Gestural Signing: Treatment for a Letter Writing to Dictation Impairment

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M.T. is a fifty year old right handed male who experienced a left thrombotic CVA in September of 1975. A language evaluation, completed at a private hospital at two weeks post-onset, found that M.T. had severe impairments in auditory and visual comprehension, fluent verbal expression marked by paraphasic errors, right hemiparesis and severe dysgraphia.

At four months post-onset he was referred to the Ann Arbor Veterans Administration Hospital for treatment of his language disorder. The results of our initial evaluation are shown in Figure 1 (Week -60). By this time M.T. had apparently made good progress in auditory and visual comprehension. Verbal expression remained somewhat impaired, as evidenced by depressed scores on subtest I of the PICA (Porch, 1967). In addition, scores on subtest II and III were depressed. He remained severely dysgraphic for all but graphic copying tasks and demonstrated a three to four digit forward short-term-memory span.

M.T. was treated for a fourteen month period with a remediation program designed to cause improvement in all modalities. Figure 1 also shows the PICA scores at the end of that fourteen month treatment interval (Week 0). During this period of time M.T.'s overall PICA scores moved from the 62nd percentile to the 74th percentile, however, little change was evidenced in graphic tasks.

During this treatment interval two techniques were used to produce improvement in M.T.'s writing abilities. The Fernald Approach (Fernald, 1943) is the frequently recommended (Schuell, 1964; Longrich, 1955; Haskins, 1976) treatment for dysgraphia which is based on reauditorization and tracing. The phono-visual approach is essentially a paired-associate learning task in which the sound of the letter is paired with a key word. Though both of these techniques were used in treating his dysgraphia, apparently, neither was sufficient to cause significant change.

This patient's performance on selected subtests of the Minnesota Test for Differential Diagnosis of Aphasia (Schuell, 1965) (Table I) indicated that visual reception skills were intact. In addition, graphic copying tasks and sequential number writing were unimpaired. However, the writing of single letters to dictation was at a 52% correct level and written and oral spelling of word test were at a 0% correct level. It should also be noted that letter naming was at a 96% correct level.

A review of M.T.'s performance on subtest D of the PICA at Week 0 indicated that: 1) the individual letter cue was required for all written responses which were greater than three letters; 2) M.T. often was unable to recall how to write a letter when it was dictated by the examiner and so left a blank space and 3) he sometimes wrote an incorrect letter in response to the letter-by-letter cue.

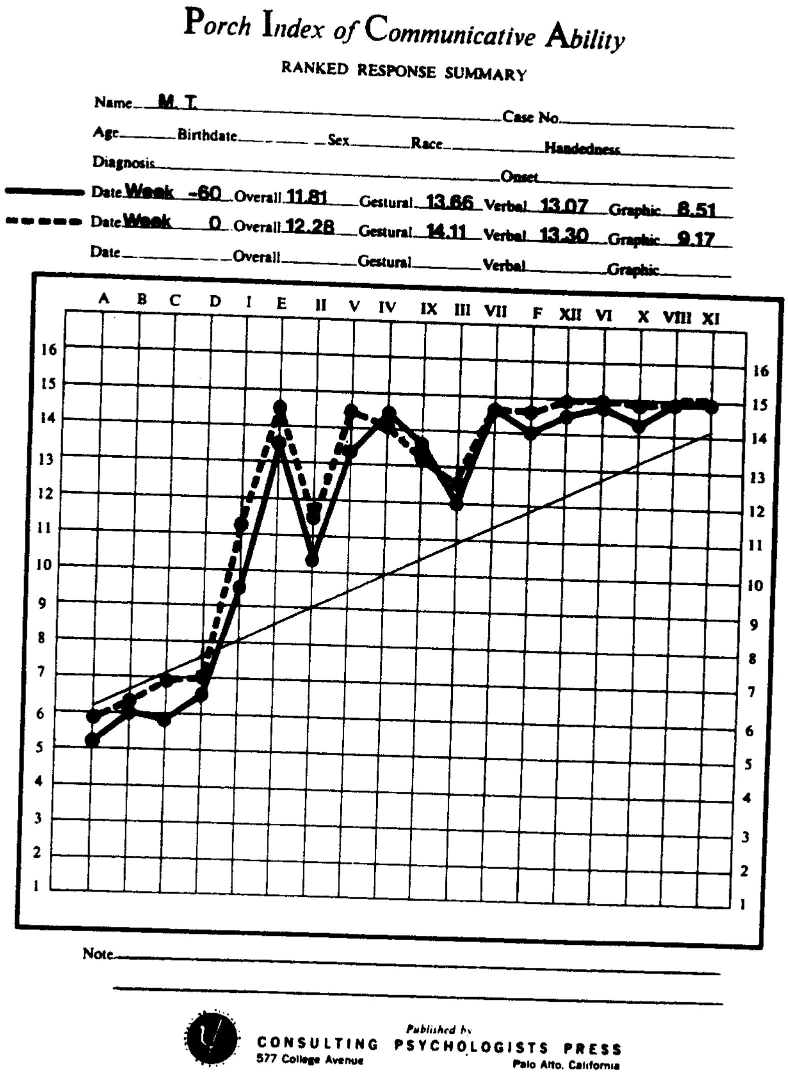

Figure 1. PICA scores at the beginning and end of 60 weeks of traditional treatment.

