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Bergson's ''Matter and Memory'' and Modern Selectionist Theories of Memory

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Bergson's reflections (in *Matter and Memory,* 1896) on memory anticipated development of modern selectionist theories of memory. Selectionist models offer new and potentially useful approaches to a theory of remembering. On the model of natural selection, these selectionist theories require at least two processing components: a device which generates a range of memory representations and a selection process which preserves a subset of those representations. Bergson shows how the subjective experience of remembering might be understood within a selectionist framework.

INTRODUCTION

Henri Bergson (1859–1941) was one of France's most prominent turn-of-the-century philosophers interested in problems of psychology. The range of his psychological interests was astonishing and included consciousness, perception, habits, memory, the aphasias, dreams, laughter, intuition, time perception, brain functions, multiple personality disorder, the deja vu experience, and much else besides. He was one of the first philosophers (indeed one of the first scholars) to use data from neuropsychological dissociations to illuminate problems of cognition.

In this paper I want to discuss some of the themes Bergson explored in one of his earliest and greatest works: *Matter and Memory* (originally published as ''*Matière et mémoire: Essai sur la relation du corps avec l'ésprit,*'' Paris: F. Alcan, 1896). Although Bergson's major concern in that work was to develop a solution to the mind–body problem, he also apparently felt obliged to develop a detailed theory of memory. I hope to show that Bergson's memory theory is ''selectionist'' or Darwinian in character and that it compares well with modern selectionist theories of memory and ''learning'' such as those proposed by Young (1979), Edelman (1987), Changeux and Dehaene (1989), and others. Bergson's work anticipated these modern

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approaches to memory by almost a century. I also hope to convince modern students of cognition that selectionist models might be usefully applied to problems of memory.

While other investigators in the cognitive sciences have successfully used selectionist approaches to illuminate problems in their specific areas (e.g., on language: Piatelli-Palmarini, 1989; Chomsky, 1988; conceptual and cognitive development: see papers in Mehler & Fox, 1985; color vision: Varela, Thompson, & Rosch, 1992; perception: Shepard, 1984; creativity: Campbell, 1960; theory and epistemology: Popper, 1963; social exchange/reasoning: Cosmides, 1989), cognitive memory researchers (with the exception of Edelman) have not. It is, of course, an open question as to whether selectionist approaches will illuminate anything in the area of cognitive memory theory. There are several reasons, however, to think that they might illuminate problems in memory (see below). The point is that they have not yet been tried. Bergson's work might be helpful to those interested in applying selectionist ideas to memory phenomena.

Selectionist Theories

Selectionist models require at least two distinct processes: a generator of variation that produces an array of elements or traits which become the raw material for the selection process, and a selection process (Changeux & Dehaene, 1989), which acts to reduce the number of elements in the initial array (Ward, 1989; Plotkin, 1994). In general, the elements selected are those that happen by chance to be useful in some way for the organism undergoing selection. Some theorists (e.g. Young, 1979) would add an amplification process which spreads effects of selection through the system. Selection also requires that the elements (e.g., traits) subject to selection must exhibit some degree of consistency through time. If the elements changed randomly and continuously, it would not be possible for the ''selector'' to act selectively with respect to a given trait (Ward, 1989). The main effect of selection, then, is to alter the observed frequency distribution of traits represented in the initial array by reducing the number of elements in the initial array.

Just as Nature in its profligacy generates a huge number of forms or possibilities on the chance that some range of these will match a given ecological niche, so too, the generator in a memory system would produce a range of forms (memories). Some few of these memory images would, by chance, match some informational features of the external world or from another cognitive system. If other branches of biology are any guide (e.g., the immune system, see Jerne, 1985), we would expect the number of generated forms to be quite large. In the immune system, for example, there is a vast repertoire of molecules which can produce antibodies that can recognize any possible antigen. Antibodies are manufactured by lymphocytes which circulate through the blood, bone marrow, immune system glands (e.g., lymph

nodes and thymus), and other sites. There are approximately 10^{12} lymphocytes. B-lymphocytes produce the antibody molecules, while T-lymphocytes regulate production of antibodies. Human B-lymphocytes are capable of producing over 10 million different varieties of antibodies. This repertoire of antibodies can recognize and respond to any molecule existing in the world (antigens). An antigen binds to or selects certain of these antibodies which are then amplified by a process of clonal multiplication. Once the antigen is bound several varieties of immune system molecules can then be activated to destroy the invader. Thus, the immune system is characterized by an initial diversity (a repertoire of antibody molecules) that can meet (via selection and amplification) any challenge.

