CHAPTER 1

MEMORY AND REMEMBERING

To begin at the beginning, we should try to characterize the domain of our concern, namely, memory and remembering. What is a memory? Is it a place, a repository, a storehouse, or a state, a set of dispositions or abilities? What is remembering? Is it an act, a drawn-out process, an automatic reflex to a question, is it a striving or an achievement, and what are its objects? We may begin to frame our replies by listing just a few of the kinds of things that people claim that they can remember. We can remember an event, an action, a person, a place, a feeling, a procedure, a recipe, a poem, a melody, a foreign language, an emotion. We can remember our sensory experiences—the appearances of things to our senses of touch, smell, hearing, taste, and sight. We can remember our thoughts as well as products of our imaginations. Although memories are typically thought to refer to past events, they can refer to present or future events ("I just remembered that I have a doctor's appointment tomorrow"); we can also remember timeless laws or truths of mathematics and logic.

Just as there are many different kinds of things we remember, so are there many qualitatively distinct ways in which we remember. For present purposes, we will distinguish between memories represented as images, as propositions, as skills, and as emotional responses to signals. Let us consider each of these briefly.

**Imagery.** This is the standard label for "mental pictures," revivals of impressions, or re-activation of perceptual experiences. Mental imagery is supposed to be specified for the appearance of concrete objects and events; the appearance refers to how something looked, sounded, or felt at a "primary" uninterpreted level, if that is possible for memories. Imagery is also used to
remember any images we had earlier put together in imagination. Of course, we
 can also describe concrete objects or events and store those verbal descriptions
(or propositions). A currently controversial issue is whether there is much
usable "appearance" information that has not already been translated by the
perceptual apparatus into propositions, at least at the level of conceptual
knowledge if not in overt sentences. We will avoid that issue for now.

Propositions. This is factual memory, remembering that proposition "p" is
true; remembering that event X happened, or that s-and-so was the case, that
object Y had property Y, that X had relation R to Y. It includes timeless facts or
laws of science. It may also include descriptions of sensory appearances, such as
a characterization of what something resembled (e.g., "Caesar had a large hawk-
nose"). Although remembering a proposition may entail the ability to supply a
descriptive sentence, it is more than remembering that sentence since the
proposition can probably be paraphrased. Similarly one may remember how to
utter a sentence (as in unfamiliar language) without in the least being said to be
remembering the meaningful proposition which that utterance denotes.

Skills. Regarding our psychomotor skills, we speak of remembering how
to do something such as bicycling, swimming, or hitting a baseball. In such
cases, although we can speak of our ability to do something, the ultimate test of
remembering is that we actually perform the skilled response. Psychomotor
skills may perhaps be arranged along a continuum according to how easily they
can be symbolically coded and described verbally and effectively to another
person. How to navigate by the stars or how to fry an omelet, for instance, are
skills that are easily communicated to adults. How to play a piano, or to dance a
ballet, or to sing operatic area is beyond effective communication. The more
"motor" the skill, the less the communicable propositional content there is to it.
Our ability to speak and understand language is, of course, one of our greatest
skills, involving some tacit (unconscious) accounting of or knowledge of (memory for) the grammatical rules of our language. Our knowledge of rules of logical deduction may be tacit in the same sense as our knowledge of grammatical rules. In these cases, we can produce and discriminate between grammatical and ungrammatical, or between logical and illogical arguments, though we are unable to state the discrimination rule in its full generality. Many of the skills acquired in education are procedures, sets of instructions on how to do something, to achieve some result, to solve some problem. We remember how to compute successive powers of a number, how to invert a matrix, how to integrate a differential equation, etc.: these are all "situation-action" pairs or "productions" of a special kind to be analyzed later.

