THE GENERALIZATION OF EXCEPTIONAL KNOWLEDGE

THE GENERALIZATION OF EXCEPTIONAL KNOWLEDGE
IN
WORD PRONUNCIATION TASKS

By

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ABSTRACT

Models of word pronunciation have tended to emphasize either generalized knowledge in the form of letter-to-sound correspondence rules or item specific knowledge in the form of rote associations. Simple formulations of both types of models have been found to be clearly insufficient to account for the pattern of results obtained with three types of items: regular words, exceptional words and pseudowords. The general findings are: 1- pseudowords take longer for response initiation than words; 2- although slower, pseudowords are pronounced quite easily by most readers; 3- exception words take longer for response initiation than regular words. Even a dual-process formulation, based on item specific knowledge for some type of items and generalized correspondence rules for other items, fails to account for some of the differences in pronunciation latencies which have been observed between regular and exceptional words.

Glushko (1979a) has proposed that the regular-exceptional distinction should be replaced by a consistent-inconsistent distinction. The thrust of his argument is based on his finding that regular words like MINT have the same pronunciation latencies as exceptional words like PINT. Hence when one controls for a certain type

of similarity between words, there is no difference between regular and exceptional words. However, a difference is found between words whose final three letters share a consistent pronunciation (such as MINK and PINK) and words whose terminal letter groups have more than one pronunciation (such as MINT and PINT).

Glushko's model, the activation-synthesis model, is based on the elimination of the regular-exceptional distinction. On the basis of this elimination, it is possible to make a number of extensions to the activation-synthesis model. Empirical verifications of these potential extensions were attempted using manipulations intended to increase or decrease the amount of conflict present when target items were presented for pronunciation. Inconclusive results were obtained from a first manipulation which used a repeated list paradigm. A second manipulation revealed that it was possible to speed up the pronunciation of a pseudoword by priming with regular words but not by priming with exceptional words. However, priming with exceptional words increased the number of exceptional pronunciations which were emitted for the subsequent pseudoword.

The pattern of results is consistent with the conclusion that the regular-irregular distinction should be maintained and superimposed on the consistent-inconsistent distinction. The argument is made that the inconsistency effect may be due to the activation of inconsistency detectors by words which contain specially coded letter groups. It is further suggested that the activation of inconsistency detectors would modify the usual response generation or retrieval process. This modified process would allow access to the exceptional information which would be somewhat resistant to the usual generalization phenomena observed in word pronunciation. Suggestions are also made as to the nature of the cues which could activate the inconsistency detectors.

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CHAPTER 1: INTRODUCTION

Having learned English as a second language, I have always been intrigued by what appeared to me to be a substantial degree of inconsistency in its letter-to-sound correspondences. For example, HOW and LOW have different vowel sounds but the only difference in the spelling of the two words is in terms of their initial consonants. It is not possible to attribute this difference in vowel sound to the difference in initial consonants since other words having the same difference in initial consonants do not differ in vowel sound, such as HAND and LAND. Hence to explain why HOW and LOW differ in vowel sound, it appears to be necessary to call upon knowledge other than generalized letter-to-sound correspondence rules. This knowledge could be in the form of item specific knowledge or in the form of highly conditionalized rules. There does not appear to be any simple procedure to distinguish between the last two alternatives.

THE PROBLEM OF EXCEPTIONAL PRONUNCIATIONS.

My subjective impression of the high degree of irregularity in English letter-to-sound correspondences is not an isolated case. Most French-Canadians I have questioned concerning the regularity of both French and English have given approximately the same phenomenological report. They will wonder why DONE is not pronounced as TONE when "everybody knows it should be". Similarly, my nine year old son would occasionally pronounce COMB so that it rhymes with BOMB.

Although I have not done any systematic investigation on this question, it is my strong suspicion that native users of English do not have the same impression of inconsistency. The few times I have asked native English speakers what information they use to decide on the pronunciation of HOW and LOW, their reaction is mostly one of surprise at the realization that indeed the two words have different vowel sounds although they are quite similar in their written form.

There could be at least two reasons for this divergence in subjective impressions. The first reason could be that there is a real and substantial difference in the consistency of the letter-to-sound correspondences of the two languages, with French being much more regular. Hence, a person going from French to English would be used to a higher degree of consistency and would be especially sensitive to the irregularities. On the other hand, since the native user of English is used to the inconsistency of the English language, he or she would not be sensitive to it. In addition he may have developed specific procedures to handle the irregularity.

The second reason may be that familiarity leads to a feeling of regularity. Hence because of the extensive experience with the native language, it is quite plausible that the first language appears completely predictable and regular to the user. The Englishman would consider English to be highly regular while he would consider French to be much more irregular. Similarly, French would appear highly regular to a Frenchman while English would appear highly irregular. As a rule, the second language would generally be considered more exceptional simply because it is less familiar.

Comparisons of the two languages strongly support the view that English shows much more surface inconsistency in its letter-to-sound correspondences than French. Venezky (1970) estimates that as much as 15% of the English words do not fit in regular pronunciation patterns. He argues, however, that knowledge of the history of the language and of borrowings from other languages can explain most irregularities. It is clear that such knowledge is not generally available to the average user of the language and that for him such patterns would indeed be irregular. The problem may be further compounded by the fact that many of the exceptional words are high frequency words, for example THE, WAS, THERE, WERE, and HAVE. Hanna (1966) have reported that 20% of all word types are irregular while Hunnicutt

(1976) estimated that 50% of the 1000 more frequent words are irregular. In comparison, one source (Thimonnier, 1970) estimates that there are, in total, only 300 problem words in French. There are then empirical grounds to the impression that English is more inconsistent in its letter-to-sound correspondences than French.

One potential consequence of such a difference is that users of the two languages may have developed different processing mechanisms for word pronunciation. If users of French have developed rule-based pronunciation mechanisms they could be highly vulnerable to irregular items. This could explain why native users of French would be so sensitive to pronunciation inconsistencies in English. Alternatively, users of English may have developed pronunciation mechanisms which are much more dependent on item specific knowledge. Hence, they would be largely insensitive to inconsistencies in generalized letter-to-sound correspondences.

The case of the English language is also especially intriguing because it appears to be a situation where the processing of a substantial number of special cases is done without the explicit awareness of the existence of such special cases. Such a situation is reminiscent of the type of performance demonstrated by experts. The expert is often considered as a person who can rapidly identify special cases where the usual rules of thumb for the domain do not apply. Generally, this type of expertise is only gained through extensive immediate experience with a domain. In such fields, it is usually not sufficient to learn a set of rules along with a few applications. Word pronunciation is a task at which most of us have had extensive training and practical experience and at which we become highly fluent. As such, understanding of pronunciation mechanisms in English may be specially relevant for models of expert knowledge in addition to its potential contribution to the development of more effective training programs for initial reading and second language training.

The present thesis represents an attempt to extend and validate a recent model of word pronunciation. Although not fully articulated, the activation-synthesis model was proposed by Glushko (1979a) to account for recent findings in the pronunciation of English words and pseudowords. Two major extensions of the model are tested. The results obtained failed to support the model. An alternative model is proposed to account for all the available data on word pronunciation. The new model could easily be extended to other areas of expertise.

CHAPTER 2: THE KNOWLEDGE AVAILABLE FOR WORD PRONUNCIATION.

Because of the type of learning experience which readers have had or possibly because of the nature of the task itself, two special problems are encountered when studies of reading are done. A first problem concerns the diversity of knowledge which can be associated to one specific stimulus item. The other problem concerns the apparent inaccessibility of the underlying processes to introspective report.

SELECTION OF A RESPONSE AMONG ACTIVATED ALTERNATIVES.

