

The Utility of an Information Processing Approach in Speech and Language Evaluation

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Wepman (1951) listed 34 non-language factors which he felt could influence the aphasic patient's behavior. These factors included memory, attention and concentration, irritability and fatigability, and reduced spontaneity. Memory is the variable which will be emphasized in this paper for three reasons: There is a rich experimental literature in normals which hasn't been integrated with clinical practice; there is a recent interest in applying analysis of memory factors to aphasic patients; and probably most importantly because memory can have a significant impact on functional language skills.

Information Processing Approach

In psychology as well as speech pathology, there has been an emphasis upon the stimulus and response with little emphasis on good control of processing variables (Klatzky, 1975; Sies, 1974). This is certainly changing in neuropsychology with the integration of information processing and cognitive psychology. This approach is very specifically having an impact in aphasiology with the recent emphasis on the role of memory factors in repetition deficits (Warrington and Shallice, 1969; Heilman, Scholes and Watson, 1976; Saffran, Marin, Schwartz, and Rubman, 1977; Locke and Deck, 1978; Rothi, 1979).

The purpose of information processing approaches is to understand how tasks are solved and information is processed. In the context of aphasia, the goal is to understand what is happening between the stimulus and the response. Very simply, there is an attempt to separate tasks into input, processing and output components.

Although the information processing approach is relatively new in aphasia, it is not just of theoretical interest. Awareness of this approach can be useful to clinicians and can lead to better specification of patient deficits. We know from observation that two patients can get the same score on a test, but that they can be failing for different reasons. From a diagnostic and treatment standpoint, we want to know the reasons for failure. This means that the limits of the patient's performance must be tested. In many cases, this means that the different components of the task must be determined from an information processing standpoint. If standardized procedures are not available, non-standard procedures must be used to better specify what aspect of the task is creating difficulty for a particular patient. Let's take an example from Schuell's Minnesota Test for the Differential Diagnosis of Aphasia (1973). Her sentence comprehension subtest requires the patient to listen to a paragraph and then to answer questions about the paragraph. There is likely to be considerable disagreement in specifying the task components, but this example is provided to emphasize the importance of component analysis. This test grossly depends on adequate hearing, understanding of complex narrative material which is dependent on ability to associate and remember words and sentences in the paragraph, ability to understand questions, ability to remember the

question and narrative material, ability to make a yes/no decision and ability to respond appropriately. Obviously, a patient's performance could break down at any one or several of these stages, and the clinician must have other tests available or must add non-standard tests to get a better idea of where the breakdown is occurring. A way of doing this might be to test hearing separately and then test immediate comprehension for sentences, possibly through picture matching. The impact of memory could be tested grossly by looking at the pattern of errors and determining if more errors were made at the beginning than at the end of the paragraph. If memory is a crucial factor, more errors should be made when questions are asked about the beginning than the end of the paragraph. Memory could be assessed separate from interference by asking questions after each sentence rather than just at the end of the paragraph or simply testing comprehension at different delay intervals. On a task as complex as this, there are numerous ways in which the task can be broken down to more specifically determine the reasons for a patient's deficits.

The issue of memory also becomes quite important on language tasks when one is comparing the difference between a patient's ability to understand single commands with his ability to understand sequences of commands. In this task input and output, as well as memory and other processing characteristics, are changing. This is true of the Token Test (Lesser, 1976), the Minnesota Test for the Differential Diagnosis of Aphasia (Schuell, 1973), and the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1976).

Using an information processing approach, memory can be separated into four stages: sensory registration, encoding, storage, and retrieval. Theoretically, registration is the input stage, where the organism almost passively accepts the stimulus without modification. Encoding is the point where, depending on the task requirements, the organism organizes the information in a particular way. Many investigators feel that level of processing in this encoding stage determines whether information is stored (Craik and Lockhart, 1972). For instance, if information is encoded semantically rather than just phonemically, it is more likely to be remembered later. Interference during this period can also determine whether information is stored. Storage is the stage where information is transferred from short-term memory, where constant rehearsal is required, to long-term memory, which is more reliable. Even if storage occurs, the patient may still not be able to remember or retrieve the information. In this case, the clinician would like to know what conditions of retrieval increase the probability of remembering. For instance, can the patient recognize but not recall, or are there phonemic or semantic cues which can be given to aid recall?