**Emotional signaling.** People are capable of a wide range of emotional responses, and these can become associated with a range of stimuli (signals) which were formerly ineffective. It is commonly supposed that this associative process follows the principles of Pavlovian ("classical") conditioning. Included here would be our feelings of fear, ennui, nausea, joy, depression, sexual arousal, anxiety, and aggressiveness; all of those can come to be signaled by learned cues. For instance, the thought of eating a particular abhorred food can make us sick to the point of vomiting. Music can make us weep just as can poetry and descriptions of sad or joyful scenes. Movies regularly arouse the full range of our emotions; the predominate emotion they arouse is used to classify them as a horror movie, a tear-jerker, a comedy, a tragedy, as pornography, etc. It is often claimed that we may have emotional reactions in a situation to subtle cues which we are unable to identify and label. Some neuroses are characterized not only by this inability to describe the controlling environment, but by the further inability of our description to modify the reaction to it.
To summarize, then, we have divided ways of remembering into images, propositions, skills, and emotions. The first two and the last might be said to be memories of our prior states of mind—a revival of a perception, an interpretation or thought, an emotion. They include knowledge of words (the internal lexicon), knowledge of individuals, and universal concepts. The skills category includes not only motor skills but also intellectual ones such as procedures which use linguistic "rules" in speaking and understanding speech, or which use implicit conceptual knowledge (e.g., that Agents perform Actions, that Actions and Agents in communicating meaning have Properties, Objects and Instruments). We may also include under skills those procedures (whether innate or learned) which enable us automatically to make logical inferences; for example, when we assent to the reasonableness of "Spinoza must have had an elbow," despite having never heard that proposition before, we are instantiating an inference rule, namely, "A property of all members of a class is also a property of any arbitrary member."

**Autobiographical Context**

In the prototypical illustrations of memory, namely, when we care remembering an event we witnessed, we have a strong impression of having been there. We remember ourselves as witnesses. We not only remember the Stanford-Cal football game of 1972, we remember where we sat, the people sitting next to us, our emotional reactions during the game, and so on. In short, we can expand the causal context surrounding the event in questions and our witnessing of it.

Although this contextual expansion is a potential feature of many of our personal memories, it must be admitted that we can know and remember many facts about ourselves that do not have this kind of personal immediacy about them. Many of the facts I know about my early childhood are propositions
about those times told to me later by my parents (e.g., that a dog bit my hand). Although I was a witness to such an event, I do not recall myself as a witness to it. My knowledge in this instance is logically on a par with my knowledge that Brutus stabbed Caesar. So, personal autobiographical knowledge need not have that subjective feeling of our having been a witness to the scene.

Consider the proposal that a hallmark of a memory is that we can remember the context in which we first learned that information. For instance, in searching memory for information about a familiar face, we say to our prospective acquaintance "I know I've met you somewhere before; weren't you at the AMA convention in Hawaii in 1972?", and we try to recall contextual information that will support our initial (but uncertain) feeling of familiarity with the face along. As further examples, people with alleged "photographic memories" report being able to recall where on a page they read a particular fact; we may remember an occasion on which our parents told us a particular fact about our childhood. And so on.

Such examples do not imply that when we are remembering a fact that we are only remembering the occasion upon which we learned it (which is absurd); nor is it even necessary that we remember that original context of acquisition. Our behavior often exemplifies use of remembered facts, laws, or relations where the acquisition context is irrelevant, if not altogether irretrievable. For instance, in talking or reading, we access lexical memories thousands of times without any ability to indicate when we learned a given word. The point is that although autobiographical context may be sufficient feature of a memory, it is clearly not a necessary feature.
CHAPTER 2
POSSIBLE DEFINITIONS OF MEMORY

We will consider several plausible definitions of the concept of memory, and will try to indicate where they are inadequate in some respects. The venerable Dean of American Psychology, William James, defined it as follows:

"Memory is the knowledge of an event or fact, of which meantime we have not been thinking, with the additional consciousness that we have thought or experienced it before."

There are a number of clear instances of memories which are excluded by the above criteria, there are other phenomena which are included by these criteria that are not normally thought of as memories. First, by focusing on factual knowledge, James excludes motor skill, linguistic competence, memory for vocabulary items, emotional reactions, and so on. Second, "memory" is said to require absence of the item from thought for a brief time. But were someone to remember a telephone number over a minute or so by continually rehearsing it to himself, we would doubtless refer to his recall as a memory, albeit a "short-term" memory. Third, as noted before, we may often remember a fact (e.g., Newton's laws of motion) without being aware of remembering anything from the past or an event of the past, without being aware of having thought of it before. We simply retrieve the laws upon demand without any added tinge of "pastness." Fourthly, the criteria are too broad insofar as they appear to qualify déjà vu, that his "memory" of having been in this situation before is in fact in error.