The average child will start formal training in reading when he is five or six years old and will often continue such training until he is seventeen or eighteen. At first he is required to reproduce a known articulatory response whenever a specific written pattern is presented. Later he will be asked to present a verbal summary of what is read, to identify the parts of speech, to give the written representation of a spoken passage, or to correct errors in a written text. These are but a few of the operations which a skilled user of the language is expected to be able to master.

One of the problems raised by this diverse knowledge, which can become available, is that of the selection of the information relevant for a specific task. One solution to this problem is to consider that different sources of information can become activated in different contexts. A large number of experiments have provided evidence which is consistent with the hypothesis of contextual effects (Meyer, Schvaneveldt and Ruddy, 1974; Warren, 1977). In other words, it is possible to make a subject produce different responses or to modify to speed of responding to the same nominal stimulus when certain situational aspects are altered.

In this class of experiments, it is usually assumed that some threshold amount of activation is required before a response can be produced. Instead of selecting between fully activated responses, it is assumed that the potential responses can show differential amounts of activation depending on the context. Some of these context effects can be under the control of overt instructions while others are more subtle and appear to be more independent of the subject's conscious control. It would then appear that some information is more easily activated in certain situations than in others.

A second solution is to assume that, in most situations, some type of inhibitory mechanism would operate to block activation of the irrelevant information. Neill (1977) has shown such a mechanism in a Stroop task. This type of inhibitory notion is very old in psychology. Freud and Pavlov were among the early theorists to use the concept to explain response selection.

IMPLICIT KNOWLEDGE.

Although a portion of the knowledge or procedures which are used in daily activities appear to be open to instrospection and verbal report, there are many areas of behavior where the subject is unable to describe adequately the knowledge which he uses to make decisions or to guide his performance (Reber, 1976; Brooks, 1978b). The argument has been made (Neisser, 1967) that generally we are only aware of the product but not of the process of most mental operations. Others have argued instead that, in developing fluency, perceptual and cognitive processes become automatic and as such to do require attentional resources for their operation (Laberge and Samuels, 1974).

Reading is one of the domains of human performance where a high degree of automaticity can be expected because of the extensive and varied practice which is required to attain fluency. Consequently, some methods have to be devised to get around the non-availability of valid introspective report. For example, it may be possible to get an indication of whether a subject can use a certain type of letter-to-sound correspondence rule by providing the subject with preliminary information which is consistent with a given rule. If such preliminary information facilitates response production or speeds up response execution while conflicting information interferes with response production, then some support is provided for the hypothesis that subjects can use such rules of correspondence.

THE PRESENT STUDY.

The present thesis represents an attempt to identify some of the constraints which have to be imposed on any model of the structure of the information available for word pronunciation. The task, which was used, required that the subjects pronounce as rapidly as possible single items or lists of items which were presented to them. It did not necessarily require that the subjects access what have been considered higher processes or levels of representation. It was not even necessary for subjects to be aware that the items were or were not words. As such, the results to be reported may not have anything to do with reading for meaning or the reading of continuous text. Rather, the intent was to verify what type of knowledge can be activated for generalization to novel items or to produce decrements in performance on a word naming task as a result of some inhibitory process. The type of interference and facilitation which can be produced should provide insight into some of the constraints which are inherent in the knowledge structure that may be available.

There are at least three major reasons to study the mechanisms and knowledge structures underlying word pronunciation. A first preoccupation arises from the need to develop effective methods for the teaching of initial reading which might lead more rapidly to adult-like performance. One of the component skills that has to be mastered is the mapping of the written form to the spoken form. Although it may not be the dominant activity of an adult reader, it is clearly a skill which he has mastered and at which he remains highly fluent. Secondly the teaching of a second language is very common in this country. The identification of specific pronunciation mechanisms in one language may point to potential sources of interference across languages. This might be especially true for languages such as English and French which share a common alphabet and a large number of identically written words which are pronounced differently. Thirdly, the potentially strong relationship between phonological recoding and semantic representation argues for a good understanding of pronunciation mechanisms.

1- Methods for teaching initial reading.

Discussions of methods for teaching initial reading have centered around the sight versus phonics controversy. Chall (1967) has presented a detailed description of the consensual method for teaching initial reading which was dominant between 1930 and 1955 in the United States. Intertwined with the eight principles, which she describes, was a strong insistence on the necessity of presenting words as units which have meanings. Although not completely excluding the use of phonics, these so-called sight methods were putting a strong emphasis on item specific learning. The proponents of such methods held that the task of the beginning reader was to learn specific responses to written words.

This view of learning to read was highly consistent with the associationistic flavor that was prevalent at the time in psychology. In addition, many workers in psychology viewed the discovery of the word superiority effect by Cattell (1886) as supportive evidence for the sight methods. Cattell had found that it was possible to identify more letters when words were presented than when random letter sequences were presented. It then appeared highly plausible that words were identified before the individual letters were recognized. From such a viewpoint whole-word learning became very important while learning of correspondence rules based on word parts was considered to be a distraction from the main task.

Serious questioning of this dominant viewpoint started with the appearance in 1955 of a best selling book by Flesch, entitled "Why Johnny Can't Read". The alternative that was being proposed was that the child should learn generalized rules for converting print to sound instead of specific item learning. Sixteen years later, Aukerman (1971) was able to present a summarized description of about 100 alternatives to the basal reader of the traditional sight method. He grouped these methods in ten categories. Six of the categories described almost exclusively methods based on learning of letter-to-sound correspondences.

Workers in linguistics had produced descriptions of the English language which were quite efficient in capturing some of the regularities which are observed in users of the language. This led some workers (Bloomfield, 1961; Lefevre, 1964) to propose that it would be more efficient if a reader learned the abstract pronunciation rules (letter-to-sound correspondences) and then used these to pronounce all words, both old and new, instead of relying on rote associations. From this viewpoint, the major emphasis was the explicit teaching of the sound value for each letter or limited set of letters.

The application of spelling-to-sound correspondence rules encounters difficulty in the English language because of the presence of exceptional words. As a result, there have been a number of attempts to reform the spelling of English. Among these are the UNIFON system proposed by

Malone (1962), the "fonetik-alfabet" proposed by Davis (1963), the Fonetic English Spelling proposed by Rohner (1966), and, to some extent, the Initial Teaching Alphabet (or ITA) described by Downing (1965, 1967). The ITA system was designed for initial training of reading with a gradual transition to the traditional alphabet. All these systems proposed to add symbols to the 26 letters already used in English. With the increased number of symbols, it became possible to maintain consistency in the symbol-to-sound correspondences. Although some extensive testing of such reforms has been done, most notably with the Initial Teaching Alphabet, general acceptance of these spelling reforms has yet to occur.

There are possibly two major reasons why resistance to the spelling reforms has been encountered. Firstly, there is a basic incompatibility between present spelling of English and the proposed systems. Such a reform would make all previously published books obsolete for children trained with the new system. In addition, the books published with the new system would be difficult, if not impossible, to read for people trained with the old system. A second reason stems from the arguments presented by Chomsky (1970) that the spelling of English reflects consistency of semantic relationships which may be more important than consistency of sound relationships. This could explain why words such as 'courage' and 'courageous' maintain the same spelling up to the letter 'e' although they differ in pronunciation.

With the advent of personal computers and the general availability of communication networks which make available large information bases, the argument based on incompatibility between the spelling systems loses much of its validity since it will become very easy to make all written information available in the two formats. However, the argument based on the necessity of semantic consistency may remain quite valid. Hence, it becomes important to study what processes and knowledge structures are available to the users of English. If phonological consistency appeared to be a critical factor in that it determines major components of the knowledge structures and of the processes available for information retrieval, it would argue for continued experimentation with spelling reforms.

2- Comparative linguistics.

As just mentioned, the teaching methods proposed for initial reading in English have tended to emphasize either item specific learning or generalized learning in terms of letter-to-sound correspondence rules. This difference in emphasis may be especially pertinent to a language such as English which shows a substantial degree of surface inconsistency between the written symbols and the sound values assigned to them.