In order to better understand the nature of this patient's dysgraphia, the authors reviewed a model of the cognitive processes involved in writing to dictation (Weigl and Fradis, 1977). The authors of this model make use of the concepts of decoding stimuli and encoding responses. In addition, the concept of transcoding is fundamental to the model. Transcoding is defined as: "transposing certain prescribed units of one code system into the relevant units of another code system" (Weigl, 1974).

TABLE I. M.T.'S PERFORMANCE ON SELECTED SUBTESTS OF THE MINNESOTA TEST FOR DIFFERENTIAL DIAGNOSIS OF APHASIA.

TASK	PERCENT CORRECT
VISUAL RECEPTION	
MATCHING GEOMETRIC FORMS	100%
MATCHING LETTERS	100%
MATCHING WORDS TO PICTURES	100%
MATCHING PRINTED TO SPOKEN WORDS	100%
SENTENCE COMPREHENSION	100%
POINTING TO LETTERS NAMED BY E	100%
GRAPHIC EXPRESSION	
COPYING GREEK LETTERS	100%
WRITING NUMBERS 1-20	100%
REPRODUCING A WHEEL	100%
REPRODUCING LETTERS	100%
WRITING LETTERS NAMED BY E	52% ←
WRITING WORDS NAMED BY E	0% ←
ORAL SPELLING OF WORDS NAMED BY E	0% ←
NAMING	
NAMING LETTERS	96%

The model presented in this paper is based on the model of Weigl and Fradis, but has been converted to the terms used by Atkinson and Wescourt (1975) and Lachman (1973). The model will be discussed in terms of the letter writing to dictation task because this is the disability for which M.T. first received treatment. The model is shown in Figure 2.

Weigl and Fradis contend that when a subject is first learning to write to dictation the auditory stimulus, e.g. the spoken letter "a," must be associated with some internal acoustic representation of past experience with that stimulus. That internal representation is here termed the auditory perceptual code or auditory p-code and represents stimulus decodin Next, the auditory p-code must be transcoded into an internal representatio of the visual characteristics of that stimulus (visual p-code). Following the auditory to visual transcoding stage (Type-1 transcoding) it is necessary for the visual p-code to be transcoded into a grapho-motor code (Type-transcoding). The grapho-motor code supplies the subject with the motor movements necessary to commit the graphic response to paper. When the grapho-motor code has been retrieved the graphic response can be produced. Once an individual has become an accomplished writer, Weigl and Fradis contend that a condensation of the cognitive processes takes place. In such a condensed cognitive system it is possible for the subject directly to transcode from auditory perceptual information to grapho-motor informati

