Auditory Processing Deficits in Aphasia Evidenced on the Revised Token Test: Incidence and Prediction of Across Subtest and Across Item Within Subtest Patterns

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Schuell (1954, 1974), Porch (1970) and Brookshire (1972) have described several patterns of auditory processing deficits in persons with aphasia. Since Brookshire (1974) synthesized and postulated about the nature, mechanisms, and therapeutic importance of these patterns, only three studies appear to have confirmed their existence. LaPointe, Horner, Lieberman and Riski (1974) used a battery of tests to confirm the existence of patterns which occur across subtests. While confirming the existence of the types, they found that a single pattern type characterized only about 17% of their subjects. In other words, in addition to a predominant pattern, one, two or even three secondary patterns also characterized their performance. Noll and Randolph (1978) also discussed across subtest patterns. They suggested that their patterns could be explained by either the linguistic nature or the length of the stimulus.

De Simoni, Keith, Holt and Darley (1979) confirmed, using the Porch Index of Communicative Ability (PICA), the existence of two pattern types (tuning-in and fading-out) which occurred across item - within subtests. The patterns that Porch addressed, and some offered by Brookshire also appear to be across item - within subtest patterns. The patterns offered by Schuell and some offered by Brookshire apparently describe behaviors and mechanisms which occur within a single stimulus item, that is, within the comprehension of a single sentence.

The names given the patterns by the various authors, either intentionally (which is the most probable) or unintentionally, suggest the underlying mechanisms which cause them. Yet, the names of the patterns are quite consistent whether describing across subtest, across item - within subtest, or within item behavior. Because we feel it may be premature to discuss the mechanisms causing the patterns, we suggest discussing pattern types according to the type of test material being examined (across subtest, across item-within subtest, or within item). This paper is an attempt to describe and verify within subtest and across subtest patterns only. Although we acknowledge the existence and probable importance of within item patterns, no attempt to analyze or discuss those data will be made in this paper.

Our purposes for undertaking this investigation were five. The first was to provide concurrent validity to the above authors' findings that the patterns actually exist. The second was to examine the Revised Token Test's (RTT) structure relative to its ability to elicit and capture behaviors which form these various patterns (because they are hypothesized to be caused by differing underlying cognitive or physiological mechanisms, and should, therefore, respond to different types of treatment). The third purpose of this investigation was to determine the consistency with which pattern types occurred for any given individual (a measure of Revised Token Test redundancy). Fourth, the interaction of pattern type with the nature of the task (length and linguistic structure) was to be determined. Finally, the predictability of any pattern, given the presence of any other pattern-type, or given the individual biographical characteristics of time post onset, etiology, severity of auditory processing deficit and subject's age was to be examined.

Method

The subjects consisted of thirty left-hemisphere-damaged aphasic adults who were heterogeneous with respect to age, sex, etiology, site of lesion, duration post onset and overall severity of aphasia (A more detailed description of these subjects can be found in McNeil and Prescott, 1978.).

The patterns of auditory deficit established for this study were consistent conceptually with those patterns described by Brookshire and others. The Revised Token Test (McNeil and Prescott, 1978) was used to elicit the behaviors from which the patterns were to be described. The operational definitions for each of the patterns which was established for this investigation follows. A difference score of .20 or more between items or subtests was required in order for items or subtests to be judged as different (e.g. 12.00 would be judged as different from 12.20 but not 12.10). This difference was judged to be a conservative one for across item - within subtest patterns.[1]

Across Item - Within Subtest Patterns

The structure of the RTT is such that three patterns could occur within any given subtest. The first pattern (illustrated in Figure 1) we termed tuning-out. Other names for this pattern might include fading-out, fatigue, noise build-up and unsustained auditory attention. Operationally, the pattern occurred if the patient's performance progressively decreased across all ten items within a subtest or until a plateau was reached.

Figure 2 illustrates what we termed tuning-in: another name for this pattern might be slow rise time. This pattern occurred when the patient's performance got progressively better across all ten items within a subtest or until a plateau was reached.

Figure 3 illustrates the intermittent pattern. Other names for this pattern might include intermittent inattention and intermittent imperception This pattern occurred when the patient's performance fluctuated by .20 or more per item and was not attributable to fatigue or tuning-in behavior.

It should be mentioned that a fourth pattern, (in which no fluctuations in performance occur) could potentially manifest itself. Although not illus trated, the profile would be essentially flat, regardless of the level at which it occurred on the ordinate. It should also be mentioned that this pattern did not occur in the subject sample.

Across Subtest Patterns

Figure 4 shows a pattern consistent with what we called tuning-out. Other names for this pattern might include: fading out, noise build-up, and

[1] It should be noted that in order for these patterns to be validly analyzed, the items within any given subtest must be established as homogeneous. This has been established with the Revised Token Test (McNeil and Prescott, 1978).

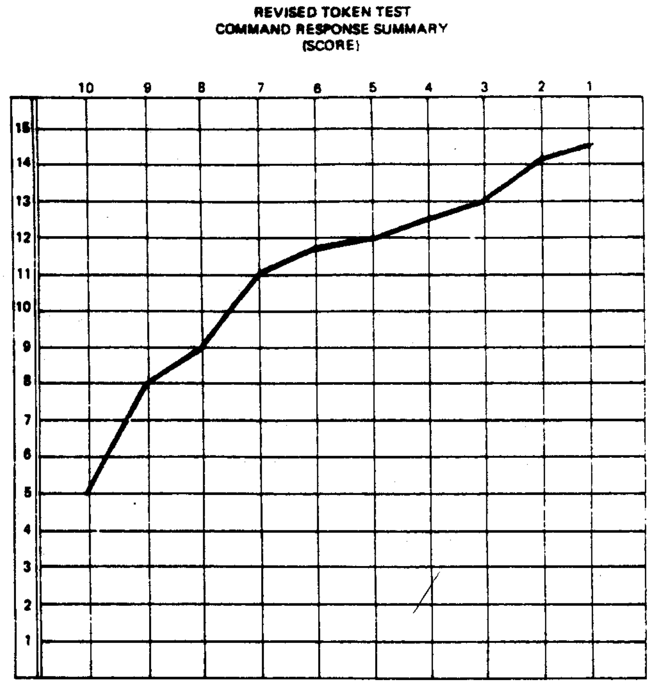

Figure 1. Tuning out across items within subtests.

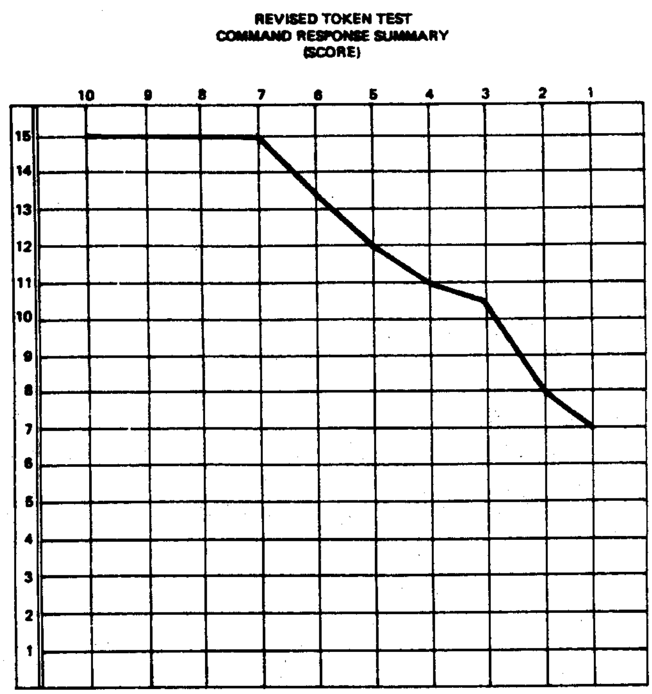

Figure 2. Tuning in across items within subtests.