Comparative linguistics have shown that languages greatly differ in the extent to which they rely on the alphabetical system, that is, a system where the symbols are generally related to the sound of the word instead of its meaning. Chinese, in its written form, consists of symbols which represent meaning more than sound (Tzeng, Hung and Wang, 1977). In addition, it would appear that, even within alphabetical languages, there are substantial differences in the degree of consistency in the correspondences between the written symbols and the spoken sounds.

If languages differ in the degree of consistency between the symbols used to represent the words and the phonological representations of these same words, it is possible that their users also differ in their reliance on phonological codes for the activation of other information. In a completely phonetic language, the learning of rules could be the major objective of initial teaching methods. The learning of correspondence rules would permit a one-to-one access to an existing pathway. The memory load required for such learning would be quite limited since the letter-to-sound correspondence rules would be considerably more limited in number than would be the words.

Within a language such as English, it is easy to produce situations where the most common letter-to-sound correspondences do not hold. For example, the pseudowords DINT and BINT are visually quite similar to the exceptionally pronounced word PINT. If the user of English depends mostly on item specific information or large unit information (Baron, 1977) to pronounce words, he may well pronounce BINT to rhyme with PINT. However, the "short" (unglided) vowel sound encountered in MINT is considered to be the regular pronunciation of INT. If we find that users pronounce BINT with the short vowel sound, then the results would be consistent with the generalized learning position. Alternatively, a "long" (glided) vowel sound would be consistent with the specific item learning hypothesis in conjunction with some generalization gradient based on similarity. This form of the hypothesis would also predict that the pseudoword KINT would receive the regular pronunciation since it is quite similar to HINT.

The fact that many people speak a second language with an accent also suggests that there are major differences between languages in the mechanisms underlying their pronunciation. Young children can apparently learn the correct pronunciation of two languages concurrently without demonstrating the accent phenomenon. It may be because they have not yet developed strong generalized learning, specific to one language, and, consequently, they would not use the pronunciation mechanisms of this language to pronounce the other one.

French also shows some inconsistency in its letter-to-sound correspondences, but to a lesser degree than

English. If the structure of a language influences to some extent the cognitive structures that the users develop, it may be possible to detect differences in the ways users of French and users of English handle regular words and exception words. The potential pay-off of such a finding would be an indication of the teaching methods which would be more advantageous for training in a given language. It would also help in identifying the potential sources of interference in second language training. Information on how previous knowledge of English may determine the processing mechanism which a person has developed, may shed light on how this knowledge could interfere with the learning of French or vice versa.

3- Phonological recoding.

Apart from interest in developing efficient teaching methods for initial reading, understanding of the pronunciation mechanisms may be very useful for the modelling of memory mechanisms and structures. On the basis of acoustic confusability of visually and aurally presented items (Conrad, 1964; Baddeley, 1966; Sperling, 1967; Wickelgren, 1965), it has been argued that visually presented items are recoded phonologically before any other information associated with the items can be accessed in memory (Atkinson and Schiffrin, 1968; Norman, 1972). As mentioned earlier, the argument for phonological recoding of visually presented material can also be based on the parsimony principle. Since the child already knows how to speak, and, has already developed a representational structure by the time he learns to read, it could be economical to access meaning through this existing pathway.

The evidence concerning phonemic recoding for word identification is at best controversial (Rubenstein, Lewis and Rubenstein, 1971; Meyer Schvaneveldt and Ruddy, 1974; Rayner and Posnansky, 1978; Baron, 1973; Saffran and Marin, 1977; Stanovich and Bauer, 1978; and Kleiman, 1975). In addition, it does not provide any clear indication as to what mechanisms and knowledge structures are required for the recoding to occur. Hence, it would appear that an understanding of the pronunciation process could probably be useful in the efforts to unravel the mystery of how human memories are structured and how they operate. For example, Laberge and Samuels (1974) have proposed a model of reading which allows for two such pathways to meaning. They view phonological recoding as the dominant pathway. They also allow for immediate semantic access from visual information, but they view this as a secondary development which results from automatization based on extensive practice. Studies of what use a reader can make of phonological knowledge may provide a good understanding of the relative importance of the direct visual-to-meaning pathway and the sound-mediated pathway.

SIMILARITY AS A BASIS FOR GENERALIZED LEARNING.

Similarity has been used extensively as an explanatory construct in human and animal behavior. Pavlov's generalization, Hull-Spence gradients, and, Osgood's similarity surface are all landmark conceptualisations which were highly dependent on similarity across situations or stimuli. There have been many glaring difficulties with it; most notably the difficulty of obtaining independent measures of similarity and the lack of symmetric relationships in similarity ratings indicating potentially strong context effects (Tversky, 1977). Recent emphasis on cognitive processes allows much more flexibility to the organism in the selection of information and its processing than did traditional theories based on stimulus generalization and differentiation. This new emphasis on the active role played by the user of the information has led to a de-emphasis of the role of item similarity. However, renewed interest in similarity as an explanatory construct can be seen by the proposal of analogical processing most notably in the domain of isolated word pronunciation (Brooks, 1977, 1978a; Baron, 1977; Glushko, 1979a; McClelland and Rumelhart, 1981; and Rumelhart and

McClelland, 1982).

Processing on the basis of item similarity allows an easy route for transfer of learning. This is especially so when categorical responding is required from the subject. In this case all the similar items have associated to them one common response, while another set of items which differs markedly from the first set have a different response (Brooks, 1978b). A difficulty arises for this simple formulation when one item in the first set of similar items is an exception and is assigned to the other response class. The automaticity and simplicity of the generalization mechanism tends to disappear. One option would be to insert a tag detector which can block or inhibit the generalization mechanism. The tag detector has to be inserted before or concurrent to the initial stages of the generalization mechanism so that it can interrupt it. However, for a tag to be recognized, it implies extensive processing of item specific knowledge. It then becomes difficult to talk about generalized learning when so much item specific knowledge has to be processed before a decision can be made on whether to apply or to inhibit the generalized process. If so much item specific information is already available, why would the articulatory information not be available already? Hence, models of item processing based on tags to denote exceptionality will need to explain how, in a system based on generalized knowledge, highly item specific information can be recognized before the general process is applied to the item.

There is an inherent difficulty in distinguishing implicitly abstracted rules from generalization based on item specific information since they both predict the same type of performance in a completely regular environment. One situation where it may be possible to do so is in the case of word pronunciation since there appears to be a substantial number of non-correspondence of similarity relationships between the stimulus and response domains. Hence the study of what type of interference and facilitation can occur in word pronunciation could provide very valuable information.

CHAPTER 3: MODELS OF WORD PRONUNCIATION.

There have been five general classes of proposals to answer the question of what type of information is available for the pronunciation of individual words:

1- letter-to-sound correspondence rules;

2- item specific associations;

3- two process models;

4- transformation on an analogy;

5- averaging on sets of analogies.

Each class of proposals will be presented briefly along with examples of the arguments and the evidence on which it is based.

GRAPHEME TO PHONEME CORRESPONDENCE RULES.

Following the discovery of acoustic confusability of letters in short-term memory, models of reading have been developed which view phonological recoding as being an important component of the reading process, even in the case of silent reading. Hence, not only would phonological information be important in overt word pronunciation but also in many other tasks where semantic and lexical information has to be retrieved from memory. The use of such a mechanism would be parsimonious in the sense that it can call upon an existing pathway to semantic, syntactic or other information stored in memory. Since beginning readers can already understand spoken language when they begin to read, they must have some type of phonological representation which permits them to access or activate other information.

There have been a number of proposals to account for how the phonological recoding occurs. These proposals often differ on the size of the units on which the recoding is based.