First, let's take a closer look at the information processing approach in general. This approach separates tasks into input, processing, and output components.

You're all quite familiar with the variables which can affect input and output. These include modality of stimulus (auditory, visual, somatosensory) or modality of response (verbal, graphic, gestural). Stimulus or response type must also be considered and in my framework would be grossly differentiated as linguistic or visuospatial.

Type of input and output has been of particular interest to the neuropsychologist. Analysis of the aphasic patient's visuospatial skills is important for diagnostic and treatment purposes. Recent studies have emphasized the utility of visuospatial skills to compensate for language deficits (Patten, 1972; Jones-Gotman and Milner, 1978; West, 1977), and adequate

information regarding the patient's visuospatial skills is needed before the utility of these techniques can be determined. Therefore, visuospatial skills should be assessed either in conjunction with a neuropsychologist or as part of a speech and language battery.

The processing aspect of the information processing model which is the most difficult to operationally define also has significant implications for language evaluation. Obviously, processing is affected by input and output characteristics. If an input is presented aurally or visually that will affect processing. Ideally, if we want to look at how information is organized, remembered and used, tests would be designed which keep input and output relatively constant and just change what the patient is supposed to do with the information. Processing can include both strategy and memory. There are frequently several different ways a task can be completed, and this is where the strategy issue becomes important. This is particularly important in aphasic patients, since they may need to use a different strategy than they used prior to their brain injury, such as a strategy based more on visuospatial than linguistic encoding (Jones-Gotman, 1978).

The issue of controlling input, output and processing characteristics can be discussed in the context of visuospatial and language skills which are frequently compared in individual patients. Parallel language and visuospatial tests can be designed. For instance, to assess memory in a linguistic and visuospatial mode, a delayed match to sample technique could be used where the patient is asked to match words to pictures or nonsense figures to nonsense figures at different orientations. Different delays between standard and matching stimuli could be used and accuracy of recognition could be compared between the linguistic and visuospatial tasks. In this case, the input and processing demands both change. These types of paradigms can be used relatively easily. It is only necessary for the clinician to carefully appraise the task and to attempt to change as few variables as possible and to be aware of what variables are changing.

Posner and Mitchell (1967) have derived a task which manipulates processing without changing input and output. This task relies on using alphabetic material, but requires the subject to judge letter pairs as the same or different based on whether they look physically the same or whether they have the same name. Naming identifications are made more rapidly by the left hemisphere, while physical identifications are made more rapidly by the right hemisphere (Cohen, 1972).

Memory

One multidimensional aspect of information processing which is now being explored in aphasic patients is memory. Three variables which influence memory will be discussed in some detail: Interference, chunking, and level of processing.

Interference. There are two types of interference: proactive and retroactive. Proactive interference refers to the situation where an event preceding the event to be remembered interferes with memory of the second event. This concept is important in testing and treatment and emphasizes the need to be aware of order effects and the need to allow enough time between trials to prevent proactive interference. Retroactive interference refers to the decreased recall of an event which occurs as a result of an intervening event. If we go back to Schuell's paragraph test, it is clear that both retroactive and proactive interference can operate.

One of the explanations for retroactive interference is that it prevents rehearsal of the initial event. The theoretical notion is that people must rehearse information continually to remember it until it has been stored. In order to assess the importance of rehearsal in aphasic patients, Rothi (1979) used a variation of the Brown-Peterson paradigm. This paradigm is based on work by Brown (1958) and Peterson and Peterson (1959) where they presented consonant trigrams to normals. After 0-18 sec of counting backwards, these subjects were asked to recall the trigram. Figure 1 illustrates their results. As expected, when rehearsal of the trigram was prevented, recall decreased with time. Rothi suggested that without interference (dotted line) no deterioration of performance should be demonstrated.

