Memory dimensions
- the TOSCANINI, A account

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1. Introduction

1. 1. Philosophical and theoretical considerations

Memory is phenomenological in the sense that you know when you remember something, if only at different levels of certainty, i.e. we regard a memory as a phenomenon. Some knowledge may be very close to logical truth, for instance that you know that you went up this morning, and also that you know that you did that before noon. We don't have to repeat the old Cartesian arguments regarding what we know about ourselves and the world around us, because the facts regarding such quite "certain" knowledge; the level of its certainty is rather a question for empirical research.

However, the philosopher who started the discourse regarding the subjective vs the objective knowledge showed that what we intuitively regard as truth among all our conceptions of the world around us and ourselves is dependent, not only of our ability to know things, but on the general nature of what the boundaries are for saying anything truthfully about the things in the world and our ability to know (Kant, 1776). Instead of without criticism accepting the empiricism of the day (Hume, 1748) Immanuel Kant postulated that we may only know things about phenomena. We may accept hypotheses about the Higg's particle, about the speed of light, the location of certain visual cortices, etc, but we don't know these things as certainly as we know that we are awake, that we went up this morning or that the shortest way between two points is a straight line, not to mention all the so called analytical truths such as mathematical or logical truths.

In physiology we may hypothesize many things regarding wakefulness, the level of arousal at every moment of awareness, the rise of arousal during awakening, the involvement of brain stem nerve cells during awakening; geometry may teach us many things about the straight line, and different kinds of geometry may describe quite precisely how the distance between

two points may be measured. Despite all that, for us knowing or remembering persons, including the scientists involved in those specialities, what we know is based on what we regard as relevant phenomena. We rely on them, not because we disregard the world as it is in its physical or neuropsychological sense, but because we most of the time, in our real lives, don't have anything else to base our judgements on. It is not that we generally are uninterested in the scientific findings regarding these things: for the remembering or knowing person it is evident that we have gone up this morning too, and checking our watches we are 100% certain that it happened before noon or several hours before that too.

This knowledge is thus based on phenomena, phenomena that constitute the world around us, and that we claim to take part in.

But a phenomenon is not just a perception or a single memory of it. Although, neuropsychologists sometimes may regard perception as a more basic science in the sense that the sense organs have been studied for a long time, and because the nature of perception may seem somewhat easier to study due to its alleged non-temporal character, that makes experimentation a little bit less cumbersome than doing research on memory with retention intervals on the scale of years. In perceptual research, especially within departments of the so called psycho-physics, the findings are clearly relationships between physical phenomena, or if you prefer: objective physical facts, and the subjective, or if you may: psychological, jugdgements of them. In other terms this research is based on physical and psychological phenomena.

Notice: until now the author did not mention the word "phenomenology" even once. This is because it is not needed, and would probably only discourage many readers to go on.

1. 2. Current views in memory research

In the 1880's the first real experiments on memory were made (Ebbinghaus, 1885). Five years later memory was defined as a two-partite function: primary and secondary memory (James, 1890). William James theory was based on introspection, and was not corroborated by hard evidence from series of experiments as was the case with Hermann Ebbinghaus, whom we will return to in chapter 2. During the decades to follow memory was studied

empirically but the impression of the author is that memory was then regarded only as one among five or six other cognitive or intelligence factors (Thurstone, 1938).

In the late 40's Donald Hebb introduced the term *engram* in order to explain the relationship between brain and behavior in memory: an engram is the the result of repeated activation at "synaptic knobs" (Hebb, 1949). After Hebb the search for specific engrams, that are responsible for diffeent kinds of memory, has been the focus for a large part of neuropsychological research on memory.

1. 2. 1. The Information processing paradigm

About 1960 a step towards a kind of cognitive psychology that was similar in kind to the one represented by Ebbinghaus was taken. During the 60's a large number of studies on memory were undertaken, and we may say with some confidence that modern memory theory was established by the workers in the field that are still active (Murdock, 1974; Baddeley, 1995). By the end of the 60's the so called *stage model of memory* was introduced (Atkinson & Shiffrin, 1968), and the Jamesean theoretical division of memory was in a sense reawakened.

But by then there were in fact three parts or stages, not just primary memory and secondary memory, that constituted memory. Three different temporal stages were identified: *sensory, short term and long term memory*. In principle this division into different types of memory is still in fashion, although several further divisions has seen the daylight. Today there has been a substitution of *working memory* for short term memory following the introduction of the term in the 70's (Baddeley & Hitch, 1972).

There are couple of contemporary definitions of memory that are worth contemplating on. Christofer Wickens says that "working memory is the temporary, attention-demanding store that we use to retain new information. Long-term memory..*is our storehouse of facts about the world and about how to do things"* (Wickens, 1992). The store-house metaphor of memory is often referred to by people in general: "I have got it somewhere, but I cannot retrieve it right now". Note also that Wickens definition of working memory implies that the main responsibility of it is to keep track of incoming information, i.e. Wickens seems to follow the concept of working memory as a preliminary store, similar to the idea of James about primary memory. Working memory is thus something else than the current content in

consciousness. This way of defining memory underscores what was said in the beginning, i.e. memory is *perceived* by us as something that we may have a hold on, but not really master, a thing, so to say, that resembles a very, very large sack of beans rather than a well ordered store.