For example, Spoehr and Smith (1973) have proposed that subjects will parse words into multiletter units which will then be converted into a corresponding phonological code. Following Hansen and Rodgers (1965), they have used the term 'vocalic center group' (VCG) as a label for the units. Each unit is based on a vowel or vowel group which can be preceded and/or followed by consonant sounds. The vocalic center group corresponds to an orthographic unit to which is assigned an articulatory or acoustic code. In a latter paper (Spoehr and Smith, 1975) they proposed a modification of the parsing algorithm which could account for differences in processing times of pronounceable pseudowords, orthographically regular consonant strings and unrelated consonant strings. This modification allowed for the insertion of a neutral vowel sound between regular consonant clusters. However, as occurs with many of the discussions of phonological recoding, they do not address the question of how exceptional words would be handled by their parsing mechanism.

On the basis of the errors of speech made by users of German and the users of English, MacKay (1972) has proposed a parsing process based on the syllable which itself can be broken down into subunits. The two subunits which are proposed consist of the initial consonant group and the vowel group. As a further argument in support of his parsing process, MacKay states that, when words are merged together, segmentations of the merging words will occur at syllable boundaries or between the two subunits of a syllable.

A model of reading based on the translation of letters into strings of systematic phonemes was proposed by Gough (1972). These phonemes would correspond to mental representations which have to be activated prior to the execution of motor commands for the articulation of a sound. Hence, as with model proposed by Spoehr and Smith (1975), it would not be necessary for the reader to execute the motor commands to arrive at a phonological representation in memory.

Gough relates his notion of systematic phonemes to the abstract phonemic representations proposed by Chomsky and Halle (1968). According to these authors, the orthography of the English language is based on a type of mental representation called lexical spelling. The translation from the lexical spelling to the the phonetic representation is done through a set of phonological rules (C. Chomsky, 1970). Although they attempt to specify some of these last rules, their proposals are far from a complete description of the language.

Other workers (Venezky, 1970; Wijk, 1966) have attempted to derive a system of correspondences between the written symbols and the sounds directly from the written and spoken forms of the language. Although the rules which are proposed are more extensive than the previous formulations, they still do not constitute an exhaustive system. There are many exceptions and lacks of consistency in the correspondences that they have proposed. Venezky estimates that his rules account for about 85 percent of the English language. Hence, about one word in seven cannot be easily accounted for by the rules proposed. A further complication arises from the possibility that exceptions may tend to be high frequency words, such as WAS, THERE, and WERE. If this relationship holds, it would mean that substantially more than 15 percent of the individual words, which are encountered in most texts, would be pronounced exceptionally.

Finally, there are a number of other workers (Baron and Strawson, 1976; Forster and Chambers, 1973; Frederiksen and Kroll, 1976; Gough and Cosky, 1977; Mason, 1978; Stanovich and Bauer, 1978) who have assumed the existence of grapheme-to-phoneme correspondence rules that can be used for pronouncing nonwords and novel items without specifying what are the units or the rules which would be used.

A further argument used to support the primacy of rules is based on the demonstrated ease with which subjects are able to produce pronunciations of pseudowords. The arguments states that if people are able to easily pronounce novel letter strings, it must be because they have available some type of generalized knowledge which could take the form of a set of abstract rules. This generalized knowledge would be applied more or less automatically, independently of whether novel or familiar letter strings are to be pronounced. This argument carries weight if the only alternative is to consider item-specific knowledge without much generalization across items. However, if one allows for generalization of instance-based knowledge, then the argument is weakened.

A closely related issue is concerned with the explicitness of the knowledge used for word pronunciation. If rules are accepted, then it has to be assumed that they are mostly implicit since readers have great difficulty in relating what are the rules they are using. Using artificial alphabets, it can be shown that subjects can indeed pronounce words without being able to report relevant letter-to-sound correspondences. The presence of these correspondences, even when camouflaged, results in faster performance in a word pronunciation task (Brooks, 1977, 1978a; Baron, 1977). Here, also, a model based on generalization from instance-based knowledge would explain the results.

Models based on rules are usually assumed to have fewer storage requirements than models based on item specific learning. They also provide a simple mechanism for generalization to novel items. One major difficulty for these models, however, arises from the presence in English of a substantial number of items which, at least on the surface, appear to contravene whatever rules of pronunciation that have been proposed.

ITEM SPECIFIC LEARNING.

Because of the presence of these exceptional words which cannot be handled by simple rule-based mechanisms, some authors have proposed that the basic mechanism for pronunciation is dependent on the activation of specific lexical entries in long term memory. They tend to assume that the phonological representation is stored as a unit in memory and can become activated only after its corresponding lexical entry has been reached.

For example, Forster and Chambers (1973) have put forward the argument that lexical retrieval has to occur before a pronunciation can be produced. They base their argument on the fact that, in their experiments, pronunciation of words was initiated about 50 milliseconds earlier that pronunciation of pseudowords when it would be expected that the application of pronunciation rules should be just as fast for nonwords as it is for words. They also attached substantial importance to the existence of a positive correlation between pronunciation times and lexical decision times in the case of words and of the absence of such a correlation in the case of nonwords. Hence they argue that a process analogous to a dictionary look-up would explain their results while a model based on prior phonological recoding would not be adequate. This is because the prior phonological recoding hypothesis requires that the recoding take place for both the naming task and the lexical decision task. A correlation between response times of both tasks should then be observed. Finally, they argue that the word frequency effect would be due to the greater availability of the lexical entry of high frequency words.

This preliminary activation of lexical entries could be done on the basis of the identification of word features or on the basis of holistic processing. Smith (1969, 1971, 1973) has argued for the use of word features and of the sequential dependencies between these features to explain the so-called word superiority effect. Hence, these features at the word level would bypass the identification of individual letters and consequently would bypass letter-to-sound correspondence rules.

Other models have proposed that word identification does not require the identification of component units other than the whole word itself. For example, on the basis of results obtained in a word and letter detection task, Johnson (1975) has proposed that words can be treated as single units. He found that subjects could identify a word more rapidly than they could identify a letter within a word. In addition, the subjects could identify a word just as rapidly as they could identify letters in isolation. Such results are consistent with the hypothesis that words can be identified as units.

The continued existence of exceptionally pronounced words in the language could be expected if users of the language depend on such word specific retrieval mechanisms. Indeed, there would be no need to distinguish between exceptional and regular items since both would require the activation of internal representations before articulatory and phonological knowledge could become available. Also there would be no need for pronunciation rules since lexical entries would constitute internal representations to which could be associated outputs units called pronunciations.

However, such a mechanism by itself encounters difficulty with readers' demonstrated ability to pronounce pseudowords. Since there should not exist any stored pronunciations for pseudowords, readers should experience great difficulty in pronouncing them. The model also had difficulty with early results which indicated that pronunciation of exceptional words required more time than the pronunciation of regular words. However, as will be discussed later, when one controls for similarity of items, this difference in pronunciation latencies disappears.

THE TWO PROCESS MODELS.

Two class of mechanisms have been considered so far for word pronunciation. One type of mechanism is based on spelling-to-sound correspondence rules. The other mechanism is assumed to be based on item-specific learning. Simple formulations of both types of models have difficulty with some part of the evidence which has been obtained on the pronunciation of words and pseudowords.

Baron and Strawson (1976) have provided evidence which is consistent with the view that readers have available two different processes for pronouncing words and pseudowords. They also provide evidence which suggests that these readers differ in the degree of reliance they put on either of the mechanisms. They were able to identify a group of subjects who appeared to rely extensively on letter-to-sound correspondences while a second group seemed more dependent on item specific knowledge. If readers do have available two processes for pronouncing words, then some combination of the two basic processes might partially explain the general pattern of results which have been obtained with words and pseudowords. For example, a reader could rely on rules of correspondence to pronounce regular words and pseudowords while relying on item specific knowledge to pronounce exceptional words. Or, the reader could depend on item specific knowledge to pronounce both types of words and on rules of correspondence to pronounce pseudowords. However there are difficulties with both versions of a dual process model. The first version does not account for the difference in response latencies observed between regular words and pseudowords. The second version had difficulty in accounting for the difference observed in response latencies between regular and exceptional words.