An alternative definition of memory identifies it with "knowledge of our own past." But this definition is inadequate for several reasons. We remarked earlier that timeless facts or non-autobiographical facts of history can be clear
examples of memories, but neither can be construed as knowledge of one's personal history. Also, I can know things about my own past without remembering it; for instance, from present thinking about my present knowledge, I can deduce a fact that must have been true about me at an earlier time; yet, I cannot be said to be now remembering this new fact about my past. Of course, the proposed definition also does not apply to skills, to remembering how to do such and such.

Passing on to another attempt, consider the "systems" approach which would define memory as "a system for storage and retrieval of information." The immediate problem with this proposal is that it includes far too much. On this account, books are memories, as are wax molds, notebooks, scratch-pads, tape recorders, magnetic cores, films, videotapes, and so on. Aside from the fact that these lack certain essential biological components, these memory-candidates fail to qualify in this respect: (1) they passively record and passively retain faithfully the sequence of symbols or "state settings" affixed to them, and (2) there is not way to access the contents of memory about an object except by scanning for all the physical locations in which it occurs on the tape and interpreting the information to either side of those token occurrences. Even the most faithful tape recorder needs an interpreter to decide from "noise" into "meaning." Perhaps the principal failing of this "systems" definition is that it fails to describe differences between the acts of remembering, of imagining, of thinking, of dreaming, of hallucinating, and so on. This is partly what James was attempting with his reference to the "pastness" of the experience of remembering.

As a final attempt, we may define "remembering" as "the act of retrieving information from a biological "storehouse," the information having been recorded there as a result of experience, with the retrieved information being
used to support or to guide current performance or current mental activities. The act of retrieval may or may not be accompanied by awareness of pastness, of the context of learning of the information, or even awareness of the retrieval act itself. This definition seems reasonable enough until we being to quibble over the meaning of the significant terms of kinds of things qualify as acts? Only achievements? Or do attempts count as acts? If I try to remember a name but fail after examining a number of candidates suggested by my memory, have I not been remembering all those intermediate but rejected candidates? What is retrieval? What is information? What are its dimensions? What is experience and what does it mean to say that "information about experience is recorded?" What's a biological storehouse? These are some of them; many questions that spring to mind upon reading such a definition. They are questions that theories of memory (as well as theories of knowledge) try to answer in a slow, circuitous manner. Much of this text will be elaborating these notions of a biological storehouse, the structure of information recorded there by experience, and how it might be retrieved to guide mnemonic performance.

Moving on from these inadequate attempts at definition, we should note that the concept of memory is a very open-textured, polymorphous concept; although we have reliable intuitions about the usages of the terms, to which we will return later, a full definition seems out of the questions at present.

Knowledge and Mistaken Memories

In every day language as well as in the law courts, the fact that someone remembers witnessing some event is taken as presumptive evidence that the event occurred. The testimony of eye witnesses (e.g., "I recall seeing the defendant stab the victim") is justifiably strong evidence. Thus, for an assertion p, the remark "I remember " implies "I believe p" or "I know p" and is taken as presumptive evidence for "p is true." The verb "remember" in this linguistic
environment is signaling the listener regarding the strength of your belief in the assertion; this is a similar function to that carried by other illustrations such as "I guess that, imagined that, dreamt that, made up the story that, know that, am positively certain that,...". The verb comments upon the nature of the evidence or certification you think you have for the assertion which follows.

Although we may agree that remembering relies upon the use of some kind of past information, we may ask about the status of memories as certificates of knowledge. Philosophers suppose generally that self-referential remarks, such as "I have a toothache, are beyond doubt or dispute; they are "incorrugible" or incapable of being corrected. But consider malingering: in malingering, a person's self-referential remarks are not construed as veridical reports upon his inner state but are rather instrumental means for achieving other goals (e.g., the child who pleads illness is allowed to stay home from school). The distinction between the two cases is drawn partially according to (a) the situations that elicit the utterance and (b) the reinforcing consequences that follow upon the statement.