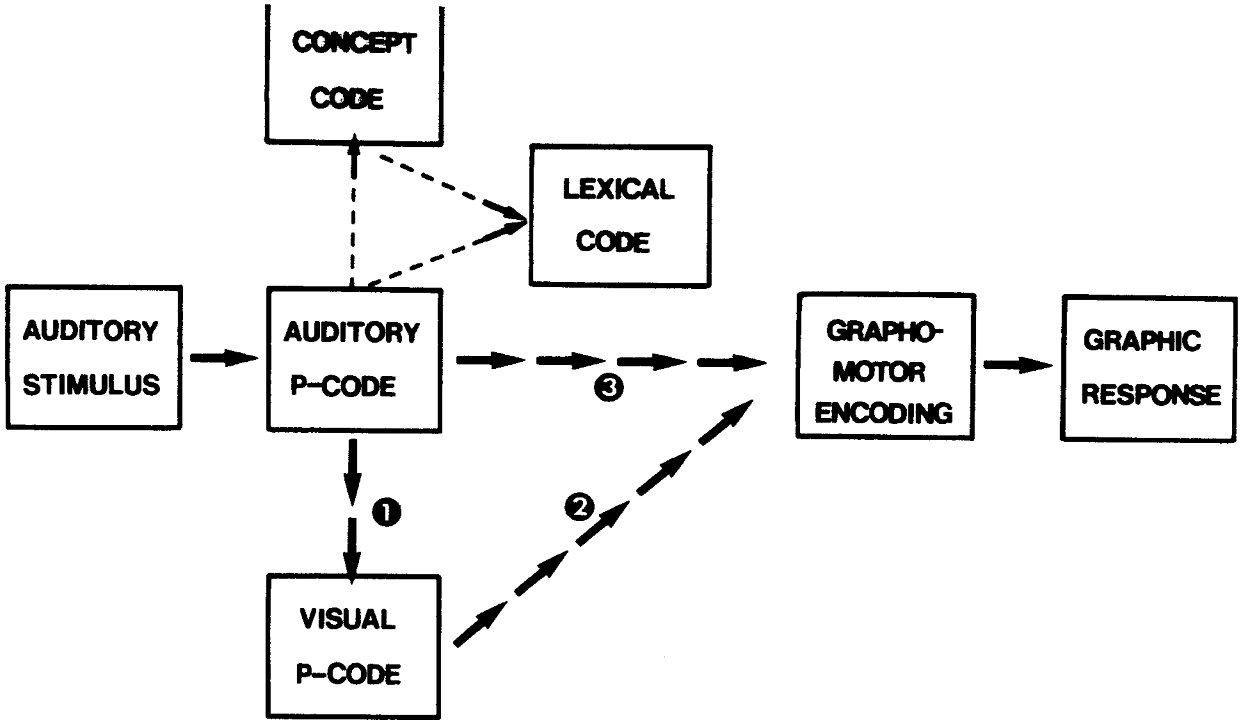

Figure 2. A model of the cognitive processes involved in a letter-writing to dictation task.

(Type-3 transcoding), thereby bypassing the need to transcode to and from visual p-code information. This condensation of the processes in writing to dictation results in a system which is more efficient.

When damage to the cognitive system is experienced, there is a dissolution of this condensed cognitive system. That is, the system reverts to the less efficient auditory p-code to visual p-code to grapho-motor code transcoding process.

When a letter writing to dictation impairment exists, Weigl and Fradis contend that it is due to disrupted transcoding processes within the system. It appears then, that the breakdown in writing to dictation could be due to a breakdown in Type-1 or Type-2 transcoding processes described. Because Type-3 transcoding represents a condensation of the system, and because writing to dictation is possible through the more circuitous combination of Type-1 and Type-2 transcoding, it can be concluded that a writing to dictation impairment cannot be due solely to a breakdown in Type-3 transcoding. In order to determine the status of transcoding Type-1 (auditory p-code to visual p-code) and transcoding Type-2 (visual p-code to grapho-motor code) M.T. was given two additional tasks to perform. The first task was a letter copying task and the second was a letter recognition task.

A model of the cognitive processes involved in graphic copying is shown in Figure 3. In this task, a visual stimulus, a letter, is shown to the subject and he is asked to copy it. In order to perform the task, the

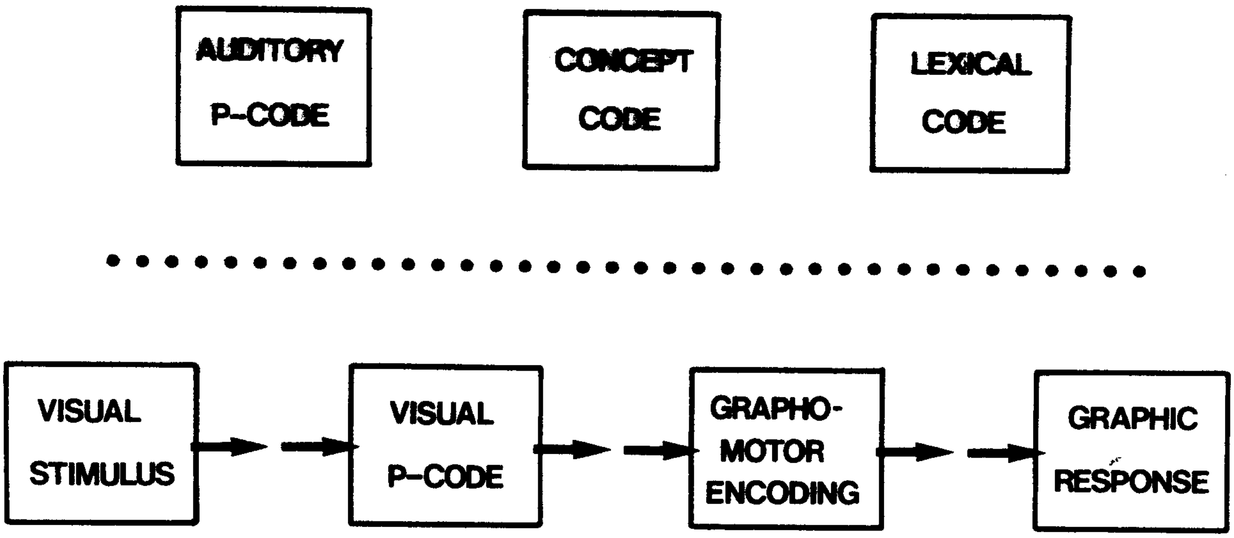

Figure 3. A model of the cognitive processes involved in a graphic copying task.

subject must locate a visual p-code within the system which is based on past experience with the visual stimulus. If he has no past experience with the visual stimulus, he must construct a visual perceptual code. The visual p-code must then be transcoded into a grapho-motor code and finally the response is produced. The information placed above the dotted line in the model (auditory p-code, concept code and lexical code information) is not required to allow the subject to perform this task. Thus, this model explains how it is possible to copy the elements of an unfamiliar language without having any previous experience with that language. Performance in this task was used to determine the status of Type-2 transcoding ability. M.T. performed without error in the letter copying task, indicating that this transcoding stage remained intact.