TRANSFORMATION ON AN ANALOGY.

One alternative has been to look for a form of processing that would permit transfer to pseudowords while being mostly dependent on item specific knowledge. Baron (1977, 1979) proposed an analogy model whereby a newly presented item like KAT activates the representation of similar words such as SAT . The subject would then apply a transformation to the activated response, such as replacing the S by a K, to produce the appropriate response. Such a model contains rule-like specifications to determine what transformation rule to apply. In the example presented, it means that some knowledge of the sound value of the initial consonant is necessary to specify the transformation required on the activated pronunciation. Hence, Baron's model is based on a combination of rule-based and item-specific knowledge.

Somewhat different versions of analogy models have been suggested by Ohala (1974), Smith and Baker (1975), Baker and Smith (1976), and Sternberg and Krohn (1975).

Such formulations have the advantage of greatly simplifying the type of rules which have to be learned. They also allow for generalization to old and new items on the basis of simple rules which are applied to item specific knowledge.

AVERAGING ON A SET OF ANALOGIES.

Brooks (1978a) has described another type of analogy model based on whole-word information. According to the model, there is initially a large amount of specific item learning. Once this learning has occurred, the analogy process operates to facilitate pronunciation of old and novel words alike. A newly presented item would activate all the stored words which are very similar to it. The activation of each of these items would result in the activation of a number of pronunciation responses, each of which has a number of components. Whichever components are more highly activated would be emitted to produce a spoken response. For example, the presentation of RENT would activate the motor components of BENT, RANT, REST, and REND. The summation of the response components for each letter position would result in the appropriate response. Glushko's (1979a) proposal of an activation-synthesis model, to be described later, has much in common with this analogical model.

Analogy models provide a powerful mechanism for generalization to old and novel items alike. Being based mostly on item specific knowledge, they do not require the abstraction of rules of pronunciation which often appear difficult to describe explicitly or to specify completely. They also allow generalization on the basis of word features such as shape, length, letters in position, etc... All of these are features which are usually ignored when rules of pronunciation are presented.

There is at least one severe limitation to analogy models, however. If such a model is allowed to operate automatically, in the long run, it should exert pressure towards regularization of the dominant spelling-to-sound correspondences. Linguists (De Saussure, 1966; Greenberg, 1968) have described such a mechanism to explain changes and evolution in the language. Whenever such a change occurs, it serves to extend to a new instance a pattern or regularity which is already shared by a number of other items. Hence, resorting to an analogy mechanism leaves unresolved the question of how the high degree of surface irregularity, which is encountered in the English language, can be maintained in a domain where generalization is assumed to occur.

Some additional form of item-specific learning has to be added to the basic process to explain the continued existence of exceptional pronunciations. The first type of item-specific information would be the phonological knowledge associated with regularly pronounced words which would normally be easily generalizable to other similar items. The second type of information would be the knowledge associated with exceptionally pronounced words which would not be so easily generalizable to other items. Furthermore, this second type of phonological knowledge would be protected somehow from the generalization associated with regular items.

For example, if an item is highly familiar and highly available, there might not be any necessity nor enough time for an analogy mechanism to become active.

Hence, high frequency words might be much more independent of the analogy mechanism. There are some indications that exceptionally pronounced words are indeed high frequency words (Glushko, 1979a). Alternatively, some resistance to generalization could be associated with the representations of exceptionally pronounced items.

In summary, none of these models, whether based on rules or on an analogy mechanism, can seriously deny the existence of some form of item-specific learning. Rule-based models have to propose such learning to handle exceptional pronunciations, while the analogy models depend on such learning in their basic operation.

THE ACTIVATION-SYNTHESIS MODEL OF PRONUNCIATION.

One analogy model which has addressed the question of exceptional pronunciations was proposed by Glushko (1979a). On the basis of subjects' performance on the pronunciation of pseudowords and exceptions, he devised a series of experiments which, he concluded, support the formulation of a new model of word pronunciation. He distinguished between letter groups which have a consistent pronunciation in English and those which do not. The letter group INT would be inconsistent since one encounters both PINT and MINT which differ in vowel sound. Hence the presence of one exceptionally pronounced word in an orthographic neighborhood would be sufficient to make all the words in the neighborhood inconsistent items. The letter group INK would be consistent since all words ending in INK rhyme with each other, as, for example, PINK and MINK. He found that subjects took longer to pronounce words and pseudowords which contained inconsistently pronounced letter groups (PINT, MINT or BINT) than those which only contained consistently pronounced letter groups (PINK, MINK, or BINK). Additionally, he reported no difference in pronunciation latencies between items like PINT and MINT. This last result can be viewed as telling evidence against the position which asserts the predominance of rules since, in this case, a regular form takes just as long as an exceptional form.

The model which is proposed to account for this set of results is called the activation-synthesis model. According to the model, presentation of an item can activate a number of different knowledge structures. These can be instance-based, rule-based, orthographic or some other form. Whenever all the information which is presently activated is consistent, it leads to fast pronunciation times. However, when the activated information is inconsistent, a conflict is produced which leads to an increase in response latencies.

In a further experiment, Glushko (1979b) attempted to manipulate the type of information which would be activated when he presented a subsequent target item. By presenting similar words immediately before a target word, he was able to show large priming effects. A number of relationships between target and prime were manipulated. They could be the same item (e.g., DICE-DICE), they could differ in initial consonant only (e.g., FIRE-DIRE); they could differ in final consonant sound (e.g., DAZE-DATE); they could differ in the vowel (e.g., DOME-DIME); or they could differ on every aspect except the silent E rule (e.g., MOLE-DUKE). The control condition consisted of items which were unrelated both phonologically and graphemically (e.g., TRAP-DINE). Relative to the control condition,the silent E rule condition was the one that showed the smallest amount of priming (9 milliseconds) while the initial consonant condition showed the greatest amount of priming (46 milliseconds). Glushko has consequently argued against a rule-based pronunciation process since the condition which corresponds to the silent E rule was the one which produced the least priming.

It is possible to interpret these results differently. One can argue that what has been manipulated in this experiment is only visual similarity. What has been obtained, then, is a greater amount of visual priming when there is greater visual similarity between the prime and the target. To completely explain the details of Glushko's results on the other conditions, minor additional assumptions are required such as: the initial consonant is a weaker determinant of visual similarity than is the vowel, which, in turn, is less important than the terminal consonant. A priori, these do not appear implausible.

Alternatively, it is possible to argue that, in his priming experiment, Glushko has unwittingly provided evidence for a priming effect based on a rule mechanism. Since one is not often aware of pronunciation rules, if such rules exist, they may very well be completely implicit. There is no guarantee, then, that they correspond to high level abstractions like the silent E rule or to the type of patterns presented by Venezky (1970) or Wijk (1966). On the basis of implicit abstraction of rules, one could expect that two regular words that share a high degree of visual similarity, will also, in general, share a large number of rules, whatever form these rules take. Consequently, the condition which Glushko considers to be representative of rules may, in effect, be the one where the fewest rules are shared. From this viewpoint, it could be concluded that Glushko has provided strong evidence for the priming of rules.