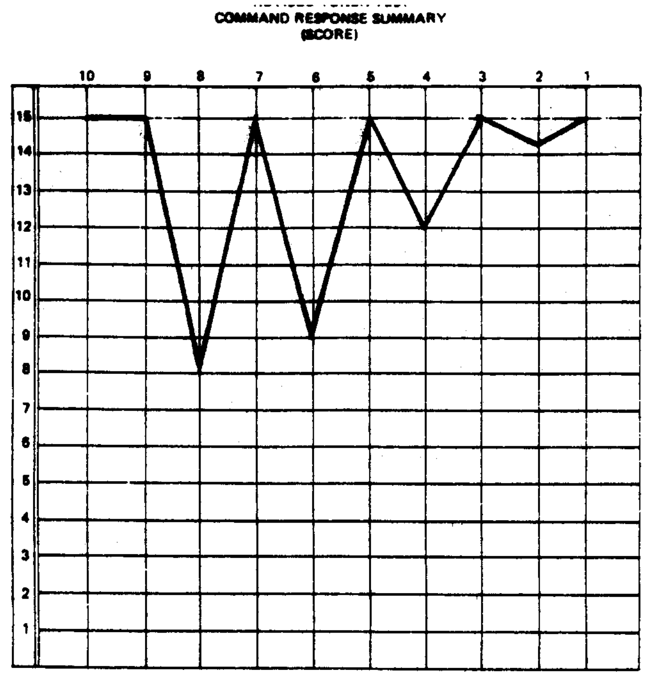

Figure 3. Intermittent across items within subtests.

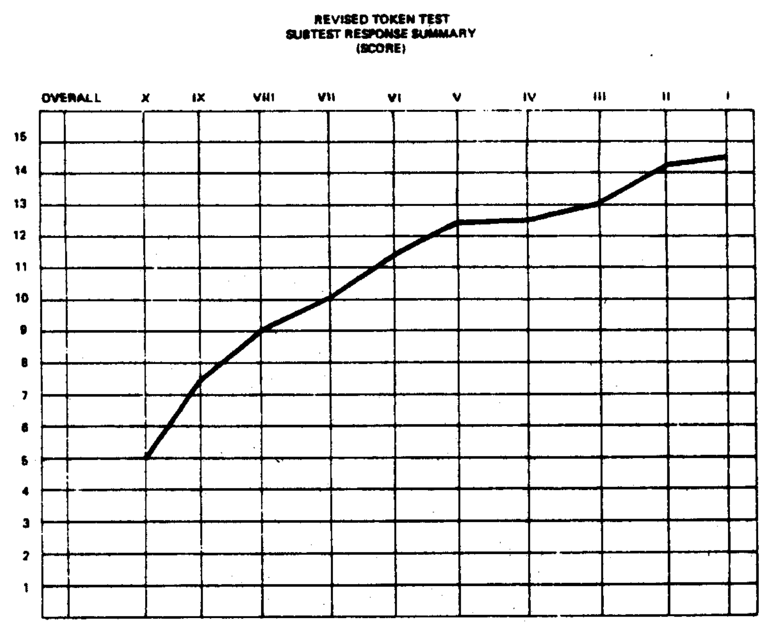

Figure 4. Tuning out across subtests.

unsustained auditory attention. Here the patient's performance progressively decreased across all ten subtests or until a plateau occurred.

Figure 5 illustrates tuning-in. Another name for this pattern may be slow rise time. The patient's performance progressively increased across all ten subtests or improved to a plateau.

Figure 6 illustrates plus-length. Other names for this pattern may include slow rise time and "learning." The patient's performance systematically increased as the number of units to be processed increased. This pattern can be observed over four comparisons using the RTT, by grouping the subtests by sentence type. Therefore, by examining subtests I to IV (homogeneous in sentence type), one can determine if a pattern of plus-length exists. Likewise, the presence of plus-length patterns can be determined by examining subtests V to VI, VII to VIII and IX to X.

Figure 7 shows a minus-length pattern. Other names for this pattern might include capacity deficit or short-term memory deficit. With this pattern the patient's performance systematically decreases as the number of units to be processed increases. As with the plus-length pattern, this pattern can be observed over the same four subtest comparisons using the RTT.

Figure 8 illustrates four patterns which we code under the general title of specific linguistic deficits. These patterns refer to the differential processing of linguistic structures as measured on the RTT. The first three patterns occur when the compound imperative sentence types (subtests III and IV) are both different[2] from each of the other three sentence types (subtests V and VI, VII and VIII, IX and X). The fourth pattern occurs when spatial prepositional phrases, (subtests V and VI), are both different from left/right prepositional phrases, subtests (VII and VIII). The fifth specific linguistic deficit pattern occurs when the spatial prepositional phrases, subtests (V and VI), are both different from adverbial clauses, subtests (IX and X). The sixth pattern occurs when left/right prepositional phrases subtests (VII and VIII) are both different from adverbial clauses, subtests (IX and X). Other possible specific linguistic deficits discussed in McNeil and Prescott (1978) will not be addressed in this investigation.

The final pattern, illustrated in Figure 9, we termed simply intermittent. Other terms that have been used for this pattern include intermittent imperception and intermittent inattention. Intermittent behavior across subtests as within subtests is fluctuating performance which cannot be attributed to any other across subtest pattern.

The methods of analysis included an examination of mean scores by items and by subtest for each of the thirty subjects. Pearson product-moment correlation coefficients were computed for patterns by subtests, subtest by subtest pattern, individual subtest pattern by overall pattern and patterns by individual biographical characteristics. In addition, mean percentage of subjects demonstrating each of the pattern types was calculated.

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[2]"both different" means that the range of scores for each subtest pair is different. The range is different if both scores are either above or below the compared subtest pair.