The store-house metaphor, however, implies that the way things are stored is somehow ordered; a store-house is something very different from a chaotic collection of things, and very far, metaphorically, from a city dump.

The idea of memory as stores in a store-house is very close to what we hope for, i.e. when we try to retrieve something from memory, we are in a way optimistic or hopeful that our experiences in the past are stored together in a useful way, and other definitions of memory sees also memory as a useful tool: *"Memory is the means by which we draw on our past experiences in order to use this information in the present"* (Sternberg, 1999).

So we go from the sack-metaphor to a tool- or spade-metaphor. The sack of memory beans, may contain all our experiences, and if we only have the right *spade*, we will dig out something useful. Although the tool-metaphor by Robert Sternberg seem to depart from the store-metaphor, it introduces a new store or sack: our *experiences*. An experience is based on a collection of perceptions at many events in the past. It seems as if Sternberg takes our experiences in the past for granted, but how can we take the collection of perceptions in the past for granted? Is it not the purpose of memory to do this? Memory is thus, according to Sternberg and other "tool-theorists" a tool to keep track of the collection of perceptions in the past in order to use them today. Why we use memory is a somewhat overkill in this respect, so we only conclude that the notion of Sternberg is that memory is a *tool* by which we keep track of our collection of perceptions in the past.

If we combine the tool- and the store metaphors, as I believe that Sternberg would in fact agree upon, we may see memory as a tool especially adapted in order to retrieve the most useful information from the store-shelves in the large store-house, that we keep somewhere in the brain. What logically follows from this metaphorical discussion is the kind of computer based metaphor that is popular in connectionist models of cognition. In a so called *content addressable system* information is retrieved by *cues* at hand (Hinton & Anderson, 1981).

This database related idea goes a step further in trying to elaborate on the combination of a store and a tool to keep track of the store, and it is obvious that theorists in this vein not just put a computer in place of the more general tool at hand, but they actually seem to leave the store-house metaphor completely.

There is much that speaks for the content addressable system as a metaphor or theory about how representations of associative elements are stored in the brain. We all know that one association leads to the other, and in so called free associative therapeutic work patients report surprising new thoughts that come to mind, and these episodes from therapeutic work have been recorded several times since it was first used by classical psychoanalys (Misiak & Sexton, 1966).

In creative ativity such as literary writing authors report how characters in novels "start to live their lives on their own", i.e. the plot revolves around a theme and subsequent scenes seem to develop without any control of the process of writing. In the everyday life of ordinary people day-dreams is a another good example of how associations seem to pop up without any apparent purpose or reason. Associations may evolve around a single perception, for example the famous passage in the novel by Proust where the taste of a Madeleine cake reminds the main character in the novel vividly about a situation in childhood.

All these examples shows that there may be a content addressable system in the brain, at least they give support to the idea that there may be a net of associative elements, where these elements meet at nodes in the net. This idea is certainly not very controversial, and it goes well hand in hand with the Hebbian idea of cell assemblies that can hold information, and communicate with other cell assemblies (Hebb, 1949.

Regarding the fundamental question of how the memory works, we still must ask ourselves how this webb of cell assemblies is controlled by the proposed cerebral database system. Who is the actual programmer or administrator of such a database system in the brain, that can make use of all searchable nodes? What the content addressable system lacks is a *supervisor*, otherwise the system would be self regulatory? Is there a homunculus database administrator in the brain, and what database system is this homunculus specialized in, SQL or FileMaker?

The last question is more serious than it sounds because in the later case the database structure or database handler is stored together with the data, while in the case of SQL or most other databases these things are separated. If there are database systems in the brain, much speaks for a division between a structuring handler and data.

If the content addressable system that consists of a webb of memory elements is self regulatory, we would have to explain how this would work, unless it only would output a chaotic string of addresses to the nodes that it parses. The system would reasonably regulate itself from a basic principle that is there already at the birth of the system.

In a well known experiment Rubin and Wallace (1989) gave one group of participants the cue "a mythical being" and none of them retrieved *ghost*. A second group were given the cue "the word ends in ost," but again, no one came up with that noun. At last, when the cue "a word naming a mythical being that ends in ost," was given, all of the participants produced the word *ghost*. Two cues that were separately ineffective produced perfect retrieval when used together, all with the same trace.

The referred experiment may be a positive example of the working of a content addressable system, if we regard it as a database that finds the word with these two cues. However, if you put these cues in the search field of Google, you will not get ghost or a picture of a ghost in the initial search, because ghost is not a high frequency word.

1. 2. 2. S-R-theory R-S-theory vs. Information processing

The most valuable thing, according to me, that behavioral psychology brought to us was the S-R-theory (Hull, 1943; Thorndike, 1898). Psychologists thereafter describe their experiments in terms of stimuli and responses, and we still use these terms even outside the psychology of learning. From Rodney Cotterill and later, however, it is clear that the direction between S and R, not only may be, but certainly should be turned the other way. Psychologists often forget that the real world is not the same as the laboratory: people do not act because of a previous stimuli. They act because it is the normal way of being human, and in general we act because we want something or want to do something. What we want and what we feel are perceptions such as satisfaction, a good taste, a relief from a burden, etc (Cotterill, 2001).

Therefore S-R-theory should on logical grounds be termed R-S-theory.