If the activation-synthesis model proposed by Glushko is appropriate, then priming with an exceptional word should be just as efficient as priming with a regular word. There are no provisions in the model for distinguishing between the two types of items. If the same amount of priming is observed in both priming conditions, it then would provide strong support for the elimination of the regular-exceptional distinction. However, if one obtained better priming with the regular words than with exceptional words, it would seriously limit the usefulness of the activation-synthesis model. In addition, such results would impose definite constraints on analogy models since it would indicate that certain analogies are better than others. The experiments described in the following two chapters represent attempts to test the hypothesis that the regular-exceptional distinction is not appropriate since the same type of generalization phenomena are observed with both types of items.

CHAPTER 4: THE REPEATED LIST EXPERIMENTS.

As was discussed earlier, if an increase in response latency for words containing inconsistently pronounced letter groups is due to a conflict caused by the inconsistency of the activated information, it may be possible to manipulate the amount of conflict by selecting which information will become activated. There are potentially two simple ways of manipulating the activated information and, subsequently, of examining the role that this activated information can play in word pronunciation. The first manipulation would consist of a repeated list paradigm. Providing the subject with specific analogies within a short list of words may help determine which information will already be highly pre-activated when subsequent presentation of the list will occur. A second way of controlling which item is activated would be to prime the pronunciation of a pseudoword such as BINT by preceding it with a word such as MINT or PINT. On the basis of the activation synthesis formulation proposed by Glushko, there should be no difference between regular and exceptional primes. The current chapter will present descriptions and results of two repeated list experiments. A following chapter will present descriptions and results of two priming experiments.

With a list containing both GULL and HULL, the repeated presentation should make the responses to both items highly activated while the responses to other similar items like PULL or DULL should remain at a lower level of activation. Since the two highly activated responses are consistent with each other (a rhyming relationship), the items should be pronounced quite rapidly without a conflict being produced. If a second list contained both PULL and GULL, then, with repeated presentation, the two inconsistent responses should both become highly activated resulting in an increased conflict. According to the activation-synthesis model, this condition should result in an increase in pronunciation latencies. In addition, if the mechanism is very robust, lists containing close analogies (GULL/HULL or PULL/BULL) should be faster than lists containing far analogies (GULL/HELL or PULL/BELL).

The repeated list format also provides an opportunity to see if the processes used by the subjects will show any lability. The following experiment was designed with these considerations in mind.

THE FIRST REPEATED LIST EXPERIMENT.

Short lists of English four-letter words were constructed so that a number of similarity relationships would be present between each of three item pairs. In some of the lists, the item pairs were close analogies to each other; for example, HULL and GULL or PULL and BULL. In other lists, the item pairs were far analogies to each other, like PULL and BELL or GULL and HELL. Finally, in a third type of list, the item pairs constituted non-corresponding analogies such as GULL and PULL. In this last list, there is greater surface similarity between the written words than between the spoken words. Within the close analogy condition, there was a list containing only regularly pronounced items (HULL-GULL) and another list containing only exceptional items (PULL-BULL). Within the far analogy condition, one list contained only regularly pronounced items (GULL-HELL) while another contained both regularly and exceptionally pronounced items (PULL-BELL).

MATERIALS. Examples of the lists for each of the five conditions are presented in Figure 1. Three inconsistent letter groups, ULL, EAR, and USH, were selected because they allowed construction of matched lists for each of the five following conditions:

A- exceptionally and regularly pronounced words providing far analogies (list E),

B- exceptionally pronounced words providing close analogies (list D),

C- both regularly and exceptionally pronounced words

FIGURE 1. Materials for the first repeated list experiment.

LIST A	LIST B	LIST C	LIST D	LIST E
Regular		Non-corresponding	Exceptional	
Far	Close		Close	Far
GULL	GULL	GULL	BULL	BELL
HELL	HULL	PULL	PULL	PULL
GEAR	GEAR	GEAR	BEAR	BOAR
HAIR	HEAR	PEAR	PEAR	PEAR
GUSH	GUSH	GUSH	BUSH	BASH
HASH	HUSH	PUSH	PUSH	PUSH

providing non-corresponding analogies (list C),

D- regularly pronounced words providing close analogies (list B),

E- regularly pronounced words providing far analogies (list A).

The six words of a list were typewritten on 3 x 5 inch index cards. Twelve ordering of the items were determined by randomly selecting twelve different permutations of the items. The only constraint that was imposed on the randomness of the process was that each item had to appear twice in the first position of a list.

PROCEDURE. Eight McMaster undergraduates participated in the experiment in exchange for course credits. They were told that lists of six words would be repeatedly presented to them and they were to pronounce aloud all six words as rapidly as possible. They were also told that their performance would be timed.

The twelve permutations of one list were shuffled and presented to the subject one at a time. A timer was manually started as the card was put on the table in front of the subject and stopped after the subject had pronounced the sixth word. The time to read through the list was then recorded as hundredths of seconds. This procedure was repeated until blocks of twelve trials had been presented for each of the five lists. The whole sequence was then repeated four times so that each list was presented a total of 48 times. The order of presentation of the five lists within each block was partially counterbalanced across subjects by using one of the four following sequences:

ABCDE EDCBA ABCDE EDCBA,

ABCDE EDCBA EDCBA ABCDE,

EDCBA ABCDE EDCBA ABCDE,

EDCBA ABCDE ABCDE EDCBA.

RESULTS. In most of the figures used to report the data, a constant was subtracted from each score in order to make the contrasts between conditions more evident. It was noted during the experiment that on a number of occasions, the subjects experienced difficulty with the P and B distinction in lists A and B. They hesitated, stuttered, and tended to repeat an incorrect pronunciation when they were obviously trying to correct an error they had just made. Their behavior on those occasions appeared to me to be very similar to the behavior observed when people are presented with tongue-twisters such as: "Sheila is selling her shop at the seashore for shops at the seashore are sure to lose." (from the comedian Danny Kaye). These observations would be consistent with the interpretation that P and B are more similar to each other than are G and H and consequently produced a phenomenon similar to tongue twisters.

The average results, collapsed across trials, blocks and subjects, are presented in Table 1. A preliminary analysis of variance on the data (Appendix A) revealed that

TABLE 1. Average time in seconds to pronounce 6 items.

	Blocks of 12 trials		
	1 and 2	3 and 4	Average
Regular far analogy (GULL-HELL)	2.23	2.06	2.15
Regular close analogy (GULL-HULL)	2.36	2.15	2.26
Non-corresponding analogy (GULL-PULL)	2.44	2.23	2.34
Exceptional far analogy (BELL-PULL)	2.42	2.30	2.35
Exceptional close analogy (BULL-PULL)	2.61	2.46	2.54
Average	2.41	2.24	2.33

indeed lists D and E were responded to more slowly than lists A and B. Since regularity of pronunciation is confounded with the initial consonants, at least three interpretations are possible. Lists D and E could be slower because they contained words with irregular pronunciations, or alternatively, they could be slower because P and B are very similar both visually and phonologically. This increased similarity could lead to confusion and to slower response times.

The similarity explanation is based on the fact that the item pairs within and across lists differ only on two aspects. On some lists the initial consonants were G or H which could be considered to be low in similarity. Other lists had B and P as initial consonants which could be considered to be high in similarity. Finally, one list contained P and G as initial consonants. These could be of medium similarity. The second aspect on which item pairs could differ was in the vowels used on the two far analogy lists. If it is assumed that the effect of the two types of differences are additive, the following ordering is obtained in terms of overall similarity within item pairs:

A. GULL-HELL : low similarity consonants plus vowel change,

B. GULL-HULL : low similarity consonants,

C. GULL-PULL : medium similarity consonants,

D. BELL-PULL : high similarity consonants plus vowel change,

E. BULL-PULL : high similarity consonants.

This ordering parallels the results which were obtained.