Figure 4 provides a model of the processes involved in letter recognition. In this task the examiner speaks the name of a letter while an array of three visual stimuli is presented to the subject. The visual stimuli are all letters and only one letter represents the visual characteristics of the letter name spoken by the examiner. In order to perform this task, it is necessary for the subject first to decode the auditory stimulus, i.e. locate the internal auditory p-code associated with that letter name. He must also decode the three visual stimuli by locating their respective visual p-codes within his system. The subject then needs to determine with which of the three retrieved visual p-codes the retrieved auditory p-code is associated. This may involve looking for a bonding, a link or an intersect point between two of the items. When such an intersect point is identified, it signals that this is the correct response. The subject then encodes a motor pointing response and points to the selected visual stimulus. The letter recognition task was used to examine M.T.'s ability to associate auditory p-code with visual p-code information. Though M.T. performed the letter recognition task without errors, his errorless performance did not

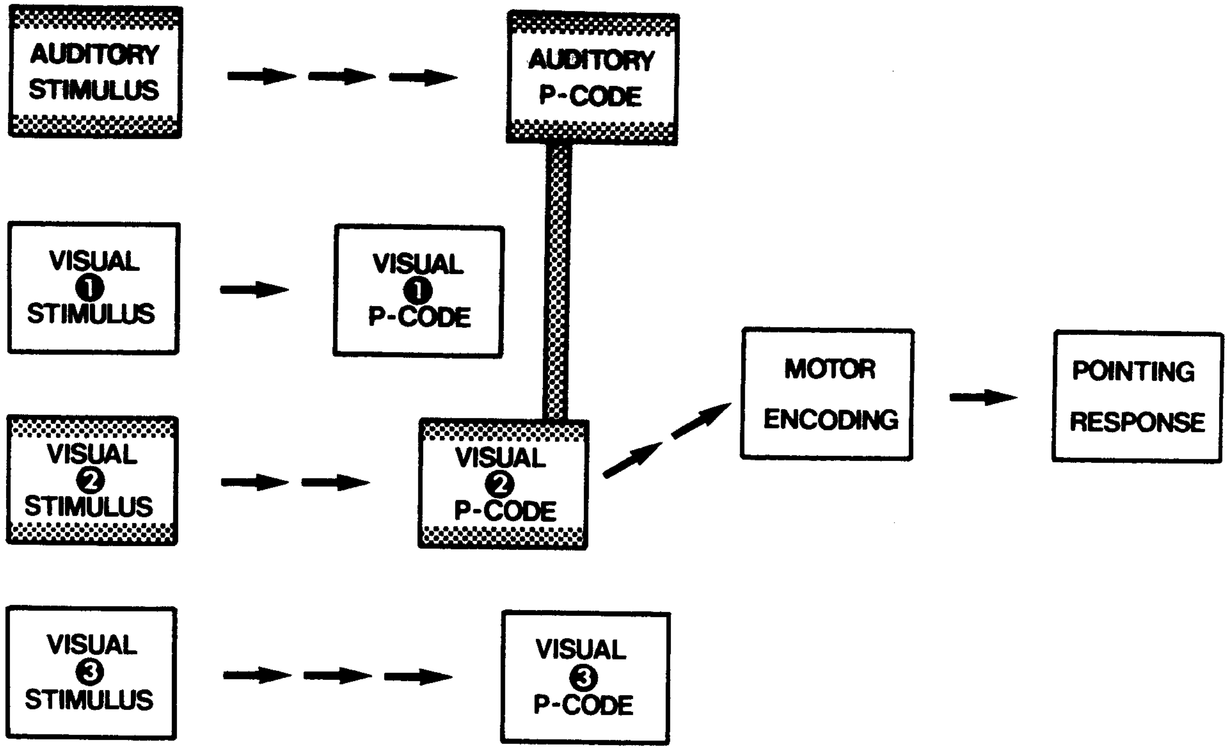

Figure 4. A model of the cognitive processes involved in a letter recognition task.

indicate that his system was capable of performing Type-1 transcoding operations. The letter recognition task cannot be considered a true test of Type-1 transcoding ability, because in the letter recognition task the environment contains both an auditory and a visual representation of the target stimulus. Once these stimuli are decoded, it is only necessary for the subject to locate a link, a bond or an intersect point that exists between them. Thus, this task is a recognition task which does not require a Type-1 transcoding ability. In the letter writing to dictation task, only one form of the target item (the letter's spoken name) exists in the environment. In order to perform the task, the auditory p-code must be transcoded into a visual p-code. Thus, this task becomes a recall or a retrieval task which requires Type-1 transcoding abilities.

