Understanding Memory:

The Systems and Processing Debate

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1 Introduction

Memory is essential for learning. However, the process of encoding and retrieving memories is not well understood. Memory researchers rely on *dissociations* to learn about how memory works in the brain. Two tasks are dissociated if performance on one task can be better in one condition at the same time that performance on the other task is better in another condition. If $task_1$ and $task_2$ can be dissociated, then this dissociation supports localizing these two tasks to different parts of the brain.

Researchers have found dissociations between both explicit/implicit tasks and perceptual/conceptual tasks, proposing many theories to explain these dissociations. These theories can be categorized under two general theoretical approaches: the *memory systems* approach and the *processing* approach. The neuropsychological tradition favors the memory systems approach while the cognitive psychological tradition favors processing approaches (Roediger, 1990). Although the debate continues, this paper will argue that the processing approach better explains the existing data, especially for normal subjects.

1.1 Memory Systems

The memory systems approach separates regions of the brain into systems performing different tasks. Different types of learning use separate neural networks. Dissociations, according to the systems approach, occur when damage to the brain is localized to one system. Two proposed and heavily studied systems are systems for handling *explicit* and *implicit* memory. Thus, if only the explicit system of the brain is damaged, one could be bad at explicit tasks but fine on implicit tasks. Others split memory into declarative and procedural subsystems, with declarative memory corresponding with verbalizable or explicit memory and procedural memory corresponding with implicit memory.

1.2 Processing

Whereas the systems approach categorizes memory into distinct subsystems, the processing approach instead focuses on the processes underlying memory. The processing approach is also known as transfer-appropriate processing or encoding specificity (Roediger, 1990). The basic premise is that memory will be better when the type of processing needed during test is the same as the processing used during study. Dissociations reflect impairment on only a certain type of process. Most distinguish between *conceptual* and *perceptual* processes. Conceptual processes rely on meaning for memory encoding, whereas perceptual processes primarily rely on form. Perceptual processing is also sometimes called data-driven processing.

2 Systems vs. Processing

Numerous studies have tried to determine the more correct approach. While studies exist to support the memory systems approach, these same studies can be used to support the processing approach. Others studies have shown support

for the processing but not systems approach. The strongest evidence against the processing theory comes from a limited pool of patients, from amnesics, who have lesions in parts of their brains. However, as a testable theory and as the theory explaining more of the available data, the processing approach is better overall compared with the systems approach.

2.1 Studies

Memory studies, looking at these two approaches, mostly follow a similar framework, involving a study phase and a test phase. During the study phase, the subject is given words, pictures, or other stimuli to process. The test phase usually follows shortly after the study phase, and the subject may or may not be told that the test is related to the material in the study phase.

2.1.1 Explicit vs. Implicit

Studies supporting the memory systems approach have shown dissociations between explicit and implicit memory. Explicit memory is tested with items consciously stored and retrieved from memory, usually in the form of recognition or recall tests. Implicit memory is not consciously processed, but learning can still be shown to occur. Examples include learning to ride a bicycle or to type on a keyboard. Implicit memory is often tested with *priming* tasks. A typical implicit task presents subjects with a list of words to read. In the test phase, word fragments are presented for the subject to complete. The subjects are not told that some word fragments can be completed with words from the initial list. Subjects are better at completing fragments for words in the original list than for fragments of new words. Another implicit task measures how quickly one can identify briefly flashed words, with some words having been seen previously. In both the fragment completion and the word identification task, subjects are assumed to have been primed by the initial word list, and, thus, should be more

successful for completing or identifying previously seen words.

In one study, a dissociation was found between recognition, an explicit task, and perceptual identification of words, an implicit task (Roediger, 1990). One condition of this study, the generate condition, had participants generate the target word based on a related word, thus the participants focused on the word semantics. In this generate condition, they never see the word itself on the screen, because words are generated in the head. In the non-generate conditions, the word is either read alone or read along with a related word. The results show that generating words leads to higher recognition but lower perceptual identification compared with the non-generate conditions. Thus, explicit memory is better when generating words and implicit memory is better when reading the word.

Other evidence used to support the systems approach demonstrate the independence of implicit and explicit memory. For example, experiments have shown no relationship between being able to explicitly recognize a word and doing well in completing a fragment of that word (Gazzaniga, Ivry, & Mangun, 1998). Other differences between explicit and implicit memory come up across age groups. Children show improvement with age on recognition but not with implicit tests, similar to results with amnesics. Old people show degradation of recognition memory over time but no change in implicit priming.

2.1.2 Perceptual vs. Conceptual

Although experiments have shown a dissociation between explicit and implicit tasks, most of the explicit tests have involved conceptual processes and most of the implicit tests have involved perceptual processes. Thus, the processing approach could explain the same dissociations and the same experiments used to support the systems approach would support the processing approach. For example, in the above study, the generate condition involved conceptual processing and word recognition, a conceptual task, showed higher performance.

Similarly, reading words is a perceptual task as is perceptual identification. This match between conceptual tasks and perceptual tasks explains the results in the processing framework as well as the systems approach.

Separating the two theories requires testing all four combinations of implicit/explicit and perceptual/conceptual. In particular, explicit/perceptual tasks and implicit/conceptual tasks are the two categories needing the most work. For example, if the systems approach is correct, dissociations should not be found between an implicit/conceptual task and an implicit/perceptual task because they are both implicit. On the other hand, the processing approach predicts that dissociations should not occur between implicit/conceptual tasks and explicit/conceptual tasks as they both use conceptual processes.