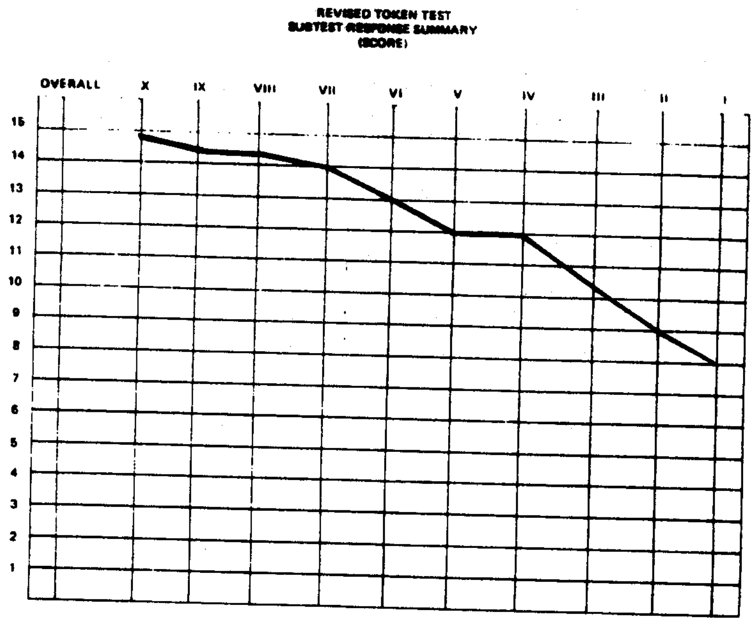

Figure 5. Tuning in across subtests.

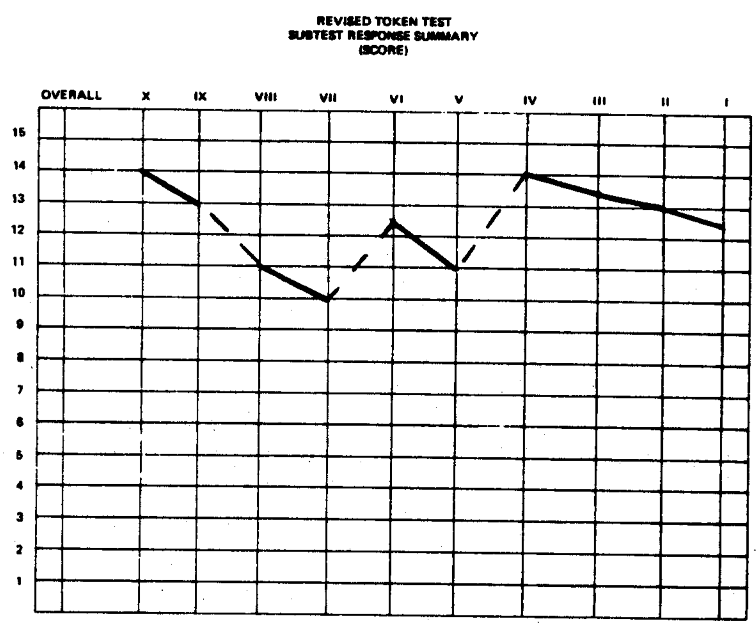

Figure 6. Plus-length across subtests.

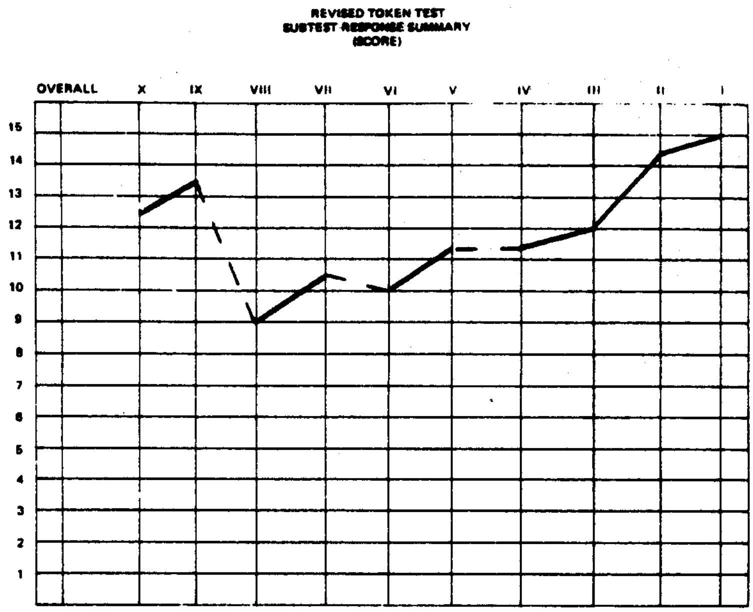

Figure 7. Minus-length across subtests.

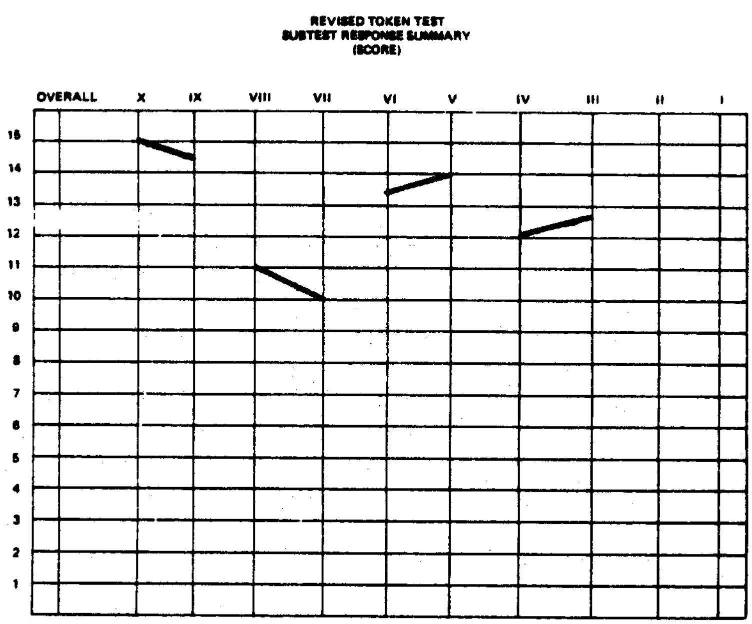

Figure 8. Specific linguistic deficits.

Results

Across Item - Wtihin Subtest Patterns

Figure 10 illustrates the percentage of patterns (300 possible patterns) and percentage of subjects (30 subjects) demonstrating a particular pattern which occurred in this investigation. The "X" data points show that 64.3 percent of all across item-within subtest patterns were intermittent. Nineteen percent were determined to be tuning-in, and 16.7 percent were tuning-out. These incidence figures were found to be relatively consistent across subjects irrespective of subtest. The "O" data points illustrate the percentage of subjects who demonstrated a particular pattern at least one time. Again, the intermittent pattern was the most consistently-occurring pattern across subjects, occurring in 100 percent of the subjects. Tuning-in occurred in about 16 percent, and tuning-out in about 27 percent of the subjects. In addition, the frequency of occurrence of patterns was relatively consistent across subtests, as shown in Table 1.

Table 1. Frequency of occurrence (in percentage of 30 subjects) of across item-within subtest pattern, for the 10 RTT subtests and for the Overall Across Subtests.