Because we did not know the status of M.T.'s writing to dictation abilities prior to the onset of his CVA, it cannot be determined whether he was ever able to perform Type-3 transcoding. However, because he showed errorless graphic copying, we can assume that Type-2 transcoding ability was intact. Though letter recognition did not provide an adequate test of M.T.'s Type-1 transcoding ability, it is assumed that because he cannot write to dictation and because Type-2 transcoding is intact, that M.T. cannot write letters to dictation due to impaired Type-1 transcoding ability.

The authors reviewed the Fernald Approach and the phono-visual approach to writing to dictation impairments and developed some suppositions concerning their failure to facilitate improvement in this patient's dysgraphia. The Fernald Approach, based on reauditorization and tracing, seems to stress transcoding Types-1 and -2. As we have seen, transcoding Type-2 already was intact. The phono-visual approach, as indicated by its name, seemed to stress transcoding Type-1. Therefore, it seems both treatment techniques were unsuccessful because they failed to produce improvement in auditory p-code to visual p-code (Type-1) transcoding.

The authors reasoned that it might be possible to establish a new perceptual code in M.T.'s system. This new perceptual code could be linked, through training, to the auditory p-codes, the visual p-codes and to the grapho-motor codes for single letters and words. The training procedure could be designed to establish transcoding to and from this new alternate perceptual code. If successful, the technique would allow writing to dictation through one of two alternate routes. The first possibility is that the auditory p-code would be transcoded into the alternate p-code. The new alternate p-code information would then be transcoded into the visual p-code. Type-2 transcoding, which remained intact, would then take place. The second possibility is that auditory perceptual information could be transcoded into the new perceptual information and then be directly transcoded into the grapho-motor code by Type-3 transcoding.

The intermediate perceptual code selected by the authors was the gestural sign system of the finger spelling alphabet. Because finger spelling was not known by the subject, it would represent a new type of perceptual coding.

TABLE II. THE SEQUENCE OF STEPS USED TO TEACH LETTER WRITING TO DICTATION BY USE OF FINGER SPELLING SIGNS.

CLINICIAN	SUBJECT
1) C SIGNS AND NAMES A LETTER WITH PRINTED LETTER IN VIEW	S SIGNS AND NAMES IN IMITATION
2) C SIGNS A LETTER	S NAMES THE LETTER
3) C NAMES A LETTER	S SIGNS THE LETTER
4) C SIGNS AND NAMES A LETTER WITH PRINTED LETTER IN VIEW	S SIGNS AND COPIES THE LETTER
5) C SIGNS AND NAMES A LETTER	S SIGNS AND WRITES THE LETTER
6) C NAMES A LETTER	S SIGNS AND WRITES THE LETTER
7) C NAMES A LETTER	S WRITES THE LETTER

The sequence of steps established to teach the task is given in Table I Basically, Step 1 was designed to establish a link between the sign and the visual characteristics of the letter; Steps 1, 2 and 3 to establish a link between the sign and the letter name; Steps 4, 5 and 6 to establish a link between the sign and the grapho-motor code and Step 7 was the uncued letter writing to dictation task we wished M.T. to accomplish.

Six manual signs whose visual characteristics corresponded to the visual characteristics of six written letters were chosen to be taught first. They were: I, J, V, W, Y and Z. M.T. had previously erred in writing all of these letters to dictation. The authors hypothesized that the visual correspondence between the gestural sign and the written symbol would aid M.T. in learning the task.

After the training sequence had been completed with these six stimuli M.T. showed improvement in writing these six letters to dictation. Therefore, additional manual signs were presented until all signs of the manual alphabet had been learned. M.T. then advanced to writing letter-pair stimuli to dictation. The effects of treatment on writing single letters and letter-pairs to dictation are shown in Figure 5.