With respect to the memory system (and other cognitive systems), some authors (e.g., Piatelli-Palmarini, 1989; Changeux & Dehaene, 1989) have suggested that combinatorial mechanisms might produce the initial diversity. If we assume (Bergson actually argued against localization of memories in the brain) that the central nervous system is the device that generates memories, then CNS structure would impose constraints on the actual number of possibilities or forms produced by the generator. Nevertheless, the numbers are astronomical.

> The basic fact is that the nervous system contains a vast number of nerve cells and fibers, perhaps ten thousand million neurons in the human cerebral cortex and at least ten thousand million in the cerebellum. Moreover, each cell makes a great number of connections: there are up to 60,000 synaptic points on a large cortical neuron . . . (Young, 1979, p. 802).

Thus, the generative power of the nervous system is clearly enormous.

There are several reasons to think that selectionist models might be useful for memory theory. Selection involves a reduction in number of states, traits, entities, or elements from an initial plenitude of possible alternatives. As Ward (1989) has pointed out in his discussion of the similarities between selection and information theory, the information content of a signal from a given source depends on the extent to which that signal represents a reduction of the total array of signals possible, in principle, from that source. Information transmission, in other words, involves a process of noise reduction and signal enhancement. Because selection effects a similar reduction in the number of possible alternatives, it necessarily produces information content in the organism undergoing the selective action—one trait is preserved while others are not. To the extent, therefore, that memory involves the acquisition and retention of information, it must be a selectionist process. Darwinian selection seems to be the preferred way nature effects information content in an organism.

A second reason why selectionist models might be useful for memory theory is that selection requires persistence of traits through time. One of the things all memory theories seek to explain is the retention or persistence

of information through time. Selection promotes retention because it (selection) necessarily heightens the information content of an organism with respect to some given ecological niche. Selection disallows continuous and random change in traits subject to selection and promotes reproduction of traits which allow for survival of the organism.

A third reason for favoring selectionist models in memory theory has to do with the putative adaptive functions of memory itself. If memory did not exist each encounter in our lives would be completely novel and therefore potentially dangerous. Nature can, in effect, anticipate every possible future situation a given organism might encounter by providing for a generator mechanism as discussed above—i.e., a mechanism that produces an array of traits (memories) that can ''match'' any possible contingency in the environment.

A fourth reason for exploring selectionist models in relation to memory is that neurobiological data suggest that the brain itself develops in a selectionist manner—that is, there is an initial overproduction of neurons which then undergo a process of selection and elimination via pruning (see Rakic, Bourgeois, Eckenhoff, Zecevic, & Goldman-Rakic, 1986). Whenever possible, cognitive models should be informed by relevant neurological constraints on the system in question.

A final reason for preferring selectionist models in memory theory is that they imply that the organism will come equipped with rich internal structure (e.g., an immune system that can recognize any potential antigen or a linguistic system that can recognize any potential sentence licensed by the grammar). Since selection requires a rich array of traits that persist through time, it necessarily requires rich internal structure in the organism possessing those traits. Those traits, in fact, constitute the structure of the organism. Empirical work in several branches of the neural and cognitive sciences seems to confirm that organisms do in fact come equipped with rich innate structure (e.g., Chomsky, 1988; Mehler & Fox, 1985).

It seems reasonable, then, to assume that selectionist models might be appropriate for memory study. Bergson's work on memory appears to be the most extensive selectionist model available to date. In what follows I first discuss some properties of modern selectionist approaches to memory and I then examine Bergson's suggestions in detail. Since there is as yet no complete modern selectionist model of memory only a few relevant themes can be explored in this paper. They are: (1) the nature of memory representations, (2) the nature of the selection mechanism, and (3) the process of remembering itself. Discussion of these three themes will allow for a comparison of modern approaches with Bergson's main ideas on memory.

