INTERACTION BETWEEN PHONETIC AND LITERAL COMPONENTS
IN PERCEPTION AND PRODUCTION OF JAPANESE SPEECH

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ABSTRACT

In order to investigate sources which cause errors in the performance of language, the mechanisms of processing speech sound and letter pattern are schematized based on the results of analysis of the errors made by adults having normal competence in various modes of performance of Japanese language. First, all the steps of processing involved in the primary and secondary functions in listening, speaking, repeating, silent reading, writing and copying are formulated. Then, the process of reading aloud and stenographing is formulated by combining the processes of silent reading and speaking or those of listening and writing, respectively, through the steps of phoneme/letter conversion. Through this modelling, it has become possible to simulate systematically the sources of errors with special regard to the interaction between phonetic and literal components in perception and production of Japanese speech.

INTRODUCTION

In the previous study on errors in performance of the Japanese language made by adults having normal competence (Reference), it was shown that many of the errors, not only in listening, speaking and reading aloud but also in silent reading, writing and copying, that could be explained either in the syntactic, semantic or orthographic level were found to be related to the phonetic level too. It was also shown that the errors that could be explained in the orthographic level occured even in speaking and reading aloud, although they occured mostly in silent reading, writing and copying.

The data were about 1,100 samples of errors, in total, in the six modes of performance. The errors which were related to the phonetic level were 70% of the total errors. Among those, the percentage for listening was 100%, and those for speaking and reading aloud were 75% and 85%, respectively. Even for silent reading, writing and copying, the errors in the phonetic level were found to be 25%, 55% and 65%, respectively. Percentage of errors which were explained in the orthographic level were 35% for silent reading, 70% for writing and also 70% for copying. For speaking and reading aloud, the errors in the orthographic level were found to be a few percent.

In order to investigate in sources which caused those errors, the mechanisms of processing speech sound and letter pattern are schematized based on the results of analysis of the data. Modes of performance of language included in the modelling are;
- listening,
- speaking,
- repeating,
- silent reading,
- writing,
- copying,
- reading aloud and
- stenographing.

MECHANISMS OF PROCESSING SPEECH AND LETTER

All the steps of processing speech sound involved in the primary functions in listening and speaking are schematized (Figure 1a). The secondary functions such as prediction in the process of listening and readjustment in the process of speaking are formulated by connecting some parts of the steps involved in the complementary primary function.

The primary function of extracting concept from speech sound as auditory input in listening is composed of the following seven steps;
- acoustical analysis of cue (L1),
- phonetic perception of feature (L2),
- phonemic judgement (L3),
- word identification (L4),
- syntactic analysis (L5),
- semantic analysis (L6) and
- concept analysis (L7).

That of generating speech sound as oral output from concept in speaking is composed of
- semantic generation (S7),
- syntactic assignment (S6),
- lexical compilation (S5),
- phonemic conversion (S4),
- phonetic conversion (S3),
- motor command generation (S2) and

acoustical synthesis of speech (S1). Each of the steps in the process of speaking corresponds to one of those in the process of listening, except for that the direction of flow from input to output is reversed.

The outputs of the steps of extracting phonetic feature, phoneme, word, syntax, meaning and concept in the process of listening are transfered via interconnections (shown in dotted lines) to the corresponding steps in the process of speaking as inputs, and the outputs of the predictive trial in those steps are compared (in CLS3, CLS4, CLS5 and CLS6) with the outputs of the previous steps in the process of listening, so that the operations of the steps are modified according to the detected difference between them. The inputs and outputs are stored in temporal memories (ML1, ML2, ML3, ML4, ML5, ML6 and ML7, and MS1, MS2, MS3, MS4, MS5, MS6 and MS7) during the operations. Those interconnections are utilized also for the readjustment in the process of speaking.

The mechanism of processing letter patterns in silent reading and writing is schematized in an analogous way to that of processing speech sound (Figure 1b).

INTERACTION BETWEEN SPEECH AND LETTER

The process of reading aloud or stenographing is formulated by combining the processes of reading and speaking or those of listening and writing, respectively, through the steps of phoneme/letter conversion. This provides the scheme which causes the interconnection between the mechanisms of processing speech sound and letter pattern.

In the process of reading aloud, letter extracted as the output of letter judgement (R3) in the process of silent reading is transfered to the input of phonetic conversion (S3) in the process of speaking (as shown in dotted line) through the step of phonological conversion (COP). In the same way, in the process of stenographing, phoneme is converted into letter (as shown also in dotted line) through the step of orthographic conversion (CPO) and transfered from the process of listening to that of writing.

By assuming all these mechanisms, possible sources of errors in performance of Japanese language, especially effects of letter pattern on processing speech sound and those of speech sound on processing letter pattern, can be simulated systemetically.

The errors that were explained best in the orthographic level but occured in processing speech sound through the auditory organs can be simulated as follows: Any of the inputs or outputs of the steps involved in the mechanism of

processing speech sound such as word, syntax, meaning, concept and phonetic feature can be transformed into phoneme via the interconnections between the processes of listening and speaking, and converted into letter through the interconnection between the mechanisms of processing speech sound and letter pattern. Then, the letter pattern can be transformed into any of the inputs or outputs of the steps involved in the mechanism of processing letter pattern such as word, syntax, meaning, concept and orthographic feature via the interconnection between the processes of silent reading and writing. When converted again into phoneme, they are accompanyed by errors characteristic of the mechanism of processing letter pattern.