Consider now memory claims such as "I remember that the Transylvanians bombed the United Nations building in 1972." Are such statement to be construed and analyzed along the same lines as "I have a queasy feeling in my stomach?" Are such memory claims incorrigible? Evidently not; we dispute our own and other people's memories all the time (trial lawyers make a habit of it). We dispute a memory claim by labeling it as something else, perhaps thereby explaining it. To a disputed memory claim, we may attack the alleged remembered: "That's a lie; you're only making that up to save your skin." We may charge that he is mistaken or exaggerating or only partly correct or that he has misinterpreted past events. We may give evidence against the claim (e.g., we destroy an "alibi" in a criminal case), and we reinterpret the claim
by saying "You've only imagined so and so" or "Your imagination has been playing tricks on you." So whereas self-reference statements can be either veridical or a lie ("malingering"), memory claims may be either veridical, a lie, or mistaken. They are not incorrigible.

Of course, there are quantitative variations in accuracy of a recounting (remembering) of an event or complex collection of information. We would not apply the label "liar" to a person who claimed to remember the Declaration of Independence, but then made two small errors in reciting the whole text. We would say that he was "substantially correct." To note a small complication here, a person may remember exactly the copy of the text he saw, yet be mistaken in his claim simply because that text was not a correct copy of the Declaration of Independence.

A host of complications also arise upon further digging into what we mean by "knowledge of an event" and "remembering an event." The problem is that events have many different descriptions or interpretations depending upon the person witnessing the event. There is not neutral "assumption free" language in which to describe events; there are just many levels. I can describe a given event as "Mary slapped John," or "Mary moved her arm so that her hand made physical contact with the left cheek of John"; or "The brain of a creature identified as Mary sent out specific efferent signals...(to be filled in technically)"; I can describe the event as "Mary asserted herself" or "Mary struck a blow for women's rights;" in other contexts and cultures, I might interpret the act as an affectionate love-tap and a hospitable invitation.

So, the event has many descriptions or interpretations, and it is these interpretations ("perceptual judgments and inferences") that presumably are stored in memory as internal representations of the event. This fact leads to several difficulties. First, it is just not correct to say that a person does or does
not remember an event; rather, one is forced to conclude that the person may not remember the event-as described at a particular level at the time his memory is tested. Thus, the query "Tell me the last event of 'women's consciousness-raising' which you witnessed?" may fail utterly to bring forth any recollection of the event in question. But if the retrieval query were couched in more specific terms or were described at a different level, then it may make contact with the description sorted in the respondent's memory, leading to his recollection of a particular interpretation of the event. The point is that we cannot cite incontestable evidence that a given event has been forgotten; rather we can only show that at particular times, particular retrieval queries ("partial descriptions") were ineffective in reinstating a fuller description of the event in question.

A second corollary is that two people's memories of the same event may disagree because of differing interpretations of it. What one witness recalls as a pistol shot, the other remembers as a car backfiring; one recalls burglar noises at the back entrance whereas another recalls noises of a cat rummaging in the garbage cans. There are often ways to adjudicate such conflicting claims, and it is the standard ways we have of citing evidence for or against any claim (e.g., a scientific hypothesis). We find the bullet hole, or find the cat in the garbage cans the next night, or learn that one reporter is unreliable or has a paranoid imagination, or whatever. Often the necessary evidence is unavailable, so the conflicting interpretations simply remain unresolved. If the issue is important enough, we may call in a jury to "weigh the evidence," but we do not thereby guarantee the truth of the decision.

Although we have been citing some reasons for doubting one's memories, it is nonetheless undeniable that our memories are often accurate. It might be useful to enumerate a few criteria we typically use as benchmarks for judging a presumptive memory claim. These are criteria for properly applying the term
"remember" to cognitive memories. As a prototype, consider the claim "I remember seeing Stanford's football team beat Ohio State in the 1972 Rose Bowl game." some criteria that this experience satisfies are as follows:

(1) **It feels to me like I'm remembering.**

This feeling itself may be a primitive "tag" or marker (like perceptual qualities) that is not necessarily reducible to a feeling about the pastness of the event.

(2) **There's evidence that the event in question happened and that I was in a position to have witnessed it.**

The normal function of one's perceptual apparatus is assumed. Demonstrations of one's powers of extra-sensory perception, for instance, might expand the range of what we consider "witnessing positions."

(3) **I can elaborate or expand the causal context in which the event occurred.**

I can relate what happened before, during, and just after the event, and add personal autobiographical notes. The more my accounts agree with that of others, the more sure I become that I am truly remembering.