Modern Selectionist Approaches to Memory

Memory representations. There are two major types of memories according to modern selectionist theory: those that become available during the generation process (internally generated forms) and those that are linked

with the amplification process (forms that are triggered by an environmental stimulus). The internally generated forms emerge as ''pre-representations'' during brain development and probably coincide with what is usually called innate structures/processes or mental representations. Thus the organism comes equipped with a plenitude of representations that are experienced as ''memories.'' Much of brain and cortical development is known to be selectionist: there is an initial proliferation of neurons and synaptic connections and a subsequent elimination or pruning of the initial diversity (Rakic, Bourgeois, Eckenhoff, Zecevic, & Goldman-Rakic, 1986; Changeux & Dehaene, 1989). In the adult, Changeux and Dehaene (1989) suggest that innate prerepresentations are probably promoted by the spontaneous activity of neurons known as cellular oscillators. These neurons require no external source of stimulation for their activity. Presumably, innate memories include everything from instinctual preferences to specialized pools of knowledge, which support various cognitive procedures to forms which correspond to Jung's archetypes. At a minimum, prerepresentations would have to correspond (or refer or be tuned to) to something like Gibsonian invariants or affordances in the outside world.

In extreme versions of the selectionist theory of memory, these innate memories constitute ALL of the memories we will ever have. The selection process selects out a small number of the total set and this selected subset becomes our remembered histories. Just as every person carries within him/her a set of antibodies that can anticipate and ''recognize'' (or meet the threat of) every possible antigen (even manmade antigens), so too every person carries a complete set of memories which can anticipate or characterize every possible world for that person. Environmental stimuli serve only to activate various portions of the innate repertoire.

In less extreme versions of the theory, the generator produces a large, but quite constrained set of options or possible memories. The set of forms is constrained by the generative power of the ''generator'' and by the needs and ecological niche of the organism. Generation of diversity is always tied to some triggering stimulus and the number of forms produced depends on the computational power of the brain.

In traditional theories of memory, an external stimulus is registered in the brain and then leaves a kind of mental representation called a trace from which something like the original stimulus can be reconstructed. In a selectionist theory, the triggering stimulus sets off a cascade of events (amplification) which lead to a proliferation of the second type of memory representations (as opposed to internally generated prerepresentations) entertained by modern selectionist theory: mental representations that bear some type of logical relation to the original external stimulus. These will be discussed more fully below. Once these externally triggered representations have been generated, a part or subset of them will be selected and thus ''retained.'' Bergson, like his modern counterparts, also distinguished between various

types of memory representations but, unlike the modern theorists, he argued that the first type (prerepresentations) were more important for an understanding of remembering.

Selection process. The selection process has been conceived in a variety of ways by modern investigators. In general the idea is that the item chosen/selected (say a Hebbean-type assembly of neurons) is stabilized while all other items/possibilities are allowed to relax back into formlessness or low levels of activation or are actively inhibited. Edelman (1987) proposes reentrant signaling and re-categorization as basic for mnemonic phenomena. Several theorists (See Changeux and Dehaene, 1989; Shepard, 1984; and Ratcliff, 1978) endorse the notion of resonance as the principle underlying activation of stored representations—what we are calling here ''selection.'' A memory is stabilized if it resonates (roughly: matches) with an item from either the environment or from another part of the cognitive system. Young (1979) suggests that reinforcement is involved in the stabilization process once a selection is made. Piatelli-Palmarini (1989) suggests that selection is essentially a triggering of a set of switches or parameters which then determine the set of possible computational procedures available to the system.

In a selectionist theory of memory there need be no notion of encoding or of retrieval (if retrieval is conceived as a search process). There is no need to encode new information into the system since it already ''contains,'' in the initial repertoire or in virtual (''generate-able'') form, all the memories possible for a given subject. That is, the generation and amplification processes determine the range of possible memories available to a person and that range is constrained by the genetic envelope appropriate to a human being as well as by the generative power of the ''generator'' process.

Similarly, searching through memory for a particular item in order to retrieve it probably does not happen. Rather, we relax our inhibitory powers so that the cognitive system is flooded with memories from the innate repertoire. The flood is allowed to continue until a match occurs between the ''retrieval cue'' and an item in memory. The match then triggers amplification. ''Encoding'' and ''retrieval'' operations are therefore conceived as by-products of the generation and selection processes.

For Bergson the selection process also entailed a kind of matching or resonance procedure but we will see that what counted as a match for Bergson depended on the ''ability'' of the memory to act as a guide for useful action.

Remembering

Aside from various suggestions as to how selection is accomplished (e.g., reentrant signaling, resonance) modern selectionist theorists have not described in any amount of detail how remembering actually occurs at the cognitive level (rather than at the neuronal level). Bergson has provided just a description. In order to document Bergson's selectionist commitments I will need to quote him rather extensively.