In the act of remembering or recollection we may not look for a perception of the past, but certainly we look for a bleak copy or *representation* of the past. The search process is in the case of conscious or non-automatic memory search *directed* in some way, it is focussed towards what we think may be at least a similar idea of the original information. In a content addressable system it is very likely that this search process may become severely random, unless the process is guided by a relatively small number of search terms or *dimensions* in order for the search process to be sufficiently focussed.

In the case of the simplest creature we know of, the amoeba, it has been found that it does not search for food at a place that it earlier searched (Cotterill, 1995). In the case of a human we don't look for a book on a shelf that we just searched, either. In both cases the principle R->S+ applies. This search principle is learned very early in child development. It may be noted that the arrow does not designate a logical relationship, it is a symbol for a psychological effect.

Take the situation of memory search early in life: the difference between searching for a ball that rolled away behind an arm-chair in the living room, and searching for the name of a school mate is only that the name of the school mate was perceived during activities at school, while the perception of the ball was much closer in time. When the child finds the ball it does not pursue an internal argument whether the ball that he/she finds really was the same ball that rolled away, and when the name of the school mate is told to his parents, he/she does not question the association between name and person.

A content addressable system thus has to be equipped by a control function, i.e. a checking mechanism, or in behavioral terms, a positive/negative reinforcer, that in one way or the other informs the individual that he/she is on the right track. The process of learning how to remember must be similar to the process of learning how to look for missing things in general, or other important learning processes.

Basic learning processes involve such procedures as how to carve and cut wood or how to hold a paper and make a drawing on it. During such learning the child uses both hands. If not ambi-dexter the child regularly uses one hand to hold, and the other to carve or draw. The

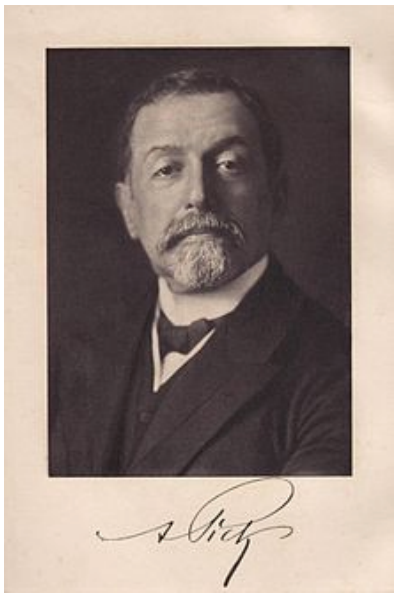
holding part of the action is static, and the carving or drawing action is dynamic. But the goal of the action is also static, while the action until finished is dynamic. A content addressable system does not take into consideration such basic facts - facts that are immediately related to the brain-behaviour relation.

Note: Considerations like those discussed above have been central during the writing of this book, but are not meant to be hypotheses to be studied in the area of early learning.

1. 2. 3. Great figures in cognitive psychology

Ulric Neisser 1928-2012) has been called "the father of cognitive psychology". His percepual and mnemonic schema-theories, and his book Cognitive psychology are evidence for that. His book Memory observed is often cited in this book.

One reason for writing this book is Ben B Murdock, more specifically his book Human memory: theory and data. Today BB Murdock is retired.



Arnold Pick (1851-1924) is the man behind the diagnoses dementia praecox (1891), an ailment similar to schizophrenia, and Pick's disease, often termed Semantic Dementia.

1. 3. Preliminary notes

1. 3. 1. Action vs. activity

During the development in early childhood the individual goes from relatively simple acts into a generalization of acts, and develops ideas about how to do things in general. One may say that actions become *idealized*. For a child of about 7 the ideal dance may be quite simple, but for the teenager of 14 the ideal dance may be quite complex. This difference is not only dependent on how skilled the individuals are at dancing, but depends on the perceptions of other people dancing, i.e. perceptual learning.

The most important role taking activities are relevant regarding social activities such as dancing, playing foot-ball, etc. The main relationship to be considered here is the perception of one's self as part of an activity. Relatively simple procedures such as moving ones limbs in accordance with music or the speed of a ball has to be regarded in a more holistic fashion: a beginner in foot-ball or group dancing has to develop a sense of being part of an activity. In doing this,
the representation of activity has to be superior to the actions involved in taking part of the activity. According to the theory behind this book the development of schematic memory is dependent on this early partaking of social activities.

1. 3. 2. Negative reinforcement

Negative reinforcement is the termination of a fear or other unpleasant emotion. Fear responses are accompanied by amygdala activation. In contrast positive reinforcement is accompanied by hippocampal activation. We may according to these hypotheses be faced by a checking system regarding the act of memory search, which is dependent for its development of two medial temporal lobe structures. However, we have not yet decided on a system in the brain, or more specifically, the cell assemblies that works from early childhood into adult age and all through life that works as such prime checkers.

1. 3. 3 Metaphoric theorizing

It seems like the metaphors used in order to define memory is guided by the history of technology. The author holds that the need for more metaphors is not very great. He would rather prefer a more Occamistic approach. William Occham (1285–1347) was an english philosopher famous for his *razor* principle: always try to keep the concepts needed for the solution of a problem to a minimum and cut the rest. This principle has since then been highly esteemed among scientists of all sorts.