(4) **I could engage in effective actions that require knowledge of that event.** For instance, I might go collect a bet I made on the game. This criterion of "appropriate behavior" has been the standard one within behavioristic accounts: I remember where the pharmacy is if I can find it unerringly when next I need a prescription filled.

Generally, we say that a memory claim is justified when any of these criteria are met. We become more confident about the claim the more criteria that it meets. Testing whether someone is "really remembering" is therefore a
little like collecting evidence for a scientific hypothesis; the more evidence we get consonant with that claim, the more confident we are that its true rather than mistaken. (But compare different indicators like recall vs. recognition, primings vs. explicit memory ...? etc.)

The Grammar and Pragmatics of "Remember"

We should note in passing what is the typical grammatical role of remember and when the term is used. Remember is a verb denoting an activity or performance; it is typically an "achievement" word, denoting an activity or performance; it is typically an "achievement" words, denoting successful completion of an act. Thus "John remembered to let the dog out" is taken to imply that the dog is out; moreover, it presupposes that he wanted to let the dog out or at least that the dog is supposed to be out. The use of forget, the obverse of remember is a performance verb, then memories are the alleged objects of that performance. It is not clear that the relation of remember to memory should be construed along the lines of the pairs breathe-breath, perceive-precept, conceive-concept, think-thought, or along the lines of manufacture-product, dig-hole, and build-bridge. The exact interpretation of the relation depends on one's theory of mind, whether one thinks of remembering as an ongoing process which has products which we label or whether remembering is analogous to revival of mental presentation or image which is then "read off" by a conscious process. These correspond very roughly to the views that memory is either a representation system or is a set of procedures for reconstructing plausible answers from a dynamic storage base.

To return to logical analysis, remember can always be interpreted as a "disposition" term. It names a "competence," possession of an ability, the cousin's name" means that under appropriate test conditions John can "actualize" the memory in an acceptable manner, by recalling or recognizing the name of his
cousin. The occurrence of such performances is, of course, the best possible evidence that John "has" the memory in question. Such dispositional terms, naming "abilities," characterize the stock of trait terms the layman uses to describe his own mental states and the behavior of others.

Just as remember ascribes a disposition to someone, so does forget: "I have forgotten X" means "I cannot presently recall X although I might be able to do so later or under better retrieval condition." Further, forget presupposes that I once had learned the information in question. Forget X differs from did not learn X or "was never exposed to X" in recounting a different history leading up to the present failure to remember.

A final word here and that regards the pragmatics of the social communications in which we use the word remember. Most of the time the avowal "I remember..." is suppressed just as is the avowal "I say to you...;" they waste time and are assumed in social conversations. A typical exchange relies constantly on memory without any heed:

Question:  "What's your name?"
Answer:    "John Smith."
Question:  "Where were you last night?"
Answer:    "At the Mets-Pirates baseball game."
Question:  "Who won?"
Answer:    "The Mets. Seaver shut out the Pirates three to nothing."
Question:  "Does that put them in first place?"
Answer:    "Yeah, a full game in front."

All such answers rely on memory, but neither Questioner nor Answerer feel called upon to note that point. This is typical.

So, when do we ask "Do you remember X?" Apparently remember is used only when there is some doubt about the issue, when there is a good
chance that you won't remember. It is as though we construct an implicit and rough "psychological model" of the person we are talking to, and within that model estimate the likelihood that he will have forgotten something. We then use "remember" to ask only about those facts which we estimate he is likely to have forgotten. We say "I know you were introduced to many people last night; can you remember my name?" We can use remember to indicate our model of the other person's mnemonic ability. It is normally an insult to ask someone whether he can remember his own name (implying "He's so dumb he can't even remember his name"); but the question is not insulting when addressed to a man suffering from brain injury or various forms of amnesia. In similar fashion, when we say "I remember X" it is typically to explicitly mention and label for our audience the nature of the support we have for the proposition asserted. We do not say as we sign our name "Wow, I've just remembered my name again!"
The point is this: although it is natural to think of remembering along the liens of removing mental articles from a memory storehouse, the term is applied in pragmatic settings only when conditions are such that the removal deserves special attention.