Bergson's memory theory. For Bergson the primary function of memory,

> . . . is to evoke all those past perceptions which are analogous to the present perception, to recall to us what preceded and followed them, and so to suggest to us that decision which is the most useful. But this is not all. By allowing us to grasp in a single intuition multiple moments of duration, it frees us from the movement of the flow of things, that is to say, from the rhythm of necessity. The more of these moments memory can contract into one, the firmer is the hold which it gives to us on matter: so the memory of a living being appears indeed to measure, above all, its powers of action upon things and to be only the intellectual reverberations of this power (p. 228; all quotations are from *Matter and Memory, 1896/1988*).

When remembering is triggered via a current perception or cue, a series of images and past perceptions become available to the rememberer. These memory images must be related to the current perception—they must be similar or analogous to the current perception. In addition, all of those memory images which preceded or followed the past perceptions which are most similar to the current perception are also recalled. The current perception in other words triggers an approach of a vast range of memory images which are formally—even distantly—related to it. (This approach of the past toward the present is essentially what we have been calling amplification but Bergson has several other names for it as we shall see.) Once this vast array of images are activated they are used to ''suggest to us the decision that is most useful.'' Apparently the images enter into some kind of inferencing or decision making process. Ultimately the images are used to guide action.

However, activation of these memory images is experienced in a single intuition as multiple moments of duration. For Bergson, ''duration'' or (roughly) lived time is counterposed to abstract, spatialized notions of time. Every moment of duration is novel, not repeatable, and inherently unpredictable. Abstract time, on the other hand, is composed of identical, spatialized instants. Each instant totally determines the next one in the chain. Time, therefore is inherently deterministic. A single episode of (Bergsonian) remembering takes us out of the realm of necessity—of being acted upon as if we were simply another object in successive, incremental, and repetitious time and places us instead in multiple moments of duration—multiple possible worlds as suggested or implied by the ensemble of past perceptions now available in memory. The memory images (and their implied possible worlds) have their own rhythm, their own movement and logic since they are moving toward a decision. Bergson calls this movement of the past towards the present *contraction.* From the point of view of present perception, however, there is an *expansion* of memory images in consciousness since a region of the past is becoming available to it. To the extent that memory can ''contract'' the moments of duration into one moment, one decision, it increases the organism's powers of action—the organism's freedom.

In summary, in a single act of (Bergsonian) remembering we have the following sequence of events. In an initial relaxation of inhibitory processes,

a vast array of images become available. Most of these images undergo a secondary process of inhibition to ferret out the non-useful images. One set of the available images (the useful set) escape the inhibitory suppression and are allowed to inform a decision concerning action.

A modern reader might formulate the sequence of events as follows: A cue, usually some current perception, triggers generation of a vast array of memory images which are in some way (?semantically) related to the cue. Once an initial set of images are triggered a further set of images are elaborated. This second set of memory images must be causally related to the first. Finally, a match is made between the perceptual cue and an internal memory and that match constitutes recognition and remembering.

This modern reading of Bergson, however, would not be entirely correct. For the modern reader, what drives the sequence of events is an external cue and then a search process. Bergson argued against this empiricist approach to memory. For Bergson, most memories/rememberings are not triggered by external cues. Rather memory has its own rhythms and laws—its own ''agenda.'' Memory's usefulness lies in the fact that it allows us to escape the influence of the present environment and thus confers on us a certain measure of autonomy. Bergson pointed to the phenomenon of spontaneous rememberings as evidence for memory's non-dependence on external cues for its operations. Spontaneous rememberings, in fact, are the norm for human beings and should be taken to be the primary focus of study in the memory field.

Every instance of a spontaneous remembering is composed, according to Bergson, of a series of phases. First the brain relaxes its inhibitory powers then there is a proliferation of memory images and finally a selection or preservation of a subset of those images. I call the initial phase of relaxation of inhibitory powers the proliferation or generation phase. After the proliferation of images or representations occurs they are entered into some kind of selection or decision making process. I call this second phase the actualization or selection phase. The actualization phase produces an array of images or mental representations which represent past perceptions as possible states of affairs or possible worlds—Bergson's moments of duration. Next comes what Bergson calls contraction—where a distinct region of the past becomes available. As contraction proceeds the past edges closer and closer to the present. This contraction of the past must occur so that it can address the present but the contraction is experienced as an expansion by present consciousness since its repertoire of images (moments of duration) increases.