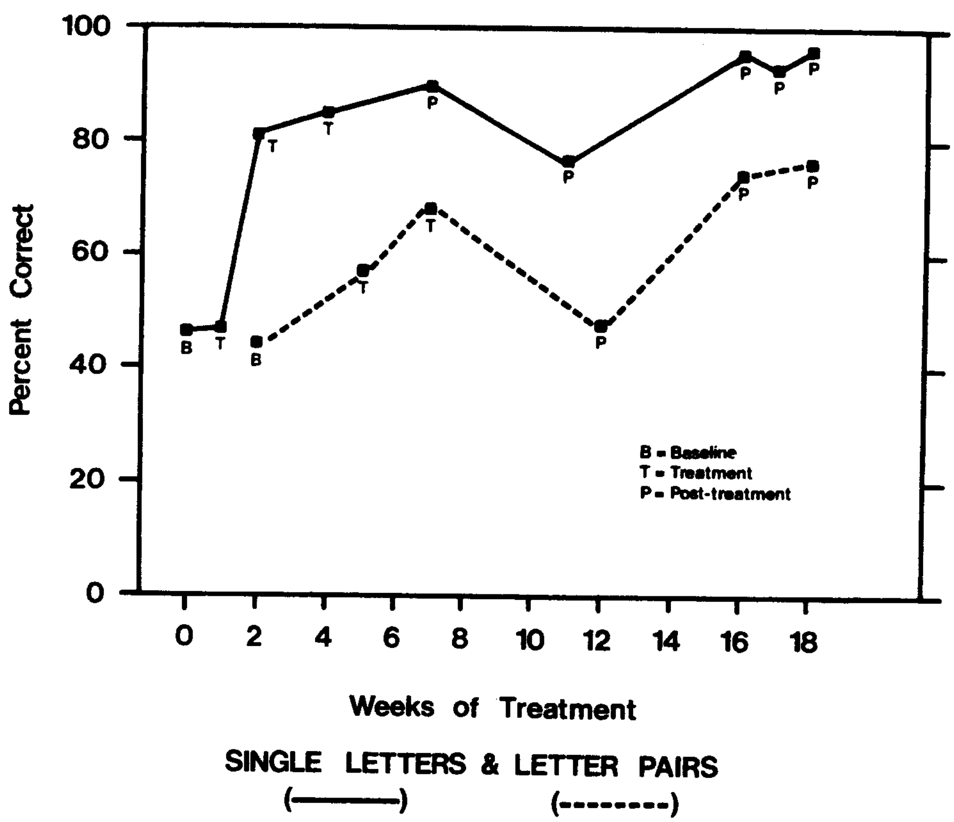

Figure 5. The effects of gestural signing treatment on writing single letters and letter pairs to dictation.

A stable baseline in single-letter writing to dictation had been shown over a 14 month period prior to the treatment. The traditional therapies mentioned earlier had not significantly affected this ability. Once the gestural signing treatment was initiated, performance in writing single letters to dictation rapidly improved. Probes of his writing of single letters to dictation stabilized at 92-96% correct.

During Week 2, shortly after his performance with single letters began to improve, baselines for writing letter-pairs and 3-4 letter sequences were established. It was noted that when letter-pairs were dictated, the patient was spontaneously signing the letters with his left hand as he wrote them with his right. Improvement was seen through Week-18. Performance with 2 letter-pairs peaked at a level 14-18% below that of single letter writing to dictation.

M.T.'s performance with 3-4 letter sequences and 3-4 letter whole words is shown in Figure 6.

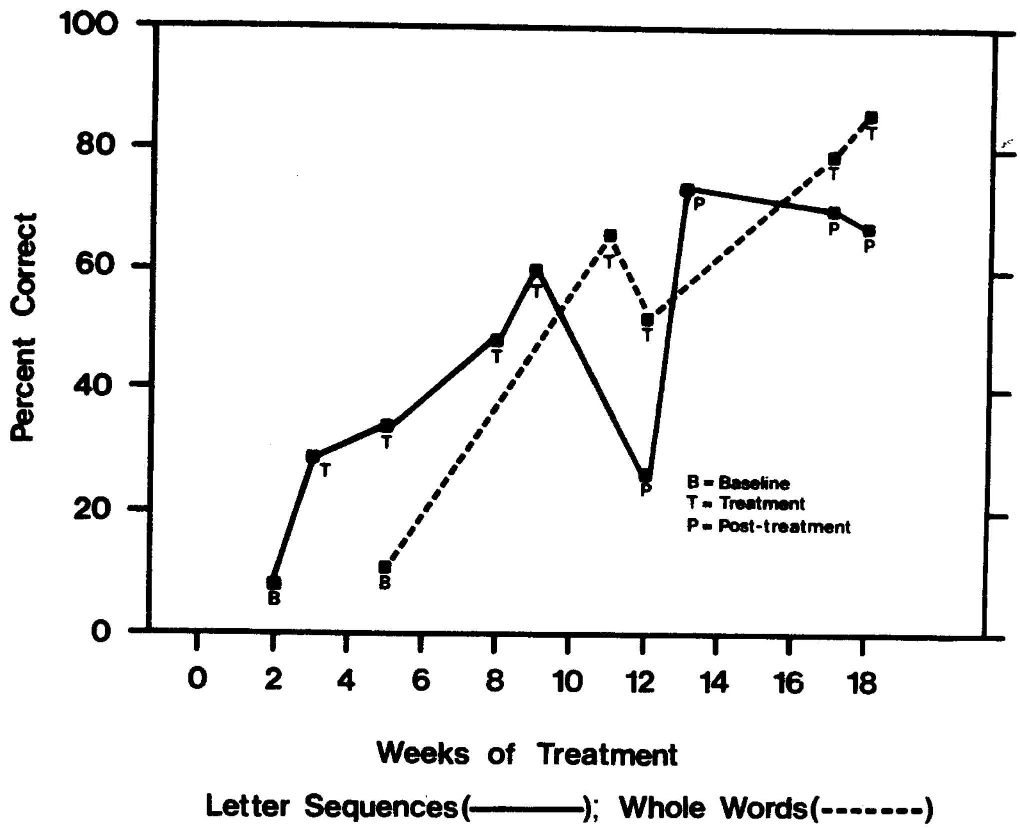

Figure 6. The effects of gestural signing treatment on writing 3-4 letter sequences and 3-4 letter words to dictation.