1. 3. 4. Learning and memory

Let us initially make a clear division between the concepts *learning* and *memory*. Long term memory is dependent on learning, and learning is dependent on short-term memory and less so on long term memory, but these dependencies goes steadily in one direction: from learning to knowledge or memory.

Learning is dependent on short term memory, as it is also dependent on attention (Klingberg, 1997). Declarative memory may not grow or develop if the material to be later retrieved has not been attended to. Likewise, the material that is being attended to may be available in short term memory, or working memory if you like, for just a few seconds if not consciously rehearsed. In order for material that has been attended to, and held for a few seconds in short term memory, to be learned, and subsequently be retrievable from long term memory, it has to be rehearsed or equiped with attributes, i.e. being coupled or associated with earlier learned material (Baddeley, 1974; Markowitsch & Stanilou, 2012).

Because earlier learned material may be associated with the currently learned material, learning is also dependent on long term memory. Note that long term memory, as it has been measured in most studies of memory, is only *recent*, i.e. something learned only minutes or hours before the test is made. In a few studies it is *diurnal*, i.e. learned the other day, or in a rare number of studies a long time ago, then it is termed *remote* long term memory.

Another, maybe more interesting point regarding short term memory, is that certain properties of it may be applied also to long term memory. These properties are *primacy* and

recency. Primacy is the tendency to remember the first or early events in a series, and recency is the tendency to always remember the last event or events close to the last event. My experience as neuropsychologist is that when people are promted regarding the last time they went to the cinema or the dentist they seem to recall it quite easily without having to think vary long, mostly 5-10 seconds.

1. 3. 5. Memory vs. forgetting

Forgetting as the opposite of remembering is a phenomenon that has been investigating ever since the days of Herrmann Ebbinghaus (1985), and numerous studies have been made in order to describe the negatively accelarating curves of forgetting. Baddeley has discussed the theme at length, and covered the conflicting theories among which especially interference and strength theories were compared (Baddeley, 1995).

Before delving deeper into this issue we will have to ask ourseleves if there is positive function for forgetting and not just a negative phenomenon. Phrased in a somewhat different way we may ask if there would be anything to gain from a memory function that never showed any forgetting. It is obvious that most of what we experience is of very little value later in life. Still we tend to remember rather useless information, and we are often informed by folk psychology that "nothing is really lost", i.e. it is percieved as only a matter of retrieval if we remember or forget.

On the other hand we may think that it would be nice to have a mechanism by which unneccessary information would be *erased* in order to give room for more useful information. But this wish seems to be coupled with a thinking of memory only as a tank or reservoir, a thought that we dismissed early in this chapter in the discussion of the store metaphore (p. 3). However, if there are engrams that represent a certain information and these engrams use certain cell assemblies in the brain, and if these cell assemblies undergoes degradation due to reduced usage, then it would not be implausible that some elements necessary to retrieve that specific engram would make it impossible to remember that specific information.

This is almost exactly what the decay or strength theory proposes. Memory traces, may decay due to some kind of erasure. Or in that case one may rather use the term erosion, because the physical destruction of neural tissue that may follow reduced or non existant

usage would bring about forgetting of those stored elements that rely on them. Such loss of memory traces could be assigned decay functions (Brown, 1959; Peterson & Peterson, 1959).

But there are other types of degrading the engram such as interference, see the chapter *Imagery vs. interference*. Interference was in fact a central issue for memory researchers in the 60s and 70s, but in our account of memory it will be treated as one of several aspects. However, interference is here seen as the opposite and negative side of the imagery dimension, for some of my collegues perhaps a surprising way of sorting things out. Interference operates on the conscious level, i.e. as a cognitive phenomenon especially at the encoding or learning phase of memory. Then we would not expect interference to be effective in the storing phase, i.e. in the engram level of LTS.

1. 3. 5. 2 Erasing vs. relearning

But, again, when would it be favourable to have an erasing function in the brain? One obvious situation is obviously when learning goes wrong, or when misconceptions arise. This may happen when misspellings are incorporated in our linguistic repertoir or when proper names, codes or any other information are erroneuosly encoded. Being a swedish speaker I often have had difficulties pronouncing the english word *interval*, e.g. without stress on the initial syllable, and the word *imagery* also caused smilar problems some years ago. It would certainly have been nice to engage an erasing function in my semantic memory in order to get rid of these embarassments.

Another of my own memory problems, that is actually quite common to other people too, is my recurring inability to immediately retrieve the names of two well known figures: these are the names of Robert de Niro's and Phil Spector, the music producer. I will always or most of the times have to use a peculiar retrieval process. Regarding the name Robert de Niro I think that personal or prejudicial factors are involved, because I find *Robert* to be an improper or unusual latin name or *de Niro* an improper english name, an effect of prejudice or lack of openness? Regarding the problems regarding the name *Phil Spector* other factors may be working, because Phil begins with a P, not an F as in the swedish name Filip, and Spector is a name that I personally have difficulties in associating with the music producer. Prejudices like that influence not only my way of thinking, and obviously it would have been very nice to be

the owner of an erasing mechanism at the time one encounters such recurring memory problems.

But again, would such an erasing function work on the encoding, storage or retrieval phase of memory? I would not argue for an erasing mechanism at the storing phase, but rather during encoding. In order to completely erase the specific erroneous encoding cues that may block, halt or in other ways lead memory search astray I would strongly argue for a relearning strategy. Because it is hard to get rid of all our prejudices regarding names, figures, people in general, etc the relearning strategy should ideally also be based on those mnemonic strategies that are taught by mnemonists.