An alternative explanation for the pattern of results could be in terms of the number of irregular items contained in the lists, in addition to the degree of similarity between items within an analogy pair. According to this interpretation, the items would be ordered as follows:

A. GULL-HELL : 2 regular plus 2 letter changes,

B. GULL-HULL : 2 regular plus 1 letter change,

C. BELL-PULL : 1 regular plus 2 letter changes,

D. GULL-PULL : 1 regular plus 1 letter change,

E. BULL-PULL : 0 regular plus 1 letter change.

Again, the rank ordering of the lists is very similar to the pattern of results, differing only for the two conditions which show the smallest difference in the table.

Finally, it is possible that the lists containing exceptionally pronounced words were slower because P and B may have associated with then articulatory components which require more time to produce than those associated with G and H. Added to this effect would be a close versus far distinction. The ordering of the conditions would again parallel the results which were obtained.

Given the pattern of results and their multiple explanations, it was deemed inappropriate to further analyse the results in terms of the original intent of the experiment. Instead, a second experiment was devised to eliminate the confounding between the similarity of the initial consonants within an item pair and the regularity of pronunciations.

THE SECOND REPEATED LIST EXPERIMENT.

The ideal experiment would have been to construct lists where the exceptionally pronounced words would have G and H as initial consonants while the regularly pronounced words would have P and B as initial consonants. Attempts to construct matched lists meeting those conditions were unsuccessful. Consequently, lists were constructed using only the consistent letter groups ILL, ANG, and ALE. All other aspects of the lists were kept constant. If the differences in response times between lists A and B and lists D and E were due to the presence of exceptional pronunciations when using the inconsistent trigrams, such a difference should not be found with the five new lists. Hence, a Consistency X Initial-consonant interaction would be expected. However if such an interaction was not found, then both the explanation in terms of the number of exceptional pronunciations and the explanation in terms of the time required to produce the P and B sounds would remain viable candidates.

Examples of the lists containing only regularly pronounced words are presented in Figure 2.

RESULTS. A first analysis compared the P-B lists from both experiments. It was expected that, if either the similarity explanation or the articulatory explanation were valid, then there would be no difference between the group which had to pronounce words containing inconsistent letter patterns and the group which had to pronounce words containing only consistent letter patterns. On the other hand, the explanation based on the inherent slowness of exceptional words predicted that the groups which had to pronounce words containing exceptionally pronounced letter patterns would be slower than the group which pronounced regular items only. An analysis of variance with one between-group factor (Type of items: exceptional versus regular) and three within-group factors (Analogy: close versus far; Trials: 1 through 12; and Blocks: 1 through 4) was selected. The only lists which were considered in this analysis were those which used P and B as initial consonants (lists D and E).

The summary table for this analysis of variance is presented in Appendix B. None of the interaction or main

FIGURE 2. Materials for the second repeated list experiment.

LIST A	LIST B	LIST C	LIST D	LIST E
Regular		Control for Non-corresponding	Control for Exceptional	
Far	Close		Close	Far
GILL	GILL	GILL	BILL	BALL
HALL	HILL	PILL	PILL	PILL
GANG	GANG	GANG	BING	BUNG
HUNG	HANG	PANG	PANG	PANG
GALE	GALE	GALE	BALE	BOLE
HOLE	HALE	PALE	PALE	PALE

effect terms which involved the between group factor reached significance. Hence, it appears that it is not the presence of exceptional pronunciations per se which led to longer latencies of the P/B lists. Rather, it would appear that the greater similarity between P and B or the longer times required to produce the P and B sounds resulted in slower response latencies independently of whether regular or exceptional pronunciations were required. Hence, on the basis of these two experiments, it was not possible to verify the prediction that exceptional words should facilitate the pronunciation of exceptional neighbors just as much as regular words should facilitate the pronunciation of regular neighbors.

Because there remained two possible interpretation for the P/B effect, a further analysis was done on the three remaining conditions which did not include the P/B confounding. One interesting contrast which this analysis allowed was the one between the close analogy condition and the non-corresponding analogy condition. On the basis of the activation-synthesis model, it was expected that a list containing PULL and GULL would produce longer response times than a list containing HULL and GULL since the first list would result in the activation of conflicting responses. This analysis was based on a split-plot design with one between-group factor (Consistent versus inconsistent trigrams) and three within-group factors (Type of analogy:

close, far and non-corresponding; Blocks: 1, 2, 3, and 4; and Trials: 1 through 12). A summary table of the analysis is presented in Appendix C.

Except for the between-group factor, all main effects were statistically reliable beyond the $p=.001$ level (Figures 3, 4, and 5). The non-corresponding analogy condition was substantially slower than the close analogy condition which, in turn, was slower than the far analogy condition. Pairwise contrasts are presented in Appendix D. Responses on block 1 were significantly slower than those on the other three blocks. No further reliable differences were observed between blocks (Appendix E). Similarly, response latencies on trial 1 were slower than those on all other trials. In addition, latencies on trial 9 were shorter than those on trials 3 and 10 (Appendix F).

The Analogy * Trials interaction (Figure 6) was reliable at $p<.01$ level. Pairwise comparisons (Appendix G) reveal that the interaction is mostly attributable to the lack of a difference between the three analogy conditions on the last three trials while the latencies for the non-corresponding analogy condition are consistently longer than those for the far analogy condition on the first nine trials. A number of reliable differences were also observed between the close analogy condition and the other two conditions. No systematic pattern could be detected to explain these differences.

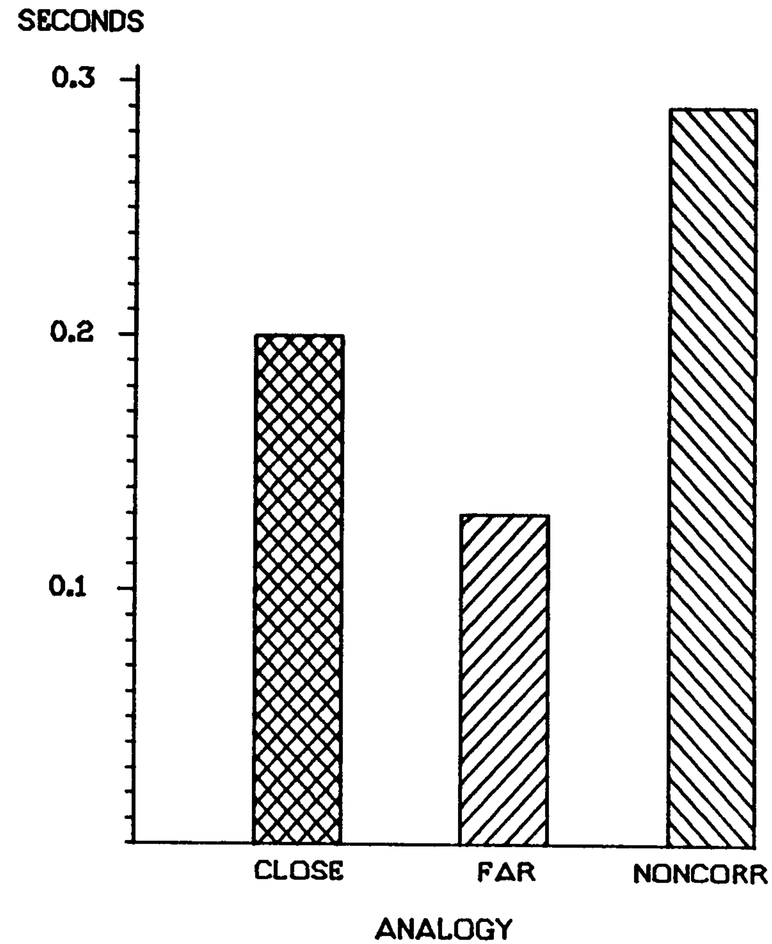

FIGURE 3: MEAN RESPONSE TIMES FOR THE DIFFERENT ANALOGY CONDITIONS.