Some investigators, testing all four combinations of memory system and processing type, have found the type of processing, whether it is a perceptual or conceptual task, more important than the explicit or implicit distinction (Blaxton, 1989). One experiment used a similar paradigm as the above experiment with generate and non-generate conditions, but added tests for explicit/perceptual and implicit/conceptual tasks. The results showed no dissociations between explicit and implicit tasks, while having a significant dissociation between the perceptual and conceptual types of processing.

2.1.3 Dissociations Within Systems

Besides sometimes finding no dissociation between systems, other studies have showed dissociations within a single system. These studies prove problematic for the memory systems approach, as dissociations between two explicit task or two implicit tasks should not occur. As an example of a dissociation between two explicit tasks, subjects study both high-frequency words and low-frequency words. During test, high frequency words are better recalled while the low frequency words are better recognized (Roediger, 1990). Although rarer, dissociations between implicit memory tasks have also been found.

The systems approach cannot explain these result without postulating new memory systems. For example, one could split explicit memory into multiple subsystems, with a system to handle high-frequency words and one to handle low-frequency words. Or there could be a system to handle recognition and one to handle recall. Adding new systems would explain the observed dissociations, but prove problematic as the theory becomes hard to disprove. New dissociations can simply be explained with extra memory systems.

2.1.4 Modality

Experiments have shown that priming on implicit tests depends a great deal on matching the form of the study and test item. Changes in modality, such as whether words are presented visually or auditorily, affect implicit tests more than explicit tests (Schacter, 1990). However, most implicit tests performed are still perceptual and most explicit tests are conceptual. If we test all other combinations also, the processing approach outperforms the systems approach. In experiments testing the effects of modality, the processing approach predicts that a change in modality will affect perceptual but not conceptual tests. The memory systems approach predicts no changes due to modality, as an explicit task is explicit whether it is presented visually or auditorily. Experiments have supported the processing theory. Conceptually driven tests were not affected by modality but perceptual tests were affected (Blaxton, 1989). These experiments show dissociations between tasks that would theoretically fall within a single memory system, making it difficult for the systems approach to explain.

2.1.5 Amnesics

Many supporting the systems approach study amnesics with brain lesions, probably because the strongest evidence *against* the processing approach comes from these amnesics. The performance of amnesics on memory tasks fits well with the memory systems approach and not so well with the processing approach.

Amnesics like the famous H.M. perform poorly on explicit tests of memory but have intact implicit memory, such as learning motor skills. Other patients, like M.S., have intact explicit memory but impaired implicit memory. These patients show the independence of the implicit and the explicit memory systems and the separability of these two types of tasks.

However, the above data is not by itself evidence against the processing theory. As most explicit tasks have also been conceptual tasks, for patients like H.M., the processing view predicts that amnesics will have impaired conceptual memory, as opposed to impaired explicit memory predicted by the systems approach. Thus, amnesics are predicted, by the processing approach, to do poorly on implicit/conceptual tasks. However, in experiments, amnesics show intact memory on implicit/conceptual tasks (Gabrieli, 1995). Amnesics are unimpaired on many forms of implicit memory, whether they be perceptual or conceptual tasks. Amnesics also show priming on both perceptual and conceptual implicit memory tests (Roediger, 1990). Some experiments showed success or failure solely based on explicit or implicit test instructions (Gabrieli, 1995).

These experiments all have the common feature of showing that the distinction between the explicitness of the test matters when it comes to amnesics and that the type of processing does not matter as much. Although the processing view does not adequately explain this data on amnesics, neither does the systems view. Amnesic patients are not intact on all implicit memory tasks as they should be if they had a fully intact implicit memory system (Gabrieli, 1995). So for amnesics, the systems approach is a better, but still not perfect, theory for explaining the evidence. For normal human subjects, the situation is reversed with the processing approach providing much better explanations for the existing data than the systems approach.

2.2 Testability

As a testable theory, the processing theory is better than the systems theory. Systems theory is less testable and falsifiable than the processing approach. If an unexpected dissociation is found, the systems theory can always explain away the dissociation by positing another separate system in the brain involved in the particular dissociation. Some have proposed integrating the two approaches by proposing systems specialized for certain types of processing (Schacter, 1990). However, this hybrid theory does not directly address the issue of whether our memory works in the explicit/implicit dimension or the perceptual/conceptual dimension. Also, as additional memory systems can always be added to account for new dissociations, how does one test the theory? To explain observed dissociations could require 20-25 different memory systems (Roediger, 1990). The processing approach has been less vulnerable to this providing of explanations after the results, as additional types of processing have not been needed to explain the available data.

Processing theory also makes more concrete predictions about expected effects. If the processing at the time of study is the same as that at the time of test, then the performance will be better. The systems approach only says that all tasks using one system would be affected similarly, not giving a reason why some tasks are performed better than others or predicting a direction for the effect (Blaxton, 1995).

3 Conclusion

Experiments supporting the processing approach and not supporting the systems approach have shown a dissociation between perceptual and conceptual tests, while showing that the dissociations do not depend on the explicit and implicit distinction. The memory systems approach cannot explain these results without resorting to adding many new memory systems. With no way to

know, a priori, what systems should exist, the systems approach is not a usable theoretical model.

The primary evidence against the processing approach comes from experiments with amnesic patients, with amnesics showing mostly intact implicit memory on both conceptual and perceptual tasks. However, in the realm of normal functioning, process theory has had more success than systems theory. Given the two approaches, the processing approach is better in explaining a wider range of results. On a purely statistical basis, the processing approach is better. Normal subjects make up more of the world and the processing approach explains this group better. Amnesics, in addition, often have lesions that damage and affect the brain in mysterious ways. It is questionable how we would apply the data from amnesics to normal subjects. Although neither approach sufficiently explains all the current evidence, stronger evidence exists favoring the processing approach, making the processing approach a more tenable and more useful theory than the systems approach.

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