During Week-3, M.T. began writing 3-4 letter sequences to dictation. All the sequences were words. These words were first presented as letter-by-letter sequences. When presented in this format, performance steadily increased, but never reached the level achieved by single letters or letter-pairs. The authors interpret this as evidence of the effects of his restricted auditory and visual short-term-memory span.

During treatment, M.T. expressed a desire to be able to write to dictation when the whole word was given as the stimulus. Consequently, during Week 5 he began performing a writing to dictation task where 3-4 letter whole words were given as the stimuli. When the 3-4 letter sequences were presented as whole words, an interesting thing occurred. Performance under this condition exceeded the performance levels of both letter-pairs and 3-4 letter sequences. In fact, his ability to spell single 3-4 letter whole word stimuli was most like his ability to write single letters to dictation. This finding was taken as evidence that when given the whole word stimuli, as opposed to letter sequences, M.T. was able to "chunk" the letters into a single unit for processing. He was, in this context, able to recall the spelling pattern as a single unit, Thus, his performance in this task was not restricted by his short-term-memory deficit, because he was operating far below the 3-4 unit limit of his short-term-memory span. At the beginning of treatment M.T. performed at a 10% accuracy level with whole word stimuli. At termination he performed at an 88% level with trained 3-4 letter words.

The authors cannot provide conclusive evidence which indicates the exact nature of the cognitive change which resulted in improvement in writing to dictation. However, because only a minority of the signs bear a close visual relationship to the written letters they represent; because it was found that the rate at which the patient learned to write visually related letters vs. visually unrelated letters was not different; and because he performed more poorly when looking at his hand while producing the signs, it is likely that improvement was due to the linking effects of a kinesthetic perceptual code based on gestural signs. It appears that the linking effects could have taken place in one of two ways. First, if impaired writing to dictation was due to impaired Type-1 transcoding, the cognitive system may have been altered by treatment to allow Auditory-Kinesthetic-Visual-Grapho-motor transcoding. If the writing to dictation impairment was due to an irreparable damage to the Type-1 transcoding mechanisms, the treatment might have allowed Auditory-Kinesthetic-Grapho-motor transcoding. It is not possible to determine which of these cognitive mechanisms resulted in the improvement shown by M.T.

The final PICA examination results shown in Figure 7 were obtained at Week-16, two weeks prior to the end of treatment. Improvement is most evident on subtest D where the letter-by-letter cue was still required for all items exceeding three letters in length. A somewhat smaller degree of improvement can be seen on subtest C. The depression in subtest II and III performance remain evident.

During the final weeks of treatment, M.T. was experiencing personal problems. As a consequence he terminated treatment earlier than the authors wished, at the end of Week 18. We were unsuccessful in our attempts to get M.T. to return for follow-up testing and have been informed that M.T. has recently experienced a second CVA.

It is concluded that:

1) M.T.'s performance improved due to the linking effects produced by the development of a new kinesthetic perceptual code established by the treatment procedure.

2) Reduced short-term-memory continued to limit M.T.'s performance in letter writing and word writing to dictation tasks.

3) The short-term-memory limitations appeared to be operating in kinesthetic, as well as auditory and visual, modalities.

4) These data do not indicate that M.T.'s performance was restored to a close approximation of normal, however, they do indicate that this technique has value with selected aphasic patients; namely, those patients who have