In the selection phase, various ''moments of duration'' (or a small set of possible worlds) will be selected from the array of images or moments thrown up by the proliferation phase. What guides selection for Bergson is ''usefulness'' or ''fitness.'' But Bergsonian fitness should not be confused with classical Darwinian notions of fitness. Whatever moment best promotes freedom of action is ''fit'' and will be selected from the array of choices

thrown up by the act of remembering. The thing chosen is what we usually call the memory x when we say ''I remembered x.''

It should be noted that the selection process for Bergson cannot be a matter of mere matching (or resonance) of a memory image with the current percept. According to Bergson, matching will not work even for the case of recognition. Rather, selection is Darwinian in the sense that what is chosen is what is used—what is left over after the other possibilities/images/alternatives are ignored or discarded (e.g., allowed to decay). Thus what is chosen is not necessarily the best match or most optimal solution to a current perception or to the problem of guiding action. Even though a given model (or memory image) may be currently useful in some way in myriad other ways the model may be not useful or it may (currently) simply be irrelevant. The model (given the proliferation and amplification phases which produced the model) may possess properties which are only distantly related to the current perception. Since the criterion is usefulness rather than optimal fit (or matching) the image which survives the selection process will probably not be some copy of a past state of affairs or of a current perception. Nevertheless, Bergson occasionally uses the term matching for shorthand when describing aspects of the selection process.

The foregoing is essentially the Bergsonian theory of remembering. Bergson, however, would probably not have referred (with respect to the proliferation phase) to a generation of images. Rather, Bergson suggested that we are always steeped in a virtual infinity of images. The brain acts as a kind of inhibitory device which screens out most of these images, allowing only the useful to remain. These useful images we call the world, objects, everyday reality—and memories.

As mentioned above, any selectionist theory of memory must be composed of at least two processing components: a generation (or proliferation) phase and a selection phase. I now want to discuss some of Bergson's suggestions concerning these two phases. In order to facilitate comparison with modern selectionist approaches, I will focus on the three themes mentioned above: memory representations, the process of remembering or recollection, and the process of selection. Bergson's ideas on selection have been introduced above. I will briefly review them again in the context of Bergson's discussion of the problem of how memory processes might be mediated by the brain.

Generation/Proliferation

Mental representations. Recall that during an act of remembering in the proliferation phase a huge array of memory images becomes available to the rememberer. An initial set of memory images or representations and then a secondary set, causally related to the first, is generated in response to some cue. What are these images/representations? How is a representation related to the thing it represents? Is the relation one of identity or some more limited

type of correspondence? Traditional theories of memory assume that memory images/representations preserve something (a trace) of the object which they represent. But this trace theory is problematic according to Bergson.

> Now, here is the image which I call a material object; I have a representation of it. How then does it not appear to be in itself that which it is for me? (p. 35).

Why do I posit an outer image (object) and an inner image (representation) that are supposed to be about the same thing and then go on to assume that the two images must be different? Why do I not take the trace representation for the object itself? Why do I not mistake perceptions for memories? Bergson suggests that perceptions or object images are distinguished from memories or representations in the following way. Object-images are experienced by us as being bound up in an aggregate of other object images all causally related to each other in sequential time. An object image

> . . . is continued in those which follow it, just as it prolonged those which preceded it (pp. 35–36).

Representations (memories), on the other hand, lie outside of the series of aggregate images. A memory representation is an object image that has been removed from the aggregate—from sequential time.

> To transform its [the object image] existence into representation, it would be enough to suppress what follows it, what precedes it, and also all that fills it, and to retain only its external crust, its superficial skin. That which distinguishes it as a present image, as an objective reality, from a represented image is the necessity which obliges it to act through everyone of its points upon all the points of all other images, to transmit the whole of what it receives, to oppose to every action an equal and contrary reaction, to be in short, merely a road by which pass, in every direction, the modifications propagated throughout the immensity of the universe. I should convert it into representation if I could isolate it, especially if I could isolate its shell. Representation is there—but always virtual—being neutralized, at the very moment when it might become actual, by the obligation to continue itself and to lose itself in something else. To obtain this conversion from the virtual to the actual, it would be necessary, not to throw more light on the object, but, on the contrary, to obscure some of its aspects, to diminish it by the greater part of itself, so that the remainder, instead of being encased in its surroundings as a thing, should detach itself from them as a picture (p. 36).