Pattern	I	II	III	IV	V	VI	VII	VIII	IX	X	Over-all
INTERMITTENT	60	63	57	70	63	73	80	77	56	50	65
TUNING-IN	27	17	23	13	27	17	13	0	17	33	19
TUNING-OUT	13	20	20	17	10	10	7	23	27	17	16

The relative predominance of a particular pattern was also examined. A single predominant pattern for any individual was defined operationally as one which occurred in 80 percent of the subtests, or a pattern that occurred in 70 percent of the subtests, but with the other two patterns also occurring. Two predominant patterns were judged to have occurred when 50, 60, or 70 percent of the subtests showed one pattern and only one other pattern occurred on the remaining subtests. Therefore, if the occurrence of the three patterns was distributed relatively equally among the subtests (e.g. 6, 3, and 1; or 4, 1, and 5; or 5, 2, and 3) no predominant pattern was judged to have occurred. Figure 11 illustrates the percentage of subjects demonstrating zero, one, or two predominant pattern(s). Twenty-three percent demonstrated no predominant pattern; 37 percent demonstrated a single predominant pattern, and 40 percent demonstrated two predominant patterns. In addition, no subjects presented a single pattern across all ten subtests.

Across Subtest Patterns

Patterns which occur across subtests were also examined. Neither tuning-in nor tuning-out (fatigue) patterns occurred when examined across all ten subtests. The plus-length performance, meaning an increase in

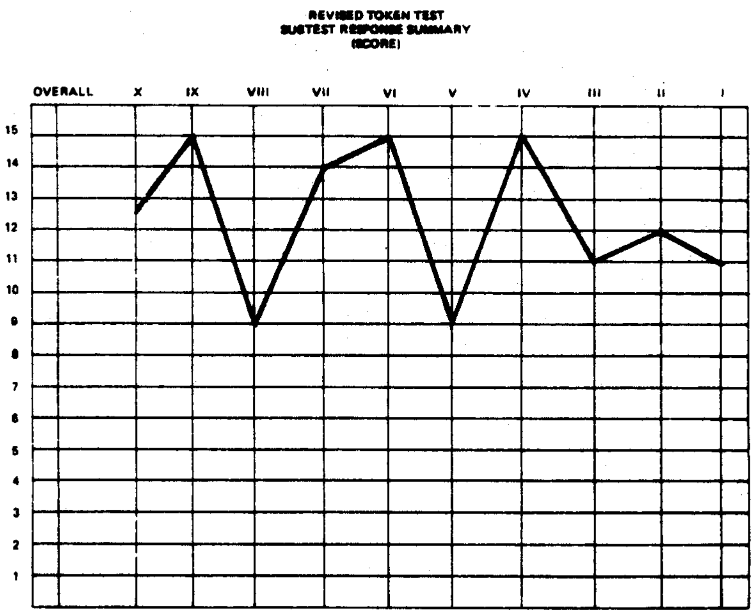

Figure 9. Intermittent across subtests.

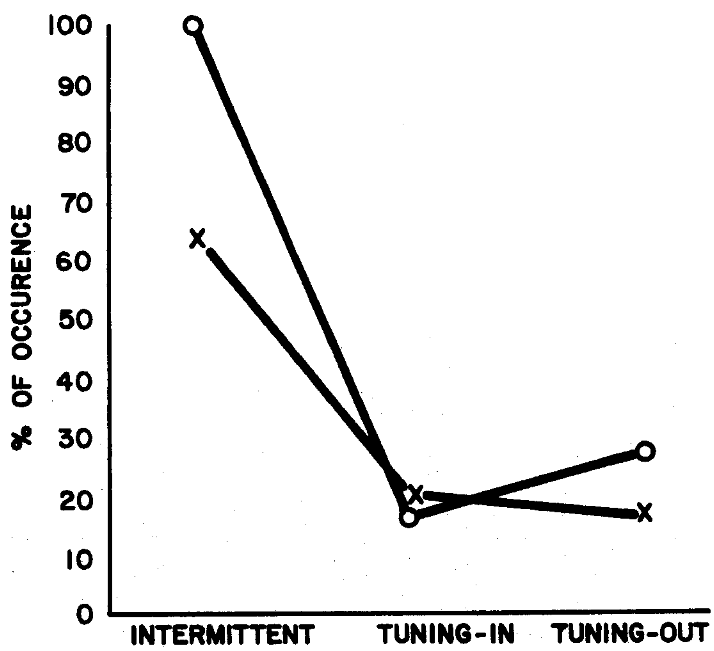

Figure 10. Percentage of 300 Patterns (X representing data points) and percentage of 30 subjects (0 representing data points) demonstrating each pattern across item within subtests on the Revised Token Test.

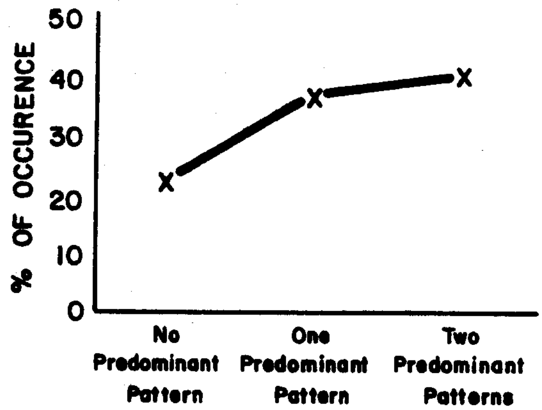

Figure 11. Percentage of 30 subjects demonstrating pattern predominance across item within subtests on the Revised Token Test.

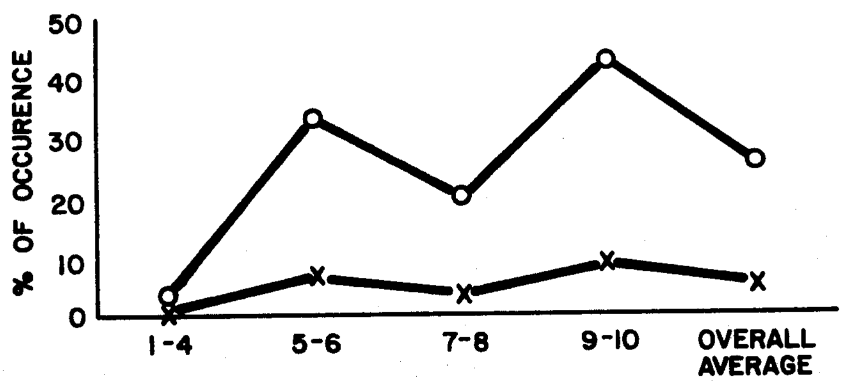

Figure 12. Percentage of plus-length patterns (X representing data points) and percentage of 30 subjects (0 representing data points) demonstrating this pattern across subtest classes on the Revised Token Test.

performance level with an increase in stimulus length, is shown in Figure 12. The line with the X marking the data points represents the percentage of patterns which occurred, while the line with the 0 data points represents the percentage of subjects demonstrating plus-length type which occurred across subtests. Plus length occurred .5 percent from subtests I to IV. Seven percent of the patterns were of the plus-length type for subtest V to VI. Four percent occurred for subtest VII to VIII, and nine percent occurred for subtest IX to X. Overall, five percent of the across subtest patterns were plus-length. The percentage of subjects demonstrating this pattern across linguistic subtest classes resembled the slope (Figure 12) of the curve for the percentage of pattern occurrence, but the percentage was substantially increased for these subjects. Three percent demonstrated plus-length performance for subtests I to IV; 33 percent for subtests IX to X. Overall, 25 percent of the subjects demonstrated plus-length on at least one of the four instances where it could have occurred.