THE REPRESENTATIONAL THEORY OF MEMORY

Running throughout the foregoing discussion of the concepts of memory and remembering has been a set of implicit assumptions about what a memory system is. These fundamental assumptions provide the core of the representational theory of memory. According to this theory, in remembering something, we are aware of (perceiving, apprehending) something at the present moment that represents or symbolizes some experience from the past. This "representative object" serves as the sign, symbol, or picture of the former event that is currently before memory. It is traditional to refer to these memory objects as "sense impressions" that have been stored in memory. The underlying
assumption that memory is a storehouse goes back to at least as far as Plato (in
Theaetetus). St. Augustine (in Confessions X, 13) wrote of "The great cave of
memory" wherein images are laid away, to be "brought forth when there is need
for them." In the Essay Concerning Human Understanding, John Locke said
that memory is "as it were the storehouse of our ideas," in which ideas are "as it
were laid out of sight." He added "this laying up of our ideas in the repository
of the memory signifies no more but this--that the mind has a power in many
cases to revive perceptions which it has once had, with this additional
perception annexed to them, that it has had them before." The standard view is
that the memory-image of a past perception is not that perception itself but a
numerically different perception which resembles or in some way represents the
past perceptions. Moreover, it is often assumed that memory images carry with
them "informational tags" of pastness (or autobiographical witnessing) and
believability, enabling the contemplator to discriminate (a) a memory from a
present perception, and (b) a memory image from an imagined figment.

A schematic illustration of these distinctions is shown in Figure 1.

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Insert Figure 1 about here

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A sequence of stimulus event A, B. ...flows on through time (left to right). These
stimulus events give rise to corresponding sensations $s_A, s_B$ unless the input is
blocked (as is event C) because attention is otherwise occupied. The sensations
may be copied into long-term memory (the $m_A$'s). The $m$'s corresponding to
temporally adjacent sense datums may also become associated to one another.
Also, $m$'s that are sufficiently activated by associations may themselves be
entered into the conscious processor, where they are presumably interpreted as
memory-images with their particular tags of familiarity, pastness, and so on.
The diagram illustrates a brief history of sensations and associated memory-images passing through the conscious processor; the "present moment" in consciousness is represented by the "window" at the right. This catches the alleged prototypical act of memory in flight: stimulus event $A$ with sensation $s_A$ has just recurred, leading to activation of memory element $m_A$; by a formerly established association, memory element $m_A$ is connected to $m_B$, so that $m_B$ will now become excited and will be entered into consciousness as a memory image stimulated by $A$. That, more or less, is the way that John Locke and David Hume saw the matter. In some respects, some current versions of memory theories have not advanced much beyond this hypothesis.

**Problems for the Representational Theory.**

Although the Representational theory has maintained its dominance in common-language descriptions of memory, philosophers have raised several complaints that create problems for this general account. A first complaint is that the theory of sense-data contained in this approach is very naive and probably mistaken. Perceptions are rarely in one-to-one correspondence with stimulus events. Rather, depending upon the contextual situation and the setting of the person's "cognitive interpreter," a given stimulus input $A$ may give rise to several quite different interpretations or perceptions. Information in memory combines with sensory information in determining the final perceptual outcome. Beyond these simple arguments against the naive doctrine of sense-data, there have been standard philosophical arguments which support skepticism and doubts about the correspondence between real-world events and sensations.

A second complication is this: how is it that a recurrence of $s_A$ in consciousness (in the window of Figure 1) is compared to elements in memory, and what causes it to make "contact" with or arouse its corresponding memory cell, $m_A$? One must remember that, on the copy theory advanced, there will be
literally hundred of thousands of such memory cells, \( m_j \); so, how does \( s_A \) find the \( m_A \) needle in that haystack? How does the system even know to "look" for an \( m \) corresponding to \( s_A \)? It is well to pause a moment to appreciate that these are real problems for the Representational theory, and they strike at the fundamental assumptions needed to make the system go.

The issue of "when does the system look for an \( m \)?" is typically answered by saying: "It always does so automatically and unconsciously, so there is not problem of deciding when or when not to search." This is not an entirely satisfactory answer; for example, modern computer theories of memory and thinking (like the General Problem Solver of Ernst & Newell, 196) maintain a firm distinction between contents of the conscious processor which are to serve as cues to search memory versus contents which are to be manipulated, added to, transformed, copied, or whatever. That is, what is to happen to a given content in the conscious processor (CP) depends on an instruction in the executive program which supervises operations within the processing unit.