1. 4. Memory in neuropsychology

In the field of neuropsychology memory is often conceived of as a relatively simple construct based on a few different systems: episodic and semantic memory representing the so called declarative or explicit memory systems, and implicit or incidental memory (Mishkin, 1982; Squire & Zola-Morgan, 1991). According to the view of the "memory systems theories" (MST) the declarative systems are responsible for conscious and effortful retrieval, while implicit memory is a form of memory that is automatic, i.e. *not* consciously searched. In addition to the explicit and the implicit systems the currently popular MST-theorists tend to add aspects of learning when they make accounts of memory.

The concept of semantic memory has been defined in a number of similar ways: Tulving (1972) defined it as "a system for receiving, retaining and transmitting information about words, concepts and cassification of concepts" (Baddeley, 1976). Later the definition was widened by Tulving: "general knowledge about words, concepts, and symbols, their meanings and associations, as well as rules for manipulating these concepts and symbols, as well as the individual's knowledge about the world as well as information regarding his or her own memory "(Lipinska-Terzis, 1996; Tulving, 1983).

It may be noted that already in 1976 Baddeley questioned the view of different systems in the brain, and he then preferred an "alternative way of conceptualizing the difference between remembering personal incidents and recalling information in terms of the degree of abstraction involved" (Baddeley, ibid). He takes an example our memory of the chemical formula for salt: "...it differs from a single personal experience in being based on a large number of personal experiences, most of which happened many years ago when we first began to learn chemistry".

What Baddely does is to take a developmental view of semantic memory: it is cumulative, and is consequently defined as our "personal and general knowledge of the world" (Baddeley, 1976, p. 318).

Regarding neurophysiology the MST theory locates the most important memory systems in the temporal lobe, more specifically the hippocampus and adjacent regions of the medial temporal lobe. This system "*is fast, has limited capacity, and performs a crucial function at the time of learning in establishing long-term declarative memory*" (Squire & Zola-Morgan, 1991). This view is widely exposed (Aggleton & Brown, 1999; Kim & Baxter, 2001). Objections to this view are few but have been presented from time to time (Horel, 1978; Vanderwolf & Cain, 1994). Gaffan, in his review of Horel's critique summarise the contra arguments towards the MST based on empirical counter evidence regarding the precise role of the hippocampus and the temporal pole in amnesia (Gaffan, 2001). In an interesting review one year later he states his position quite clearly:*"In the study of cortical localization of function, it (MST) is a prominent instantiation of the idea that the functions of cortical areas can be characterized intuitively and in a haphazard and piecemeal fashion, and it thus stands in the way of a systematic hierarchical explanation of functional localization and its breakdown in the prefrontal cortex. Additionally, in the study of cortical plasticity, it stands in the way of the simple hypothesis that all cortical areas have the same rules of plasticity"* (Gaffan, 2002).

Another type of argument against MST would be based on studies at memory clinics that shows high levels of correlation between alleged tests of semantic and episodic memory, and they often load on the same factor. In our own studies of that kind the medial temporal lobe is also strongly related to semantic memory tests such as WAIS-Similarities (Fernaeus & Hellström, 2017).

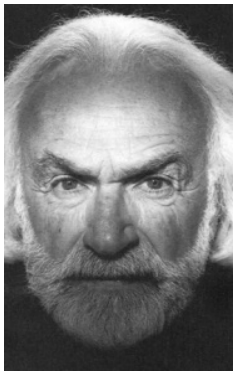
Recently an Attribute model of memory (AMM) was presented by Raymond Kesner (2013). His model of memory is a "*tripartite, multiple attribute, multiple process*" phenomenon. In short Kesner divides memory into three memory systems; (1) one Event-Based Memory, (2) a Knowledge based memory, (3) and a Rule-Based memory (Kesner, 2013). Each of these systems has several attributes: *language, time, place, response, reward value, and sensory-perception*. The Event based system is mostly based on hippocampus, the Knowledge-based Memory is based on neocortical areas such as posterior parietal cortex, Wernickes area and Broca's area for language, parietal cortex for the attribute place, etc.

The Rule-Based Memory is based on lateral prefrontal cortex for language, lateral prefrontal cortex for place, etc. In this short account of parts of the AMM we will not go deeper into the

details of Kesner's theory of memory, but return to it in the chapters on the different dimensions of memory due to the fact that it seems to be one of the most interesting, and systematically well formed theories of memory, that has been published.

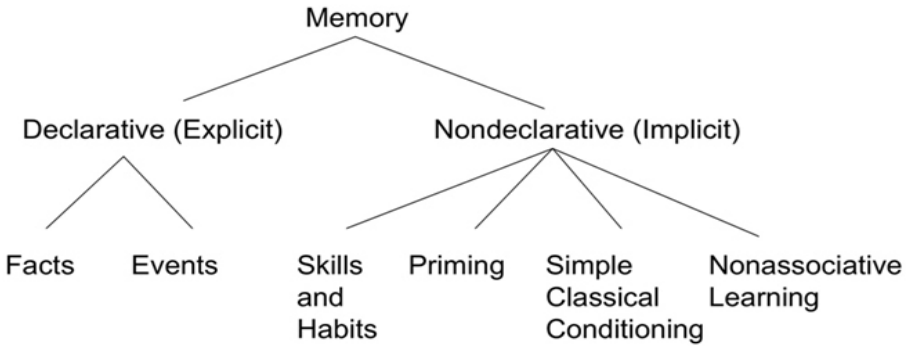
Stanley B. Klein regards episodic memory, not as a separate system, but "... a collection of functionally independent, but normally interacting functions" (2013).