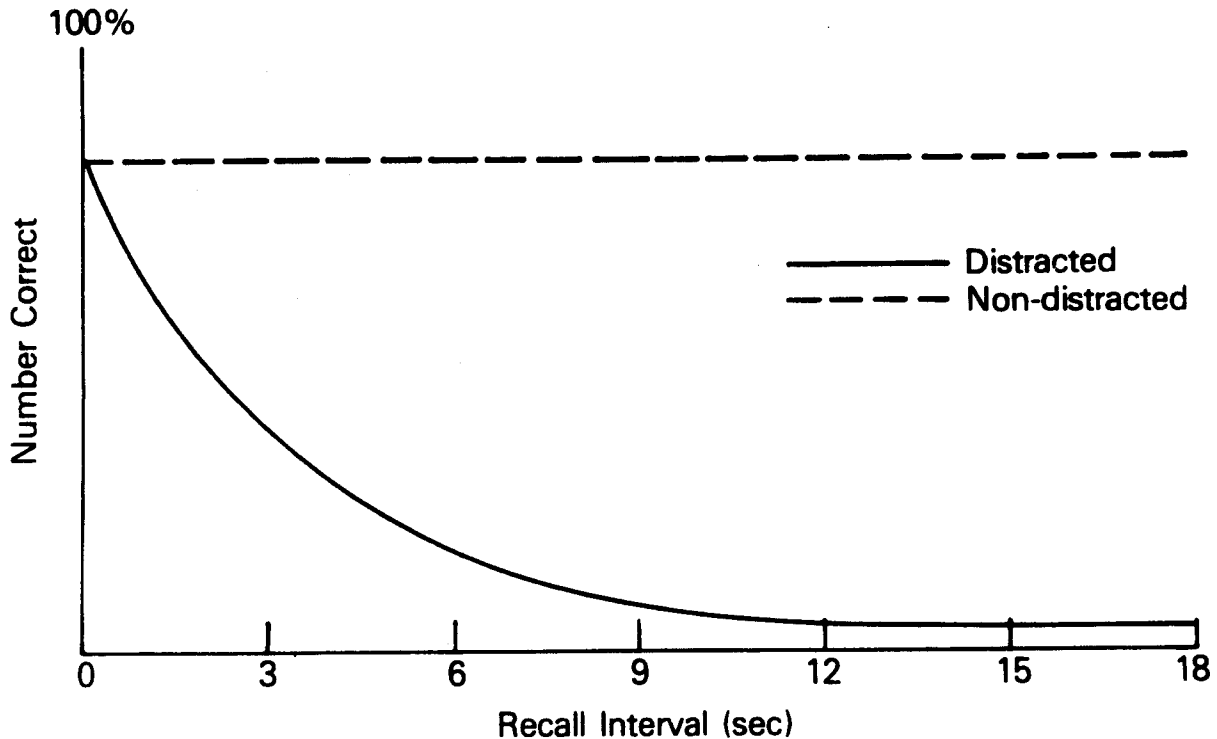


Figure 1. The solid line represents the data derived by Brown (1958) and Peterson and Peterson (1959) when the delay interval for recall of trigrams is filled with interference. The dotted line is the hypothesized performance of normal individuals when no interference is used (from Rothi, 1979).

To explore the importance of rehearsal in fluent and non-fluent aphasic patients and normal controls, she presented three words and 0-18 seconds later required the subject to point to the three pictures of the words. Performance across groups was compared with and without interference, and the interference tasks varied in difficulty, depending on the subjects. She hypothesized that those patients who used rehearsal would do well when no interference was present but would do poorly with interference. She found that all patients except the non-fluent aphasic patients performed better without interference. Although the non-fluent group's degree of aphasia did not differ from the fluent group's (according to the Porch Index of Communicative Ability), the non-fluent group's performance did not worsen when interference was present. Therefore, these patients seemed not to be using

rehearsal to perform the task. These data suggest that the repetition deficits frequently seen in these patients may be attributed to decreased rehearsal and short term memory impairment, as well as motor programming deficits.