Perhaps the principal difficulty cited above is this: how is the system to know that the memory-image, \( m_B \) say, is a "copy" of \( s_B \) and that it stands for or corresponds to \( s_B \) (and indirectly event B)? How does the system come to learn that \( m_B \) and \( s_B \) are correlated? Where is the "memory that carries the fact of their covariation?"

You may notice that this skepticism regarding how the system knows the correspondence between \( s_j \) and \( m_j \) is just a translated form of skepticism about perceptual referents, how we ever learn the correspondence between real-world stimulus events A, B, and perceptual codes \( s_A, s_B \). The problems posed by the skeptic are similar to the two cases, and require careful answers. Putting aside for now the question of the relation of events to sensory experience, let us
address ourselves to the skeptic's questions regarding the correspondence between perceptual experiences ($s_i$) and later memory images ($m_i$).

There would appear to be two ways to answer. One is to suppose that the $s$ to $m$ correspondence or mapping just exists in the innate wiring of the brain, and there simply is no problem of their intercommunication which has to be further explained. This would be similar, in modern computer memories, to having a so-called "content-addressable" memory, wherein the contents of $s_A$ directly specify the address or location of the $m_A$ cell to which other information may be attached. The problem then is to explain why the system would ever fail to recognize a recurrence of event $A$.

A second approach assumes that the $s_i$ to $m_i$ mapping is not innate, that it is arbitrary, and must be learned by the system, much like humans learn Morse code (illustrating a mapping between letters and dot-dash sequences). What is needed for this task is a device which will accumulate inductive evidence regarding the temporal covariation (autocorrelation) between $s_i$ and $m_i$ in the conscious processor. A sample "induction game" might be played with after-images, or with repeated "looking at object X" followed by trying to visualize $X$. Conceivably, such games played during a child's early development could establish the necessary correlation between $s_X$ and $m_X$. But if the mapping is really arbitrary (as is the mapping from letters to Morse code), then all ($s_i$, $m_i$) pairs would have to be induced from slow accumulation of fortuitous auto-correlations—which seems absurd. So perhaps we must remove the assumption of arbitrary mapping, and assume instead that there is some sort of principled resemblance between $s_i$ and $m_i$, some principle that can be inferred from a fortunate collection of particular/auto-correlations. Although this might solve the $s_i$-$m_i$ correspondence problem it does so only by invoking certain mechanisms that are not standard in the traditional theory. These are (1)
accumulation of auto-correlations \((s_i(t), m_i(t+A))\) at indefinite time-lags, and (2) abstraction of the principle underlying the mapping (e.g., "resemblance" along particular dimensions). It is this principle of resemblance or structural similarity that has been used repeatedly in psychological theories to explicate how a current perception \(s_A\) selectively retrieves a memory of its earlier occurrence \(m_A\).

Although the foregoing skeptical complaints have received considerable attention from philosophers, psychologists and computer scientists working on models for perception, memory, and cognition have tended not to concern themselves that much with the arguments. They tend instead to be more influenced by pragmatic considerations and synthetic arguments. If I can write a program to help a visually-guided robot move about and solve problems in a realistic visual environment, then I have somehow by-passed the issue of the unreliability or unlearnability of the word-to-perception correlation. Similar arguments can be made from simulation programs for memory—that they in one or another way finesse or solve by fiat the difficulties raised by the skeptics.

Thus, the Representational Theory is still the predominant orientation towards memory as it is studied today. Much refinement has gone into the primitive theory as stated by philosophers centuries ago. Some instances are the following:

(1) The complexities of perceptual encoding of stimulus events have been appreciated; perception is seen as an achievement of active processes which combine sensory input with memory schemata (and expectations) so as to construct a plausible interpretation of the scene.

(2) The process of recognition memory, how current input accesses information stored in memory, has been elaborated in greater detail.
(3) The nature of the information stored, its logical or propositional structure, has been enriched far beyond what was envisaged by thinkers of the last century.

(4) The concept of an interpreter or mechanical "executive," that controls actions taken dependent on the contents of the conscious processor, has ushered in qualitative differences in the class of control processes typically assumed in memory models.

(5) The abilities of the system for abstraction, inference, and induction of regularities in experience have been developed in more recent models of the mind.

These are a few of the exciting new developments within current studies of memory and how it is used. Later, we will begin to spell out many of the details of these theoretical developments.