1. 4. 2. Three great figures in modern neuropsychology



A great figure who pioneered the information processing paradigm was Karl Pribram, who actually was a coworker with B.F. Skinner, the last behaviourist of importance. With his publications of profound neurophysiological findings and theory in five decades from the beginning of thr 40's to the 90's he is a portal figure of neuropsychology in general. One of his main theses was that fourier analysis, that had been used by Gabor in holography would be used in transformations between the representational and the physiological levels of information.

Larry Squire is a well known figure behind one of the versions of the memory systems theory, se nedan.



Antonio Damasio has to be mentioned due to the variety of studies in many fields of neuropsychology: localization of memory as well as emotional processes. His research on personality and the self with strong hypotheses that posteromedial cortices, prefrontal cortex, and anterior cingulate cortex has bearings on *autobiogaphical memory*. His theory of consciousness may be characterized as a shell-theory with three stages of self: *protoself*, *core self*, and *autobiographical self*. The autobiographical self is the most conscious or the outer layer of the shell.

1. 4. 3. A preliminary account of the dimensionality of memory

The following account of *memory dimensions* will not delve deeper into the learning and memory issue. This is because the book is about *memory*, not about learning, although it might be interesting for a learning specialist to carry on reading.

The main thesis of the book on the dimensions of memory is that it strongly opposes the idea that memory is divided into *types* of memory or memory systems in the brain, instead it takes a dimensional approach. This does not mean that the author does not accept that people may have very different capacities for remembering different material. Neither does he disregard the facts regarding lesion studies that shows dissociations between types of lesion and certain memory performances. What is meant by the dimensional approach is that *any* recollection, recall or recognition may be explained by combinations of a limited number of dimensions at the bottom of a hierarchical structure - just as single personality traits may be understood as combinations of dimensions at more basic levels, as proponents of personality theories claims, although differing in details (McCree & Costa, 1990; Eysenck, 1992; McCree & Costa, Judge et al, 1999).

Though it may be received, by some memory researchers, as almost an insult to their expertise in their area of research, to be informed of a methodological alternative related to a less precise, or at least less scientifically praised, area of research as personality studies, the dimensional approach will be proposed in this book to be a preferable way to systematize and manage memory research. The reasons for this approach are not only that it has proven a quite successful way of doing personality research (Judge et al, 1999). It may be noted that the typologist way of doing research in the personality field was abandoned decades ago.

In fact, a dimensional approach has been tested earlier also in cognitive psychology: one may even say that psychology as we know it today is heavily armoured by intelligence research, and other dimensional or factor analytical based research such as interest studies, and ability studies in general (Burt, 1956; Cattell, 1963; Eysenck, 1976; Guilford, 1967; Vernon, 1965). A number of recent studies in the memory field also shows that a factor analytic, or rather *multi dimensional*, approach shows that this division is not only artificial, it does not lead to a deeper understanding of the matter (Fernaeus & Almqvist, 1998; Fernaeus et al, 2013; Fernaeus et al, 2014).

Among current memory theorists Eichenbaum, Konkel and Cohen, who are proponents of the Relational Memory Theory RTM, give support for a multi-dimensional approach, at least regarding the location of memory representations (Eichenbaum, 2004; Konkel & Cohen, 2009). The RMT is in fact one of many inspirations for the hypothesis of 10+ dimensions of memory.

Some of the memory dimensions presented below may be more important than others, and there may also be more basic memory dimensions to be found than the 10 included in this book. There are a couple of dimensions that are special: the complexity dimension involves ever more integrated combinations of the other 9 dimensions, and would possibly be regarded only as one more argument for the levels of processing approach to cognitive science (Craik & Lockhart, 1972). But it will be shown in chapter 4 that things are not that simple. The Interference vs Imagery dimension is also special because of its speculative character, and the author would therefore expect this dimension to be criticized due to that. However, if one of the ten proposed dimensions is criticized, it is not a great failure.

It may be surprising that no specific hypothesis is made regarding the factor analytic or other multidimensional structure of the relationships between the broad dimensions discussed in the book. This is because the dimensions discussed are broad, as are the personality dimensions of the Big Five, and as such they may be hard to catch with a small empirical lasso. Still there are plenty of empirical results, found within traditional or modern memory research paradigms, that easily fit within the framework of 10 basic memory dimensions. The author may be wrong regarding the number or importance of the dimensions, but he is quite certain that the dimensions are limited in number, otherwise we would be faced with great difficulties in the neuropsychological diagnostic affairs. The author is also convinced that although the number of items may be astronomical, it would not be necessary for our human brain to combine too many routes through itselt in order to remember a searched item.

Each chapter of the book begins with experimental evidence for the existence of the dimension in addition to anecdotal references followed by clinical evidence. At the end of each chapter neurophysiological evidence for the importance of each dimension will be presented.