Minus-length performance, meaning poorer performance with increasing length of stimulus, is shown in Figure 13. The line with the X marking the data points again represents the percentage of the total patterns which occurred, and the line with the 0 data points represents the percentage of subjects demonstrating minus-length. Overall, about 10 percent of the across subtest patterns were of the minus length type. This pattern accounted for 11 percent of the across subtest patterns for subtests I to IV, 10 percent for subtests V to VI, 13 percent for subtests VII to VIII, and 7 percent for subtests IX to X. On the average, 46 percent of the subjects displayed this pattern across subtest classes. The pattern was observed in 47 percent of the subjects for subtest I to IV, in 46 percent for subtests V to VI, in 60 percent for VII to VIII, and in 31 percent for subtests IX to X.

The four linguistic categories which are used on the Revised Token Test were also evaluated, relative to their relationship to within and across subtest patterns. Figure 14 illustrates the percentage of patterns (*) and subjects(•) demonstrating specific linguistic patterns. In this figure, the 3 & 4 Δ (delta) 5 & 6 means that the mean subtest scores for subtests III and IV were both different by .20 or more than either mean score for subtests V and VI and neither mean score fell between either of the paired means. About 11 percent of the patterns and 30 percent of the subjects showed a difference between subtests III & IV and V & VI. Eighteen percent of the patterns and 46 percent of the subjects performed differently between III & IV and VII & VIII. Eighteen percent of the patterns and 43 percent of the subjects showed a difference between III & IV and IX & X. Nine percent of the patterns and 20 percent of the subjects differed between V & VI and VII & VIII. Eighteen percent of the patterns and 46 percent of the subjects differed between V & VI and IX & X. Twenty-three percent of the patterns and 56 percent of the subjects showed a difference between subtests VII & VIII and IX & X.

Figure 15 illustrates the percentage of subjects demonstrating at least one pattern of each type (•), the percentage of the total patterns (*—*), and relative percentage of the total patterns (*---*). Relative percentage was tabulated first by adding the number of times a particular pattern type occurred and then dividing the plus and minus-length total by four and the specific linguistic total by six because there were four and six times as many opportunities to demonstrate these patterns as there were intermittent, tuning-in and tuning-out. Thus the percentage of

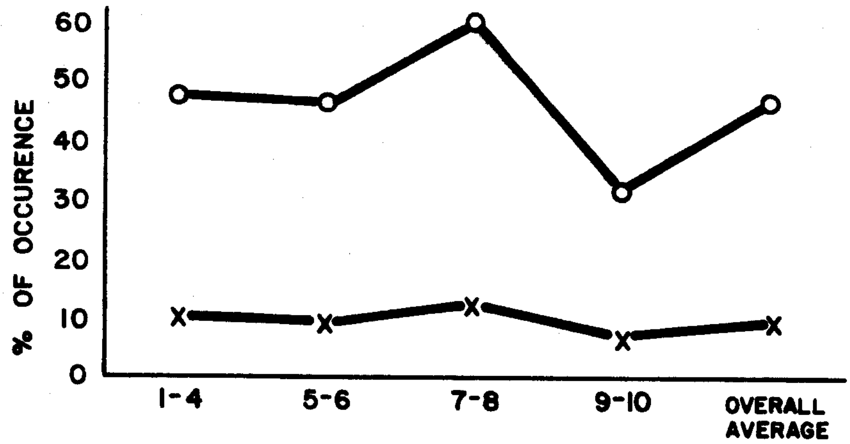

Figure 13. Percentage of Minus-length patterns (X representing data points) and percentage of 30 subjects(0 representing data points) demonstrating this pattern across subtest classes on the Revised Token Test.

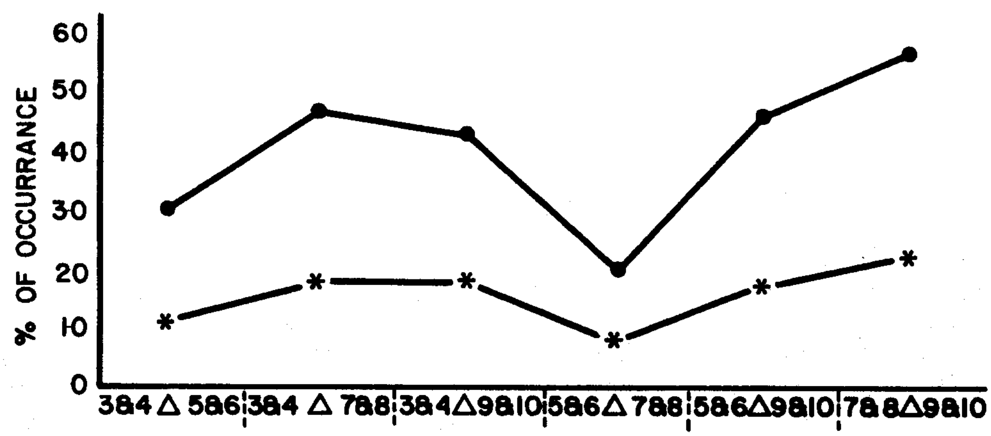

Figure 14. Percentage of specific linguistic difference patterns (* representing data points) and percentage of 30 subjects (● representing data points) demonstrating this pattern across subtests on the Revised Token Test.

pattern occurrence reflects that which one would expect to find in the general population, while the relative percentage reflects the importance of one pattern compared to another. Forty-three percent of the subjects demonstrated an intermittent pattern, while nine percent of the total patterns and nine percent of the relative frequency were of this pattern type. Sixty-three percent of the subjects demonstrated at least one instance of plus length, however, only 18 percent of all patterns were of the plus-length type. The relative frequency of plus-length was only seven percent however. Ninety percent of the subjects demonstrated at least one instance of minus-length, while 32 percent of the total patterns which occurred were of this type. Minus-length was the most predominant pattern with a relative percentage of about 14. Eighty-four percent of the subjects demonstrated at least one instance of a specific linguistic effect. Forty-two percent of all across subtest patterns were of this type, while the relative frequency was 17 percent of the total. Neither tuning-in nor tuning-out patterns occurred across subtests.