Chunking. Another variable which can affect immediate and recent memory is what is called chunking, which is a skill accomplished mnemonists use (Klatzky, 1975). Miller's data (1956) suggests that an individual remembers 7 ± 2 bits of information. More information will be recalled if it can be chunked. Normal individuals should be able to remember 7 ± 2 words as well as 7 ± 2 letters, even though the words are composed of more than 7 letters. Anything that the clinician can do to increase the probability of chunking or to assess the patient's ability to chunk could be useful. For instance, it has been found in normals that, if information is presented in visual groups (TV fbi JFK ymca) recognition memory is better than if it is presented without visual categorization (TVF bij fKY mca). The same separation can be achieved orally with temporal control by presenting familiar (TV...FBI...JFK...YMCA) or unfamiliar (TVF...BIJ...FKY...MCA) groupings.

Another factor which also appears to influence chunking in normals is syntax. When narrative more closely approximates English syntax, recall is better (Miller and Selfridge, 1950). Knowledge of syntax may be impaired in aphasic patients and may further limit their ability to remember linguistic information.

Level of Processing. Early data suggested that short term memory was based upon phonemic cues while long-term memory was dependent upon semantic factors (Baddely, 1966). While this dichotomy has been criticized, there are some data which do suggest that memory is dependent on the extent to which the linguistic information is analyzed (Craik and Lockhart, 1972). The hypothesis is that more features of the stimulus are analyzed when analysis is more complete and the probability of retrieval is greater. When information has to be remembered for only a short period, only the phonemic features of the stimulus are analyzed (Craik and Lockhart, 1972). When given more time, or the knowledge that information must be remembered for longer time, the normal individual will analyze as many distinctive linguistic features as possible.

Given this hypothesis, subtle deficits in linguistic analysis as seen in aphasic patients may be best reflected in memory tasks. Cermak and Moreines (1976) investigated this hypothesis by giving word lists to five different groups of patients. Only results from the aphasic and normal control patients will be discussed here. The subjects were required to listen to a list of words read at a 2/second rate. They were asked to raise their hand when a word within the list was repeated (repetition condition), when a word rhymed with a previous word (phonemic condition) or when a word belonged to the same category as a preceding word (semantic condition). Memory for particular features was monitored by plotting the number of correct choices as a function of the number of words intervening between the initial and probe member of the pair. In normals, accuracy of detection decreased as the number of intervening words increased. However, the number of intervening words had a greater effect for the aphasic patients than the normal patients across the repetition, rhyming and semantic conditions. These data suggest that the aphasic patients have difficulty with phonemic as well as semantic feature analysis. However, what was most interesting is that when the lists were

presented at a slower rate, the aphasic group's performance improved across all conditions.

These results emphasize the importance of considering memory factors in evaluation, since the aphasic group's performance was generally not impaired relative to controls unless an interfering stimulus intervened. Therefore, in order to pick up subtle deficits which can affect functional language, memory components of language tasks should be explicitly manipulated. By the same token, if memory factors vary across tasks and the clinician is not aware of those factors, performance differences could be due to the change in memory requirements rather than the explicitly manipulated variable.

Another thing this study emphasizes is the apparent interaction between processing level and memory and the apparent importance of presentation rate. This has implications for diagnosis as well as treatment. Rate of presentation must be well controlled; small differences can influence the patient's ability to process and remember information. Variability of presentation rate could contribute to variability of the patient's performance and even more important, the patient's level of processing may be different at different intervals. Of course, this finding also suggests manipulation of rate of presentation could be a very useful therapy tool as well.

Conclusion

Any paragraph or sentence comprehension test on standard speech and language batteries such as the Minnesota Test for the Differential Diagnosis of Aphasia (Schuell, 1973), the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1976), the Porch Index of Communicative Ability (PICA) (Porch, 1971) or the Token Test (Lesser, 1976) requires the patient to remember the first as well as the last part of the sentence or paragraph to respond appropriately. Therefore, memory factors including interference, chunking and depth of processing, could affect performance.