A representation, in other words, is obtained by progressively eliminating aspects of an object-image—especially that object's relations with other objects. The object is extracted as figure from ground by pushing away (via lateral inhibition) its neighbors. We are, in other words, presented with a plenitude—an aggregate of object images. To obtain a memory representation we inhibit portions of this aggregate until we isolate a single image from its related images in the stream of sequential time. By isolating (via a kind of lateral inhibition) an object from its causally related objects in the stream

of sequential time, we remove it from the realm of necessity and radical mechanism.

> Our representation of things would thus arise from the fact that they [things or objects] are thrown back and reflected by our freedom (p. 37).

Thus, a memory representation is distinguished from a percept or an object-image in that the former has undergone selection and is now a part of duration while the latter remains a cog in the wheel of spatialized time.

Recollection. Now memory images are also considered to be representations of absent objects or states of affairs. Memory is about the past. The past, however,

> . . . survives under two distinct forms: first, in motor mechanisms; secondly, in independent recollections (p. 78).

Here Bergson anticipates modern distinctions between habit memory and episodic memories. Habit involves repetition while episodic memories involve the unique, non-repeatable event:

> . . . its essence is to bear a date . . .'' p. 80. Habit does not ''. . . represent our past to us, it acts it; and if it still deserves the name of memory, it is not because it conserves bygone images, but because it prolongs their useful effect into the present moment (p. 82).

Habit is effortless and, once formed, non-representational. Recollection, on the other hand, requires an act of will. It involves an active letting go of the intense attachment to the present we all experience:

> To call up the past in the form of an image, we must be able to withdraw ourselves from the action of the moment, we must have the power to value the useless, we must have the will to dream (p. 83).

For Bergson, then, recollection allows us to detach ourselves from bondage to the object-world and enter into the world of duration.

To summarize thus far, during an act of recollection, there is an initial relaxation of inhibition which makes available to the rememberer a vast array of images. This relaxation of inhibition is associated with a letting go of the intense attachment to the external object. Next, a secondary process of inhibition is triggered which corresponds to the selection process. This selection process, in turn, constitutes ''retrieval.''

Retrieval. What governs or guides retrieval? Bergson points to action—useful actions, as a constraint on the selection process. Memories always seek to inform behavior—useful actions.

> As a rule, when we desire to go back along the course of the past and discover the known, localized, personal memory image which is related to the present, an effort is necessary, whereby we draw back from the act to which perception inclines us: the latter would urge us towards the future; we have to go backwards into the past. In this sense movement rather tends to drive away the image. Yet in one way

> it contributes to its approach. For though the whole series of our past images remain within us, still the representation which is analogous to the present perception has to be chosen from among all possible representations. Movements, accomplished or merely nascent, prepare this choice or at the very least mark out the field in which we shall seek the image we need (p. 95).

Selection and mind–brain relations. Bergson is at pains to point out that the selection process involves a movement of the past toward the present rather than the present calling up the past. The past comes out to meet the present perception. That essentially is what proliferation/generation implies: the past is the active agent. The present percept merely and passively matches one of the myriad possibilities presented by the past. For Bergson, the respective roles of the present and the past in the selection process speak to the ways in which memory and brain interact.

> . . . is it the perception which determines mechanically the appearance of the memories, or is it the memories which spontaneously go to meet the perception? On the answer to this question will depend the nature of the relation which philosophers will have to establish between the brain and memory. For in every perception there is a disturbance communicated by the nerves to the perceptive centers. If the passing on of this movement to other cortical centers had as its real effect the springing up of images in these, then we might in strictness maintain that memory is but a function of the brain. But if we can establish that here as elsewhere movement produces nothing but movement, that the office of sense stimulation is merely to impress on the body a certain attitude into which recollections will come to insert themselves, then . . . we should have to look for memory elsewhere. On the first hypothesis the disorders of memory occasioned by a cerebral lesion would result from the fact that the recollections occupied the damaged region and were destroyed with it. On the second hypothesis these lesions would affect our nascent and possible action but our action alone (p. 99).