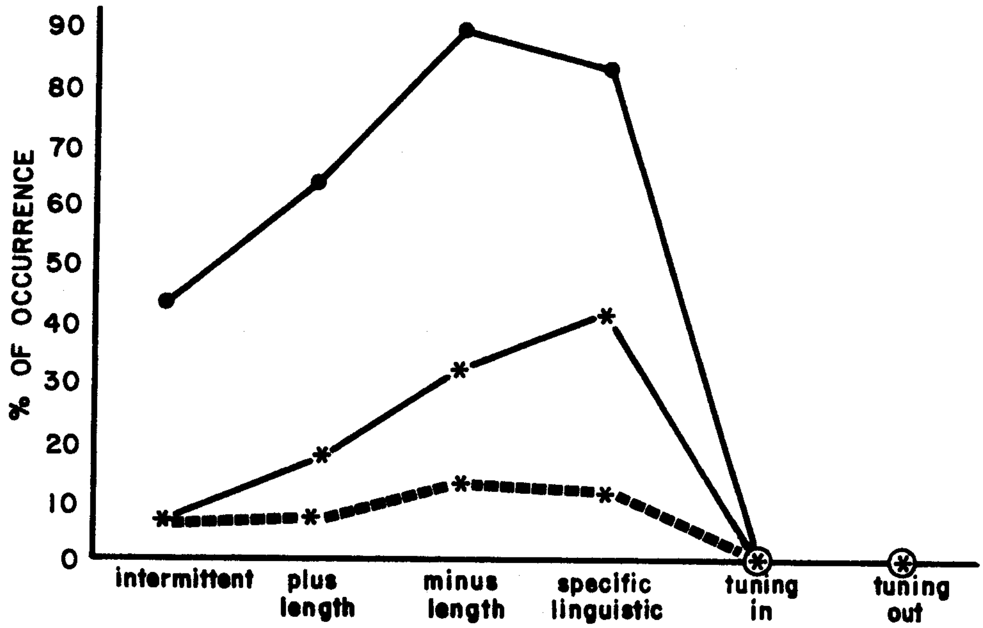

Figure 15. Percentage of across subtest patterns(* representing data points) and percentage of 30 subjects (● representing data points) demonstrating at least one pattern type on the Revised Token Test. The dashed line represents the relative occurrence of pattern types.

Pearson product-moment correlations were computed between the frequency of occurrence of pattern types (both within subtests and across subtests) and with the biographical factors of age, time post onset, subtest severity and overall severity. Table 2 provides the correlation coefficients which were obtained for the within subtest patterns. No meaningfully significant correlations across subtest patterns were found except those that would be expected from the operational definitions of pattern types. For example, if subjects did poorer with increasing length, they did not do better with increasing length. Pearson r's computed for within subtest pattern types and across subtest pattern types did not reveal correlations which would allow high predictability for any pattern type.

Table 2. Pearson product-moment correlation coefficients for pattern type by subtest and overall pattern type with biographical factors.

Pattern by Subtest	Age	Time Post Onset	Overall Score	Overall Subtest Scores									
				I	II	III	IV	V	VI	VII	VIII	IX	X
I	.02	-.18	.12	.09	.17	.10	.12	.16	.03	.22	.09	.21	.05
II	.05	.12	.28	.40*	.26	.30	.20	.32	.16	.24	.33	.34	.25
III	.26	.17	.27	.11	.17	.20	.32	.25	.27	.23	.27	.36	.17
IV	-.29	.26	-.03	-.28	-.14	-.08	-.16	-.09	.19	-.05	.10	-.25	-.19
V	.45	.09	-.01	-.09	.06	-.05	.09	.06	.03	.03	.04	-.15	-.20
VI	-.07	-.20	-.15	-.17	-.08	-.11	-.21	-.28	.05	-.17	-.03	-.28	.12
VII	-.04	.47*	.29	.02	.10	.28	.20	.32	.23	.17	.27	.45*	.25
VIII	.07	-.21	-.15	-.07	.06	.02	.12	.10	.28	.01	-.32	-.10	.15
IX	.26	-.18	.10	.06	.14	-.02	.13	.03	.21	.13	.21	-.21	-.12
X	-.14	-.11	-.09	.16	.02	.05	.05	.08	.14	.09	.22	.09	.02
Intermittent	-.12	.01	-.37*	-.21	-.35*	-.31	-.27	-.32	-.34	-.36*	-.48*	-.30	-.13
Tuning Out	-.08	-.12	.27	.30	.33	.28	.22	.21	.11	.23	.25	.31	.26
Tuning In	.21	.12	.12	-.07	.05	.06	.08	.14	.26	.16	.27	.02	.11

Even though intermittent behavior was by far the dominant pattern for all subjects for all within subtest patterns, it was not predictable from the presence of any other behavior pattern. However, Pearson r's computed between pattern type and the biographical factors of age, and time post onset revealed a couple of significant and possibly meaningful correlations. A correlation of .45 (range = .17 to .70, $p < .05$) was found between subtest V (6 element spatial prepositional imperatives) and age, suggesting that persons who are older tend to demonstrate more tuning-in behavior, while younger persons with aphasia tend to demonstrate more intermittent type patterns.

A correlation of .48 (range = .18 to .70, $p < .05$) was found between time post onset and the occurrence of the intermittent pattern type. This means that persons with a shorter time post onset tended to demonstrate more intermittent type patterns than those persons who were a longer time post onset, who tended to demonstrate more tuning-in type patterns within subtests, particularly on subtest VIII (8 element-left/right prepositional imperatives).

Subtest and overall RTT severity correlated significantly with pattern type in a few instances. Subtest I mean score correlated .40 (Range = .07 to .62, $p < .05$) with the pattern types found on subtest II. Likewise, the mean score for subtest IX correlated .45 (Range = .17 to .70, $p < .05$) with the pattern types displayed on subtest VII. This means that the higher the subtest mean scores for subtests I and IX, the less likely one was to display an (within subtest) intermittent pattern on subtests II and VII. Also, the lower the scores on I and IX, the more likely the presence of a tuning in pattern on II and VII.

Conversely, the Subtest II mean score correlated significantly ($r = -.35$ Range = -.59 to -.03, $p < .05$) with the presence of the intermittent pattern on that same subtest. Interpreted, that means that the higher the score, the more likely one was to evidence the intermittent pattern. Similar correlations were evidenced for subtest VIII ($r = -.48$, Range = -.70 to -.18, $p < .05$) and for the overall score, predicting the across subtest patterns ($r = -.37$, Range = -.60 to -.04, $p < .05$), all leading to the same prediction, that the higher the mean score for subtests and the overall, the more likely the presence of the intermittent pattern.

Correlations were not computed for pattern frequency and etiology or site of lesion; however, the percentage of patterns occurring by etiology and site are presented in Tables 3 and 4 and in Tables 5 and 6 for the lesion sites. Percentages by pattern across etiology and site appear relatively consistent, given the percentage of subjects with each biographical factor. In general, etiology and site of lesion do not appear to be related substantively to the frequency with which a particular pattern would be expected to occur.

Discussion

The results of this investigation provide concurrent evidence that persons with aphasia do not perform alike auditorally. It also provides concurrent validity that the behavior displayed by persons with aphasia can, for the most part, be categorized by those patterns described by various aphasiologists. Related to this is the notion that the patterns need to be discussed relative to the type of test material used to elicit them (within item, across item-within subtest, or across subtests). The

Table 3. Percentage of within subtest patterns by etiology.

Etiology Percent*	Thrombosis 7*	Embolism 7	Trauma 13	AVM 7	Surgery 13	Other 53	$\overline{X}$. 100
Intermittent	50%	55%	73%	50%	50%	71%	58%
Tuning-out	5%	25%	20%	30%	23%	12%	18%
Tuning-in	45%	20%	7%	20%	27%	17%	24%

*percentage of subject sample displaying that etiology

Table 4. Percentage of across subtest patterns by etiology.

Etiology Percent*	Thrombosis 7	Embolism 7	Trauma 13	AVM 7	Surgery 13	Other 53	$\overline{X}$. 100
+ length	14%	0%	37%	0%	24%	25%	17%
- length	43%	55%	31%	55%	41%	41%	44%
Linguistic	14%	36%	26%	36%	29%	22%	26%
Intermittent	29%	9%	0%	0%	6%	10%	9%

*percentage of subject sample displaying that etiology

Table 5. Percentage of within subtest patterns by site of lesion.

