded to above is that categorization, language, and world knowledge are all built upon personal experience. This seems to directly contradict Tulving who states (pg. 841):

> "Episodic memory enables individuals to remember their personally experience past, that is, to remember experienced events as embedded in a matrix of other personal happenings in subjective time. It depends on but transcends the range of the capabilities of semantic memory."

However, what Tulving calls episodic memory, I argue, relates to the process of cycling explicit memory back to implicit memory. Information about an event that is salient enough to be recognized (through implicit memory) and chunked and passed to explicit memory are returned to implicit memory in a slightly different, more symbolic, more linguistic form and reinforce the memory of the event.

One of the major pieces of evidence for the division between declarative and nondeclarative memory is the apparent double-dissociation of the two in amnesiacs (Gazzaniga, 1998: pg 272). However, this is not inconsistent with the model in (3). There are two ways that implicit memories can be entrained — either from input from sensory memory or input from explicit memory. I would argue that the two types of deficits can be accounted for by damage to the one of these input systems. If damage were caused to areas of the brain responsible for the cycling of explicit memory to implict memory, we would expect that they could not form new long term memories of specific events but, the entrainment of long term memories based on similarity of sensory input would allow the creation of new categories in the same way that children acquire new categories. However, if damage were caused to areas related to creating new memories based on sensory experience, we would expect that the ability to create new categories based on novel sensory experience would be impaired but not specific memories of events based on existing categories. As well, since sensory experience is potentially more distributed around the brain because of the various modalities, we would also expect that noticeable impairments to this system (and this system alone) would be much rarer and harder to diagnose. It is possible that all these hypotheses might be tested given sufficiently sophisticated experiments.

2.4 Ties to Biology

Since the model in (3) is more about reorganization of demonstrated phenomena within a model than arguing that the (non)existence of phenomena, there is not a lot to say about how it is implemented in "wetware." Lesions studies can determine what areas are implicated in which capacities with a rather high degree of certainty; neuroimaging techniques are somewhat harder to draw conclusions from.

Thus, I shall not deviate much from the conclusions drawn in (2), except to say that episodic and factual, world knowledge memory are likely distributed through all the areas implicated in other aspects of long term memory. The medial temporal lobe diencephalon that has been strongly implicated in the acquisition of new episodic memory, I would argue, plays a large role in mediating the cyclic return of explicit memory to implicit memory. It is not surprising that the hippocampus is so strongly implicated in memory since it acts somewhat like a "gateway" for sensory information to be associated with other areas of cortex. I suspect it would be plays a strong role in all implicit memory.

3 Summary

What has been presented here is a model of memory that, despite the currently accepted views of memory, claims that learned knowledge of all kinds is stored in the same system by the same process. This is not to say that there is not a difference between what has been called "declarative" memory and "nondeclarative" memory. "Declarative" memory is simply mediated by explicit memory and returned to the same system in a enhanced, "chunked" form.

Sensory information that is temporarily stored in Sensory Memory is recognized within Implicit Memory. If appropriate (based on task, salience, etc) and if the information is "chunkable" a limited amount of that information can be passed to Explicit Memory which roughly corresponds to what we are consciously aware of at any given moment. Again, if appropriate, that information is returned to Implicit Memory where it reinforces the salient aspects of what is already there creating episodic memories and also contributing to categorizations, world knowledge, and other types of similar long term memories.

The primary motivations for this categorization of memory are: a) the fact that what has been called "short term memory" already relies heavily on long term memory; b) the fact that aspects of language seem to be simultaneously "nondeclarative" and "declarative", yet there is no proposed method for interaction between those memory systems; c) developmentally and evolutionarily, it is more plausible that "declarative" memory is built upon "nondeclarative" yet they are typically seen as unrelated processes; and d) "declarative" and "nondeclarative" memories interact with each other in ways not possible to predict or explain using models such as (2).

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