Memory is an important aspect of functional language, and ideally verbal and non-verbal memory skills should be assessed in aphasic patients to determine their impact. Until a battery of standardized tests are designed to examine this and other information processing variables the very least that must be done is to be aware of the existence of these variables and their potential impact on speech and language performance.

References

- Anastasi, A. Psychological Testing. New York, New York: Mac Millan Publishing Co., In., 1976.
- Baddely, A.D. Short Term Memory for Word Sequences as a Function of Acoustic, Semantic, and Formal Similarity. Quarterly Journal of Experimental Psychology, 18, 362-365, 1966.
- Cermak, L.S. and Moreines, J. Verbal Retention Deficits in Aphasic and Amnesic Patients. Brain and Language, 3, 16-27, 1976.
- Craik, F.I.M. and Lockhart, R.S. Levels of Processing: A Framework for Memory Research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684, 1972.
- Goodglass, H. and Kaplan, E.F. The Assessment of Aphasia and Related Disorders. Philadelphia: Lea and Febiger, 1976.

- Goodglass, H. and Kaplan, E. Assessment of Cognitive Deficit in the Brain-injured Patient. In M.S. Gazzaniga (Ed.), The Handbook of Behavioral Neurobiology: Neuropsychology. New York: Plenum Press, 1979.
- Heilman, K., Scholes, R. and Watson, R.T. Defects of Immediate Memory in Broca's and Conduction Aphasia. Brain and Language, 3, 201-208, 1976.
- Cohen, G. Hemispheric Differences in a Letter Classification Task. Perception and Psychophysics, 11, 139-142, 1972.
- Jones-Gotman, M. and Milner, B. Right Temporal-lobe Contribution to Image-mediated Verbal Learning. Neuropsychologia, 6, 61-71, 1978.
- Klatzky, R. Human Memory: Structures and Processes. San Francisco: W.H. Freeman and Company, 1975.
- Lesser, R. Verbal and Non-verbal Memory Components in the Token Test. Neuropsychologia, 14, 79-85, 1976.
- Locke, J.L. and Deck, J.W. Retrieval Failure, Rehearsal Deficiency, and Short-term Memory Loss in the Aphasic Adult. Brain and Language, 5, 227-235, 1978.
- Miller, G.A. The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. Psychological Review, 63, 81-97, 1956.
- Miller, G.A. and Selfridge, J.A. Verbal Context and the Recall of Meaningful Material. American Journal of Psychology, 63, 176-187, 1950.
- Patten, B.M. The Ancient Art of Memory. Archives of Neurology, 26, 25-31, 1972.
- Porch, B.E. Porch Index of Communicative Ability: Administration Scoring and Interpretation. Palo Alto: Consulting Psychologists Press, 1971.
- Posner, M.I. and Mitchell, R.F. Chronometric Analysis of Classification. Psychological Review, 74, 392-409, 1967.
- Rothi, L. Retention of Verbal Information by Aphasic Individuals. Presented at the International Neuropsychological Society, New York, N.Y., 1979.
- Saffran, E., Marvin, O., Schwartz, M.F., and Rubman, A. Two Mechanisms of Auditory Verbal STM Impairment in Aphasia. Presented at the International Neuropsychological Society, Santa Fe, N.M., 1977.
- Savage, R.D. Intellect and Personality in the Aged. In W. Lynn Smith and M. Kinsbourne (Eds.), Aging and Dementia. New York: Spectrum Publications, 1977.
- Schuell, H. Differential Diagnosis of Aphasia with the Minnesota Test. Minneapolis: University of Minnesota Press, 1973.
- Sies, L.F. Aphasia Theory and Therapy: Selected Lectures and Papers of Hildred Schuell. Baltimore, MD: University Park Press, 1974.
- Warrington, E. and Shallice, T. The Selective Impairment of Auditory Verbal Short-term Memory. Brain, 92, 885-896, 1969.
- Wepman, J. Recovery from Aphasia. New York: Ronald, 1951.
- West, J. Imaging and Aphasia. In R.H. Brookshire (Ed.), Clinical Aphasiology Conference Proceedings. Minneapolis: BRK Publishers, 1977.