Bergson seems to be arguing something like the following: A sensory stimulus or perception should not be understood as activating or as becoming a memory. Memories are not weakened versions of percepts. The contents of memory do not reflect or correspond in any simple way to the things we have perceived throughout our lifetimes. Relative to the contents of memory for any given episode the perceptual stimulus associated with that episode will be impoverished. Thus memory cannot reflect the environment and empiricist approaches to memory must fail. Although we have perceived a huge number of faces in our lifetime we remember only a very few of these. We have, furthermore, never perceived, in any ordinary sense of the term, the history of a long-term cooperative relationship with a friend, yet we can provide from memory detailed sets of information and detailed memories about that relationship as it evolved over time.

Since we cannot derive the contents of memory from perceptual experience memory cannot be reduced to perceptual traces which ‘‘persist.’’ There are no such things as memory traces. If, on the other hand, memory could be considered a derivative species of perception then memory traces could

probably be localized in the brain since you would need a medium to contain these traces. But Bergson argues that the brain acts merely as an inhibitory or selective device. It allows, in response to perception, certain movements and inhibits others. Perceptions issue not in memories but in movements. Memory is not a regression from present to the past but a coming forward of the past to meet the present. When the brain is injured, memories are not lost. Instead, brain injuries influence the inhibitory powers of the brain and thus some aspects of memory are temporarily less accessible than others but no memories are lost. If memory loss could be demonstrated then localizationist theory would be supported.

According to Bergson's selectionist assumptions, a sensory stimulus' only role is to trigger something like amplification of an item or prerepresentation that is, in some sense, already ''there.'' In Bergson's conception, all of the past is ''there'' in the form of the innate repertoire or in a pre-potent virtual state—ready to be generated during amplification. Never would a lesion of the brain really destroy memories. Disorders of memory associated with brain damage can only be due to two things: (1) the inability to choose the appropriate memory from among the array of available images (insufficient inhibitory power) or (2) the inability to translate memories into motor actions. Beyond these distinctions or patterns of memory breakdown, Bergson did not advance any detailed theory of memory disorders. Yet we can infer that he might have predicted a third pattern: the inability to detach from a current external or salient stimulus (see Lhermitte, 1986, for a description of just such an ''environmental dependency syndrome'') so that one can adopt the appropriate receptive stance to the past. This inability to escape the influence of the environmentally salient present would be considered by Bergson to be a disorder in the actualization process.

Actualization and selection. ''Whenever we are trying to recover a recollection, to call up some period of our history, we become conscious of an act sui generis by which we detach ourselves from the present in order to replace ourselves, first in the past in general, then in a certain region of the past—a work of adjustment, something like the focusing of a camera. But our recollection still remains virtual; we simply prepare ourselves to receive it by adopting the appropriate attitude'' (pp. 133–135).

In a properly selectionist theory of memory, the past is the active agent which comes out to meet the present. Remembering is an act, not reducible to anything else, by which we recover the past. The past, through a relaxation of inhibition, floods the cognitive system. An array of possibilities is presented for selection. We have already seen that for Bergson, the selection process is constrained by the need to guide behavior. But this is only a very broad constraint.

> What we really need to discover is how a choice is effected among an infinite number of recollections which all resemble in some way the present perception, and

> why only one of them—this rather than that—emerges into the light of consciousness (p. 164).

Bergson suggests that selection works in tandem with the proliferation/generation process. The array of items generated is expanded until the array contains a class of representations that resemble the current percept.

> . . . it is not by a mechanical adjunction of more and more numerous elements which, while remaining unmoved, it attracts around it, but rather by an expansion of the entire consciousness which, spreading out over a larger area, discover the fuller detail of its wealth (pp. 165–166).

This expansion of memory elements in consciousness, in turn, involves two other processes: translation and rotation (see below). These collective mnemonic processes compose the aforementioned movement of the past toward the present in an original act of remembering.

> . . . memory, laden with the whole of the past, responds to the appeal of the present state by two simultaneous movements, one of translation, by which it moves in its entirety to meet experience, thus contracting more or less, though without dividing, with a view to action; and the other of rotation upon itself, by which it turns toward the situation of the moment, presenting to it that side of itself which may prove to be the most useful (pp. 168–169).