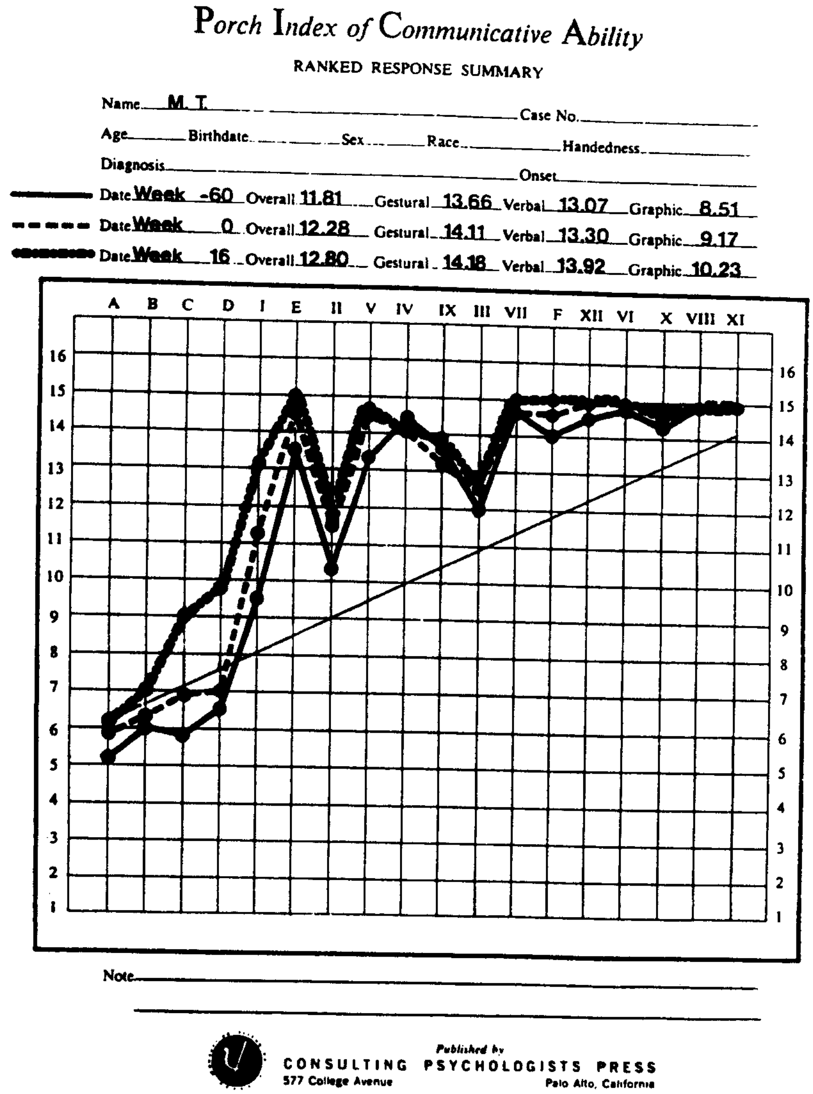

Figure 7. Changes in PICA test scores through 60 weeks of traditional treatment (Week 60--Week 0) and 16 weeks of gestural signing treatment (Week 0--Week 16).

intact Type-2 transcoding (copying) abilities for letters, but who are unable to perform Type-1 transcoding for letters (writing letters to dictation).

5) While this treatment approach has been used with partial success with one patient who had the specific symptoms and behaviors mentioned earlier, we believe that further empirical application of this method is needed before its value to dysgraphia in general can be determined.

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Discussion

Q. I didn't recall you saying where the lesion was, but if Porch is right, it should be in the left parietal lobe.

A. This patient came from a private hosptial. After he arrived in our hospital, he had a brain scan. That scan indicated a lesion in the left hemisphere in the posterior region. That's the only localizing data that we have on him. Based on those dips I, too, would think it would be a more posterior lesion in the parietal area.

Q. The second question, which I think has more clinical relevance, is was there a functional and more rational reason for doing this type of therapy? Was this important, do you think?

A. The specific problem that the patient realized was that he had a five year old daughter who was bringing home schoolwork; spelling words. She would say, "Daddy, how do you spell 'cat'?" And Daddy couldn't help her. And so that's why we spent as much time working with his graphic problems as we did. He perceived it as a significant problem.

Q. Was he able to spell 'cat' after this treatment? According to the information there, it looks as if he has gotten to the point where he can write to dictation, but can he initiate writing?

A. He had improved in writing to dictation. The question is: can he now write without dictation? Yes, he had shown improvement on writing three and four letter words. When we gave the word as a stimulus, he was able to handle that. He did not improve more, I think, on subtest C of the PICA because many of the items were much longer than that, and he did possess a short term memory problem. His word retrieval ability, his naming ability, was unimpaired, so he could retrieve the word 'cat' when he saw the picture, and then retrieve the spelling pattern for it.

Q. According to the model you used, the p-code has access to the conceptual information (the c-code). One would suppose, therefore, that if access to perceptual information is impaired you would see a corresponding deficit in naming. I was wondering, if he didn't have problems in naming as you said, it seems contrary to the model.

A. I don't think that this is contrary to the Atkinson-Wescourt model because, as I understand it, in the naming task, the individual must decode perceptual information, extract a perceptual code and, based upon that, enter the lexicon to extract the lexical code to produce the name. I understand that he may also extract conceptual information at the same time. In the letter writing task, conceptual information does not necessarily have to be involved. Weigl and Fradis pointed out cases of individuals who are able to write to dictation, but are unable to understand what they've written. So they're able to handle these transcoding processes in the absence of conceptual information.

Q. First of all, I'd like to say, congratulations on the eloquence of the rationale. I was very, very impressed, and I think you should be congratulated. I wonder if you have looked at all at the nature of the written errors he made. I think that might be linked to what you mentioned in short term memory involvement. Also, the question just raised, since some theorists think that short term memory affects acoustic coding, if you're going to go from acoustic coding to visual coding, some of those difficulties might come up in that way and, as you say, might be short-term memory problems. I was just wondering if you couldn't check this out by looking at the nature of the errors they make. In other words, if you can specify a substitution, is it more visually related or unrelated or what?

A. We didn't look specifically at the types of substitutions. We just looked at the errors, whether he was omitting letters and whether he needed the cues. (Follow up analysis of the errors types produced indicates that M.T. made visually related, acoustically related and unrelated errors. No one type predominated.)