Pattern	Site of Lesion		
	Temporal (30%)*	Parietal (13%)	Other (57%)**
Intermittent	54	58	67
Tuning-out	12	20	17
Tuning-in	23	22	16

*Percentage of subjects displaying that site of lesion

**Other refers to sites of lesion which were unspecifiable from the neurological evaluation

Table 6. Percentage of across subtest patterns by site of lesion.

Pattern	Site of Lesion		
	Temporal (30%)*	Parietal (13%)	Other (57)**
+ length	16	13	19
- length	32	50	33
Linguistic	44	31	41
Intermittent	8	6	7

*Percentage of subjects displaying that site of lesion

**Other refers to sites of lesion which were unspecifiable from the neurological evaluation three patterns sought in our across item-within subtest analysis were confirmed to exist. Evidence from both the percentage of subjects and from the percentage of pattern occurrence makes it clear that the intermittent pattern is the predominantly occurring pattern. Nearly two-thirds of all across item patterns were of the intermittent type, and every single subject demonstrated at least one subtest which was best characterized this way. Both tuning-in and tuning-out occurred relatively equally; although slightly more subjects displayed an occurrence of tuning-out than tuning-in.

Given the findings of LaPointe, et al. (1974), that a single pattern did not characterize most subject's behavior, it was not surprising that our subjects demonstrated more than one pattern. What was somewhat unexpected, however, was that nearly one-fourth of the subjects demonstrated no single predominant pattern. Also unexpected was the finding that about equally as many subjects demonstrated two predominant patterns (40 percent) as demonstrated a single predominant pattern (37 percent). The only pattern which occurred as a singularly dominant one was the intermittent pattern, occurring in about 43 percent of the subjects. Clearly then, whatever mechanisms underlie the behaviors which result in these patterns, they co-occur in a great percentage of aphasic patients. This co-occurrence seems to happen irrespective of sentence type or sentence length. One exception to this generalization occurred on subtest number VIII, in which no tuning-in patterns occurred. Whether this finding reflects a chance finding or some interaction with a previously occurring subtest, something peculiar to the interactive effects of the length and linguistic nature of the subtest, a subject selection bias, or the interaction of selection and any of the other possible effects is unknown at this time.

Tuning-in and tuning-out across subtests did not occur in this subject sample. If these processing deficits actually exist, it may be that factors such as stimulus length and grammatical class interacted on the RTT to obscure them. Possibly, but somewhat less likely, one of the other rival explanations offered above for the lack of the tuning-in pattern within subtest VIII might explain this finding. A generalization of this finding, unrelated to the purposes of this investigation, suggests that there is no significant fatigue factor across the 10 subtests of the Revised Token Test.

The relatively small percentage of plus-length pattern occurrence, which occurred across subtests, suggests one, two or three possible explanations. The first, and possibly the best explanation is that there was some minimal learning (at least task familiarization) occurring. We support this explanation by observing that only one-half of one percent (.5%) of all of the patterns and only three percent of the subjects showed this pattern on the I to IV subtest group. The other subtests have either prepositions or adverbial clauses in them, which, we believe, makes them more amenable to learning or to the development of a strategy for handling them, even when the subsequent subtest was increased in the number of critical elements to be processed. Another possible explanation for this pattern might be that some subjects displayed what Porch called "slow rise time." That is, the subject missed the initial few elements of any command, and would hence perform better given information with more critical elements (a problem with the recency effect of memory). A review of these subject's RTT item scores showed that this was not the case. They did not perform better on the latter elements in the command than on elements occurring earlier in the command. If this second explanation is not tenable, then the third, which is a combination of the first two, can also be rejected.

It is interesting, however, that a large percentage of subjects did demonstrate at least one occurrence of this learning pattern (25% overall). It may be worth speculating that this might be a prognostic factor. In other words, persons who show the capacity to organize their experience and profit from it, even when the subsequent information is more difficult, may be offering clues to better recovery. Further research will have to address this speculation.

The percentage of total across subtest patterns was slightly greater for the minus-length pattern than for the plus-length pattern in all instances except for the IX to X subtest comparison. The percentage of subjects displaying a minus-length pattern was considerably higher than those who showed a plus-length pattern. In fact, 90 percent of the subjects performed poorer on all subtest groups as the stimulus length increased, except for the comparison of subtest group IX to X. For IX and X, learning seems to have been a more potent factor than increasing stimulus length. Also, no subject showed plus-length performance across all subtest groups, but some subjects did show a minus-length performance across all subtest categories. This finding adds support to the literature and clinical experience of most aphasiologists that the number of critical elements to be processed is a relatively potent and critical factor in auditory processing in aphasics.

The linguistic nature of the task was shown to have a moderate effect on the occurrence of patterns and subjects demonstrating that effect. The difference between subtest VII & VIII and subtest group IX and X showed the greatest difference, followed by V & VI compared to IX and X, and followed by subtests III & IV compared to IX and X. Clearly, subtest IX and X are performed differently than the other subtests (usually with higher scores).

The two subtest groups with the prepositions (subtests V & VI compared to VII and VIII) showed the least differences in subtest scores. Although the prediction of subtest pattern from the type of pattern observed on another subtest was not possible, it was apparent that an interaction existed between type of pattern, linguistic category and subject. For example, increasing length may have induced poorer performance in a particular subject for left/right prepositional imperatives but not for spatial (locative) prepositional imperatives. Indeed, the conditional adverbial clauses in subtests 9 and 10 produced a reversal of the trend for poorer performance with increased length and actually showed better performance on the longer items. Thus, even though length is a potent factor in the subject's performance, the level of cognitive processing also seems to have interacted with the length of the stimulus. These data can also be interpreted to suggest that the linguistic categories sampled on the RTT are not redundant.

The relative predominance (importance) of one pattern type at the across subtest level suggests that all four pattern types evidenced here occurred about equally. The minus-length and specific linguistic patterns occurred slightly more often than the intermittent and plus-length patterns, albeit to an inconsequential degree. Specific linguistic patterns appeared to be the most frequently occurring of all pattern types (remembering that there are more chances for them to occur as compared to the other pattern types). After specific linguistic patterns, in frequency of occurrence, were minus length, plus length and intermittent. This order would be the hierarchy one might expect to find in any given individual or group, provided our sample resembled a normal distribution. However, going back to the relative frequency, one pattern type does not appear to describe this sample better than another pattern type. The percentage of subjects who demonstrated at least one instance of a particular pattern does not add greatly to the importance of any pattern type versus another except to stress that one would expect to see any of the four patterns in most patients, especially the minus-length and specific linguistic patterns.

The intermittent pattern occurring across subtests suggests one of two things. First, the mechanisms which caused the unpredictable fluctuation in subtest mean score performance is a very potent one, in that it occurred in many instances in spite of the well-documented potent factors of length and cognitive complexity. The second possible explanation for the unexpectedly high incidence of the intermittent pattern might be that the pattern is not really intermittent. Rather, we have not, as Brookshire (1974) has suggested, discovered a logical alternative (linguistic or cognitive) explanation for the variations in performance. If the first explanation is accepted, then the intermittent pattern must be viewed as a lower level physiological processing difficulty rather than a linguistic or stimulus bound phenomenon as measured by the RTT.