Thus, for Bergson, in any act of recollection we initiate the process by relinquishing attachment to the object-world. We relax our inhibitory powers so that we are able to adopt the proper receptive attitude toward the impending approach of the whole of our past. The whole of our past undergoes a kind of contraction so that it can move toward the present. The entirety of the past is translated into a form amenable to the present. The past then undergoes a rotation so that only those portions of it most relevant to the present are presented. At this point the cognitive system is flooded with, what seems to it, a vast array of memory images (expansion). Now the brain's inhibitory powers are tapped to begin the process of selection. After inhibition and suppression does its work, we are left with a narrow range of images or moments of duration and these are experienced as veridical memories of a real past state of affairs.

Comparison of selectionist and information processing models of memory. Information processing models of memory postulate three basic processes in memory: encoding, storage, and retrieval. Selectionist models also postulate three basic processes: relaxation of inhibition, generation of ''images,'' and selection of a subset of those images. The two paradigms seem to offer similar explanations for *recognition:* A stimulus is perceived, it is entered into a search process where it is compared against an array of images/memories (the images are generated in the selectionist paradigm and constitute an already established associative network in the information processing paradigm) until a match is made, then it is encoded (amplified) and stored (selected) for later retrieval (generation). These surface similarities between

the two paradigms mask fundamental differences. Encoding is not simply amplification and storage is certainly not selection.

Encoding refers to a process whereby a perceptual stimulus is translated into a format suitable for contacting a match in an associative network. In the generation/amplification phase of a selectionist operation, no translation work occurs at all. Rather, a huge number of images are generated (proliferation). In the encoding ''scenario'' a single perceptual stimulus is involved. Similarly, no storage takes place in the selectionist paradigm. Selection involves a reduction in the set of images produced during the generation phase.

Bergson's critique of association psychology. Modern information processing models of memory rely heavily on ideas originally formulated by the associationists (e.g., Locke). When Bergson began *Matter and Memory* in the cultural mileau of late 19th century France, Taine and Ribot were the leading French theorists on memory. They, according to Bergson, promoted simplistic and mechanistic models of the Mind while borrowing heavily from the British associationists. In the associationist view memory is structured by sets of mental representations which are acquired through learning. Learning is governed by the laws of association: Ideas are acquired through contiguity (in time or space) or through similarity. Memory search or retrieval is possible because the search process is not random—it can, for example, proceed systematically through semantically related ideas until it finds its match. Bergson's objection to the associationist stance with respect to memory was that it was simply uninformative or trivial.

> That every idea which arises in the mind has a relation of similarity or of contiguity with the previous mental state, we do not dispute; but a statement of the kind throws no light on the mechanism of association; nor, indeed, does it tell us anything at all. For we should seek in vain for two ideas which have not some point of resemblance, or which do not touch each other somewhere . . . what we really need to discover is how a choice is effected among an infinite number of recollections which all resemble in some way the present perception . . . (pp. 212–213)

Association by resemblance and contiguity surely occurs but that fact does not explain how recollection is possible. Why, during any single act of recognition or of remembering, does a single memory emerge into consciousness? For modern theorists, concerned with the dynamics of associative networks, selection is largely accomplished via variations on the mechanisms of (1) lateral inhibition and (2) the search process (see, for example, discussions in Grossberg, 1980; and Raaijmakers & Shiffrin, 1981). Bergson, I believe, would find such explanations impressive but not ultimately satisfying. He was less interested in proximate explanations than in evolutionarily ultimate explanations of behavior. We have seen that for Bergson what determines selection is ''usefulness'' or broadly speaking adaptation, in so far as adaptation implied autonomy from salient environmental stimuli. There may ultimately, however, be no contradiction between selectionist models and association models. The emphasis for the selectionists, including Bergson, is at

the molar behavioral level. Indeed, except for his reluctance to postulate internal structure, B. F. Skinner may be classified a selectionist. For Skinner, the organism is always emitting a plenitude of responses. Those responses which get preserved or selected are the ones which get reinforced. There may not be a difference in kind between Bergson's adaptation criterion and Skinner's reinforcement criterion. Skinner simply confined himself to a more narrow range of conceptions of ''usefulness'' than did Bergson.

Conclusions. Bergson's memory theory is clearly selectionist in character. There is an initial diversity (of memory images) and a subsequent selection process from this diversity. Selection for Bergson, however, cannot be a simple matching (of percept and memory image) process, otherwise cognition could only be a reflection of local environmental conditions. Memory images are selected (and therefore retained) if they are useful for increasing the possibilities for free action. Bergson's description of the subjective experience of recollection is rich and suggestive and potentially useful to the modern project of establishing a selectionist account of memory.

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