1. 5. Short introduction of the memory dimensions

The dimensions included and discussed in the book are ten: 1. Temporal, 2. Order, 3. Static and spatial, 4. Complexity, 5. Agency, 6. Narrative, 7. Interest, 8. Numeracy-Magnitude, 10. Imagery and Interference, 10.Automatic vs. effortful.

It has to be noted once again that this account may not be exhaustive. The dimensions above are included based on their implicit or explicit treatment in the research literature.

1.6.1. The Temporal dimension

Time is not a simple construct. We may regard it as a *flow* or we may emphasize the aspect of temporal *order*. In this account we let the order aspect be represented by its own dimension, bacause order may also be related to a spatial configuration or to a series of ordered items. Material recently encountered vs material encountered long ago belong to *the flow of the past*, however the past may be represented. The first studies to be presented in the chapter covering this are the now classical ones from the late 19th century by Ebbinghaus (1885). Clinical studies of the dissociation between dementia diagnoses and recall of recent vs remote experiences will be discussed at length.
Tests of recent or remote memory always include a rentention interval, which indicates that time per se is implicated as an important factor in memory or forgetting.

1. 6. 2. The Order dimension

The *last time* you did/saw/read something is an absolutely necessary knowledge, otherwise you would repeat an action endlessly. Even amoebas do not search for food at the last searched spot (Cotterill, 2001). The primacy and recency aspects mentioned in the introduction are related to order: first, second, etc, ..last.. The chapter on the order dimension will be strongly based on studies of short term memory, serial memory, and free recall during list learning. As was noted above order is also involved in recalling spatial configurations and series of items, and tests of serial recall try to measure different aspects of this dimension.

1. 6. 3. The Static and spatial dimension.

The chapter on the static and spatial dimension will introduce a conceptual analysis of the staticity of space in contrast to the dynamicity of time. One part of the chapter will explain how the popular method of loci is effective as a mnemonical device. Clinical data on memory for static vs dynamic information will also be discussed. The spatial is in one respect static - if you don't live near a vulcano. No wonder why mnemonists use the loci method. An anecdotal note: people tend to remember almost exactly where they were the last time they heard Last time on the radio. Tests of spatial memory are always included in memory examinations at geriatric clinics due to the common observation of Alzheimer's patients to show impairments in orientation of their geographical environment.

The neuropsychology of the static and spatial dimension includes both clinical (lesional) as well as imaging studies. Milner and collegues showed showing a right hemisphere dominance for spatial information (Milner, 1971; Smith & Milner, 1981).

1. 6. 4. The Complexity dimension: from item memory to schematic memory of different forms at higher nodes of the hierarchical structure of memory

Memory for item information is the lowest level, followed by associative, serial, and more complex memory. Ben Murdock's account of memory, that actually was the prime inspiration for the approach taken in this book, will often be cited here, as will Craik and Lockhart, the theorists most often associated with the view of levels of processing in memory or cognition. The complexity dimension is special due to its more general character. Therefore we don't see many examples of trying to measure it using specific tests.

1. 6. 5. The Agency dimension

The agency dimension relates to the *amount of personal involvement* in the material to be remembered, or more precisely: how the action of the individual at the event to be recalled assists at time of retrieval. Because the involvement of the self is of prime importance here, studies in the self biographic memory area will be reviewed in this chapter, due to the

importance of agency in the recollections of one's personal history. Absentmindedness may be a negative side effect of low level of agency.

The agency dimension is augmented by emotional involvement. However, emotions are not actions, although they play a central role in motivation. This dimension may also be found among animals. It relates to the positive or negative affection associated with the to be remembered material. A long tradition in dynamic psychology has studied this dimension, although using a different terminology, and in the behavioural learning theory positive and negative reinforcements play a central role.

There exists very few direct tests of agency, but on a higher level in combination with other dimensions autobiographical, and other episodic memory tests involve aspects of agency.

1. 6. 6. The Narrative dimension

The chapter on the narrative dimension would not have been included was it not for the studies by Susan Kemper (1993) on the prediction of memory problems and dementia from data on narrative competency up to 40 years preceding the diagnosis. Under the narrative heading there will be a relatively thourogh conceptual analysis of the differences between one of the levels of complexity and the narrative. The narrative dimension is directly involved in *meaning* and *semantics*. Because meaning involves verbal processing on a level, memory research has to study people's linguistic habits as well as their understanding of rhetoric, and how they promote memory of their past experiences. "Det dunkelt sagda are det dunkelt tänkta". The cited expression has a bearing on the propositions in the philosophical section (1.1) above, because the recollection of an episode is dependent on how the individual is capable to catch it, and thus describe it, not only for others, but also for him- or herself.

The critical reader may in fact see that there is a close resemblance between the complexity and the narrative dimensions. Both of these dimensions are based on a hierarchical way of representing memory. The fundamental difference between the two is that complexity refers to any systematic hierarchy in memory, while the narrative dimension refers to the hierarchy found exclusively in linguistic and narrative structures, i.e. our ability to tell and remember anecdotes, stories and novels.