The errors that occured in processing letter pattern through the visual organs but were explained best in the phonetic level can be simulated in analoguous way to the above.

DISCUSSION

In the previous study on errors in performance of Japanese language, it was shown that many of the errors in silent reading, writing and copying that could be explained either in the syntactic, semantic or orthographic level were found to be related to the phonetic level too, while that the errors that could be explained in the orthographic level occured even in speaking and reading aloud. But, there has been no theoretical model which describe reasonably this essential aspect of language performance.

In this study, the mechanism of the interaction between phonetic and literal components was explained, both theoretically and experimentally, through modelling various modes of perception and production of speech and letter, based on the analysis of errors in the performance of Japanese language. The model can be applied not only to the basic study of speech perception and production processes but also to the application such as automatic speech recognition and understanding.

REFERENCE

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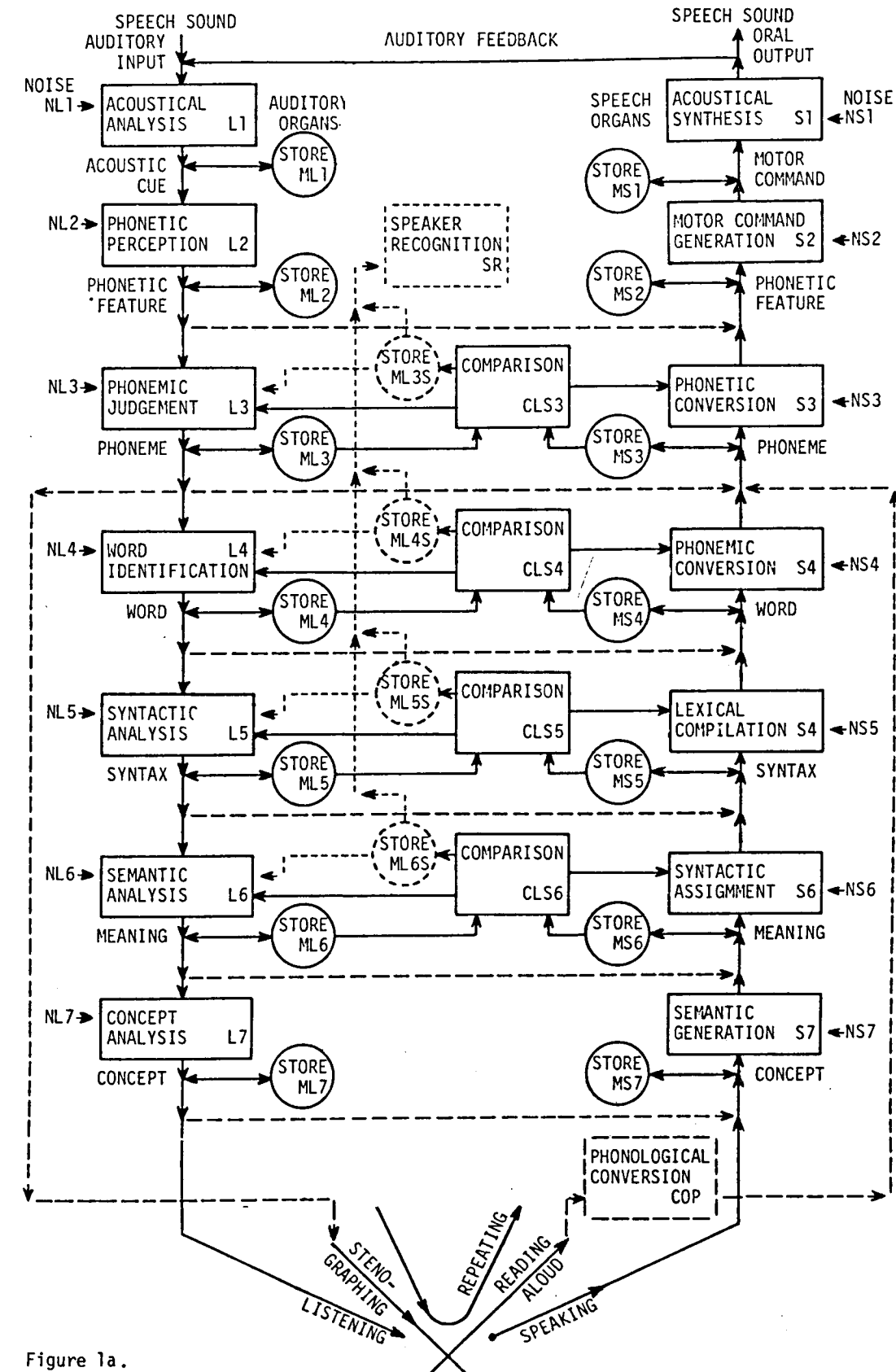

Figure 1a.

Figure 1b.

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