In contrast to the intermittent pattern's potency, tuning-in and tuning-out did not occur across subtests, attesting to their lack of potency. The factors of plus-length, minus-length, linguistic nature of the task, and intermittency appear to have been more potent factors, disguising tuning-in and out patterns. We choose this explanation rather than the possibility that they did not occur, because these two patterns were present across data points when those other factors were not present and when the stimulus data points were homogeneous with regard to difficulty (within subtests).

In general, the presence of any particular pattern did not offer a meaningful degree of predictability for the occurrence of that, or any other pattern type. Even those correlations which were found to be significantly different from zero for pattern type and age, time post onset, and severity were of such small magnitude that they offered little power of prediction. These data are interpreted as indicating some important trends which need further verification and interpretation. The trends for younger patients to demonstrate more intermittent patterns while older patients demonstrated more tuning-in patterns may be important. Likewise, the trend for intermittency with short time post onset, and the trend for tuning-in behavior as the duration of their aphasia increased may be important in the discovery of the mechanisms which cause the patterns. Similarly, the higher incidence of intermittency in the more severe patients and the higher incidence of tuning-in in the less severe patients might be related to these underlying mechanisms. Given the present data, it might be worth speculating that the patient who is shorter time post onset and younger is more likely to display intermittent behavior. In like manner, it could be speculated that persons who are longer time post and older might display more tuning-in behaviors. The contradictory findings with regard to severity and the presence of a particular pattern type make speculative generalizations difficult.

The occurrence of a given pattern type by etiology revealed an incidence which reflected the general occurrence of that pattern type regardless of the etiology. Therefore, we interpret these data as suggesting no obvious relationship between etiology and pattern type. Likewise, site of lesion information showed no obvious relationship with pattern type occurrence.

Conclusions

The following conclusions can be made from this investigation.

1. The proposed patterns of auditory processing deficits actually exist.
2. The Revised Token Test is capable of eliciting behaviors which resemble the proposed patterns.
3. The intermittent pattern was the most frequently occurring and predominant within-subtest pattern type.
4. No subject could be characterized by a single behavior pattern, and in fact two predominant patterns characterized subjects slightly more often than one. In addition, a substantial number of subjects shared all three patterns about equally.
5. These within-subtest patterns appear to be independent of the length or linguistic nature of the test material.
6. The tuning-in and tuning-out patterns did not occur across subtests.
7. The plus-length across subtests pattern was relatively rare.
8. The minus-length across subtest pattern was considerably more frequent and its pervasiveness suggests that the number of critical elements to be processed is critical for auditory processing in persons with aphasia.
9. The linguistic nature of the task seems to have a moderate effect so that for some subjects the linguistic task interacted with other variables, to make the task more difficult or more easy. The direction of the interaction was only predictable on subtests IX and X, where learning seems to occur.
10. Finally, it must be kept in mind that the presence of a given pattern does not predict the overall performance of any subject, and the RTT is therefore not redundant with respect to patterns.

We view these patterns as real and valid, especially as elicited by the RTT. Given that each element in the command is scored for every sentence stimulus, there is a greater chance to reduce the variance for the item mean score than there would be if each command were scored as plus or minus, or with a single multidimensional score (e.g. Brookshire, 1974). Therefore, we interpret these patterns as evidence for actual physiological and cognitive behaviors which are important to the understanding of auditory processing abilities in persons with aphasia. We currently have little concurrent evidence for what specific deficits are occurring, although research is currently underway and being planned to explore this area in greater depth.

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Discussion

Q: I have a question for Carlin and Mick. I'm wondering whether you had any measure of the temporal stability of the patterns you saw. For example, if you brought a patient back a week later and retested, would you tend to see the same patterns? The reason I'm asking is because we have looked at some patients now with regard to the effects of pauses in spoken messages and we're finding that what we thought was a very stable, consistent effect is really not very stable. Sometimes a patient will show a pause effect and when we bring him back he doesn't. Or he doesn't show it one time and does another. I wonder if this inconsistency might extend to the patterns you are describing. Do you have any sense of whether this is true or not?

A: The consistency of the patterns---as I have a note here in my pocket from Mick---is what we are supposed to look at next. Actually, we have not looked at that, but just from looking at the patterns and intermittency it would suggest to me some of the patterns we have looked at may be still intermittent but they just happen to occur that way.

Q: Carlin, did you have any other demonstration of that type of intermittent processing in aphasia? Did you show these patterns on other test data, or was it only on the Token Test that you have the data?

A: In the part that I was involved with, we only analyzed the R.T.T. for patterns of auditory processing, but maybe Mick would know about some of the other testing.

A: (McNeil) We do have data on 23 aphasics on the R.T.T. and the PICA.

Q: I have a question about the treatability of the patterns. Are they all treatable, some of them treatable, none of them?
A: Are they treatable? I don't know, I'm only a doctoral student. Really I don't know.

Q: Carlin, I'm not sure exactly, but the comment that stuck with me suggested that intermittency is not a function of length and complexity. Is that correct?
A: Yes.

Q: You have to prove that to me. I think that it needs to be looked at. For example, can you change the pattern of intermittency by a variety of methods, like putting in pause time, like giving them a lighted signal, like any number of things to help us better identify the nature of the intermittency? I think only then can we ferret out the kind of variables that are directly responsible for that kind of performance.

Comment: I'd like to comment on the idea of length and complexity. I think a major problem most of the time when we talk about length and complexity is the fact that we don't define what they are. It doesn't surprise me at all that they didn't correlate. For example, in two of my own studies, I found that articulatory errors did not depend upon length depending upon how you define length. I found that if you adjusted for opportunity for error there was no difference between shorter and longer syllables. In a finished study which we have not published yet, we found there is no difference in number of syllables either, if you adjust for opportunity for error, unless there is enough of a change, such as adding a morpheme, which changes the intonation pattern. So I think the real problem which was suggested by Mary Ann Wilson-- I think--and one of the fascinating things about the Token Test that we haven't addressed ourselves to is---what is the complexity that is involved? It is not just length. There are other factors that make it complex, for example, adverbial clauses. It is probably not just length but various components that change complexity as they interact.

Comment: I think the thing that makes this interpretable is that all ten items across subtests are homogeneous---or supposedly homogeneous by our data. So I don't think that is relevant, what you said, but there may be other things are interacting. The items are homogeneous across a large number of subjects, but the patterns are not. And that is what makes it interpretable.

Comment: I'm not disagreeing, what I'm saying is that I'm not surprised that length and complexity did not correlate.

Q: Carlin, is it your notion that attention and those kinds of behavioral correlates that underlie cognitive processing are really what the Token Test is measuring rather than linguistic processing and strategies?
A: I would think that whatever test you gave to a particular person would almost always involve some level of cognitive processing.

Q: Carlin, what was your comment about subtests IV and X?
A: Subtest IX and X seem to be different than the other subtests as far as length. The subjects got better on the second subtest, or subtest X; and X is longer, so they seemed to have learned something from number IX.