The ability to remember foot-ball- or atomic tables is not the same as the ability to remember and recall a story or the plot of a film. Without being overly simplistic we may say that the

narrative memory dimension makes us able to give an answer to the question *"How come?"* or *"Why?"* while the complexity dimension is related to "What?" at different levels. There may be a positive correlation between the two dimensions, however, but there is probably much more to this issue than interest or general abilities such as spatial, numerical, and verbal comprehension. We will delve deeper into this issue when we approach these dimensions more extensively in the chapters on the Complexity and the Narrative dimensions.

There may be a qualitative difference between humans and animals regarding both the narrative and the complexity dimensions due to the ability of humans to represent linguistic entities.

There are a few more or less directly devoted tests of narrative memory used in memory examinations.

1. 3. 7. The Interest dimension

Memory always depends upon the interest of the person towards the event or the subject to be remembered, because if we have interest in it we will pay more attention to it at the time of perception, and consequently we will bing into consciousness more attributes related to it. Attributes may then function as cues to the subject or event at the time of recall or recognition according to the attribute theories (Lockhart, 1969; Bower, 1972).

When we are interested in something we constantly more or less consciously gather information about a subject. A beginner in golf may recognize a couple of great figures in the game, but a keen golfer is able to tell more than 30 big names in the sport without any effort. This is also the case for football fans, who may easily not only say the names of at lest half of the teams in Premier League and Championship, but also give details regarding the latest results, transfers or characteristics regarding palying styles of different teams or their coaches.

We remember that which evoke our curiosity but why and how people start to build interest in anything is hard to explain. It would be a great fortune for teachers if they knew how to cultivate interest in shool subjects as easy as different sport heroes or pop music stars engage youths in all kinds of seemingly non important details.

The author held several courses in memory training in the 80s and also a few courses later. The main focus was on the method of loci and other mnemonic devices, and in all classes there was also an introduction to memory theory in general. At almost all of these occasions there was a participant who raised the question about the importance of interest. Unfortunately the issue was soon dropped, not due to its unimportance, but rather due its selfexplanatory nature.

There is a vast literature of experiments showing that interest plays a greeat role in learning, that we will return to in chapter 9 about this dimension. The arguments for interest as a dimension of its own are also given there. It will be argued that interest may neither be easily reduced into motivation, i.e. being close to the effort side of the Automatic vs. effortful dimension, nor is it just a part of attention. Instead interest may awaken attention.

The interest dimension may be measured directly by self reports.

1. 3. 8. Numeracy - magnitude dimension

The most common types memory tests are lists of words, digits or other material to be recalled immediately or after a prescribed retention interval. The limit of the number of such items may vary between types of stimuli, as well as between modalities.

1. 3. 9. The Imagery/Interference dimension

One of the most studied factor on memory loss or forgetting is interference. In fact the interference theory has had enormous impact on memory research for decades (McGeoch, 1932, Anderson & Bower, 1973; Underwood, 1973) This diemension is often seen as the opposite to memory decay in explaining the phenomenon of forgetting, where decay was often seen as the immediate effect of time a such. Although interference is thus a negative factor for the mnemonist, it is included as one dimension, because the real opposite to interference is the ability to resist interference. The dimension would therefore rather be labeled resistance to interference. It may be noted that other negative factors to memory such

as alcohol, cannabis, stress, trauma, etc are not included in the current account of memory dimenesion because they are *external* to the cognitive system during learning or memory retrieval processes.

Interference may be proactive or retroactive. In proactive interference items to be recalled may be similar to information encountered before the to be learned items. Earlier information would thus disturb the learner. During a long term experiment I solved a crypt crossword, and later had to recall the digit-letter associations that were involved. A common experience for me was then that if a conventional crossword had been resolved earlier that day it became difficult to keep them apart, and target words could be confused with words from the conventional crossword.

Retroactive interference occurs when you have to recall a list of words, and subsequent words are interfering with words earlier in the list. It is obvious that both proactive and retroactive interference might as well be substituted by the temporal factor: difficulties regarding later items might simply be explained by a short term memory impairment, and retroactive interference would in a similar manner be explained by inability to retain information at longer interval regardless of other intruding information. A large amount of memory studies have been directed to the solution of this issue (Underwood, 1966; A relatively recent study by our group based on clinical and control group data from the Rey-AVLT test concluded that resistance to interference could account for a large variation of the data (Fernaeus et al, 2014).

The interference dimension may be measured using tests using concurrent stimuli, for instance the simultaneous study of two lists including the same type of material. The interference factor may also be observed directly by inspection of the serial recall curve after list recall.

1. 6. 10. The Automatic vs effortful dimension

It is an often proved fact that effort is needed in order to retrieve information that is not immediately available. Another fact is that we often recall things automatically without even trying.

The attentional energy or effort engaged in the process of remembering is also subjective in the sense that the individual allocates as much mental energy as seems necessary to pursue the retrieval process. If the retrieval seems difficult, we may disengage in pursuing it. More precisely: the number or kind of attributes involved in the mnemonic process will demand more or less of the mental resources available, and this goes to a cost: less attention will be left for other tasks. The sensory material as such needs to be phenomenalized, or in other terms: represented, in order to be available for later recall.

The word fluency tests have been shown to include both automaticity and effort (Fernaeus, 2001, Fernaeus & Almkvist, 1998). Tests of incidental memory as well as priming procedures measure the automatic end of this dimension, and the effort invested in learning or recall may be measured by experimental or testing procudures involving both levels of difficulty and incentives.

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