(2.00 SUBTRACTED FROM EACH SCORE)

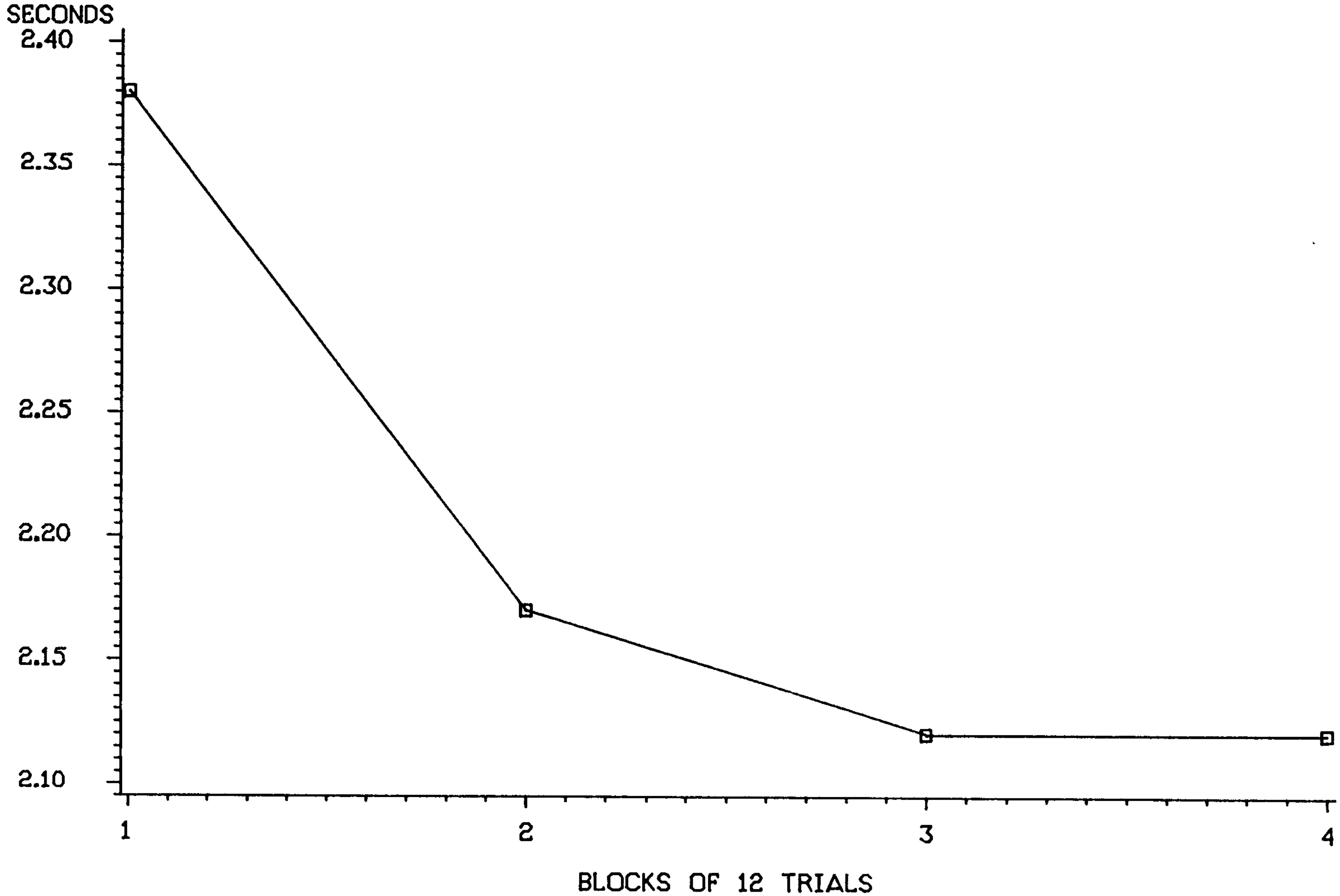

FIGURE 4: MEAN RESPONSE TIMES FOR EACH BLOCK.

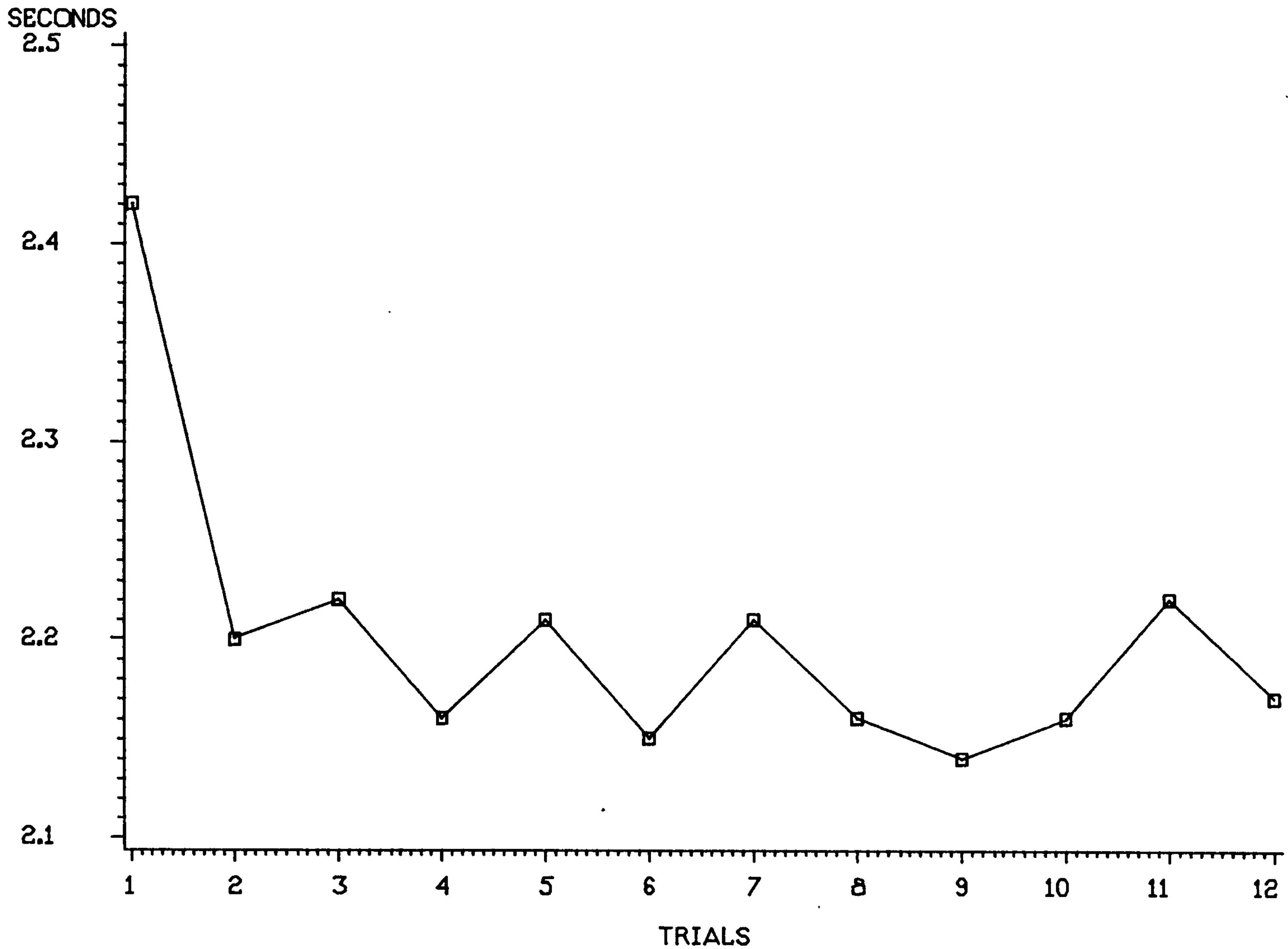

FIGURE 5: MEAN RESPONSE TIMES FOR EACH TRIAL

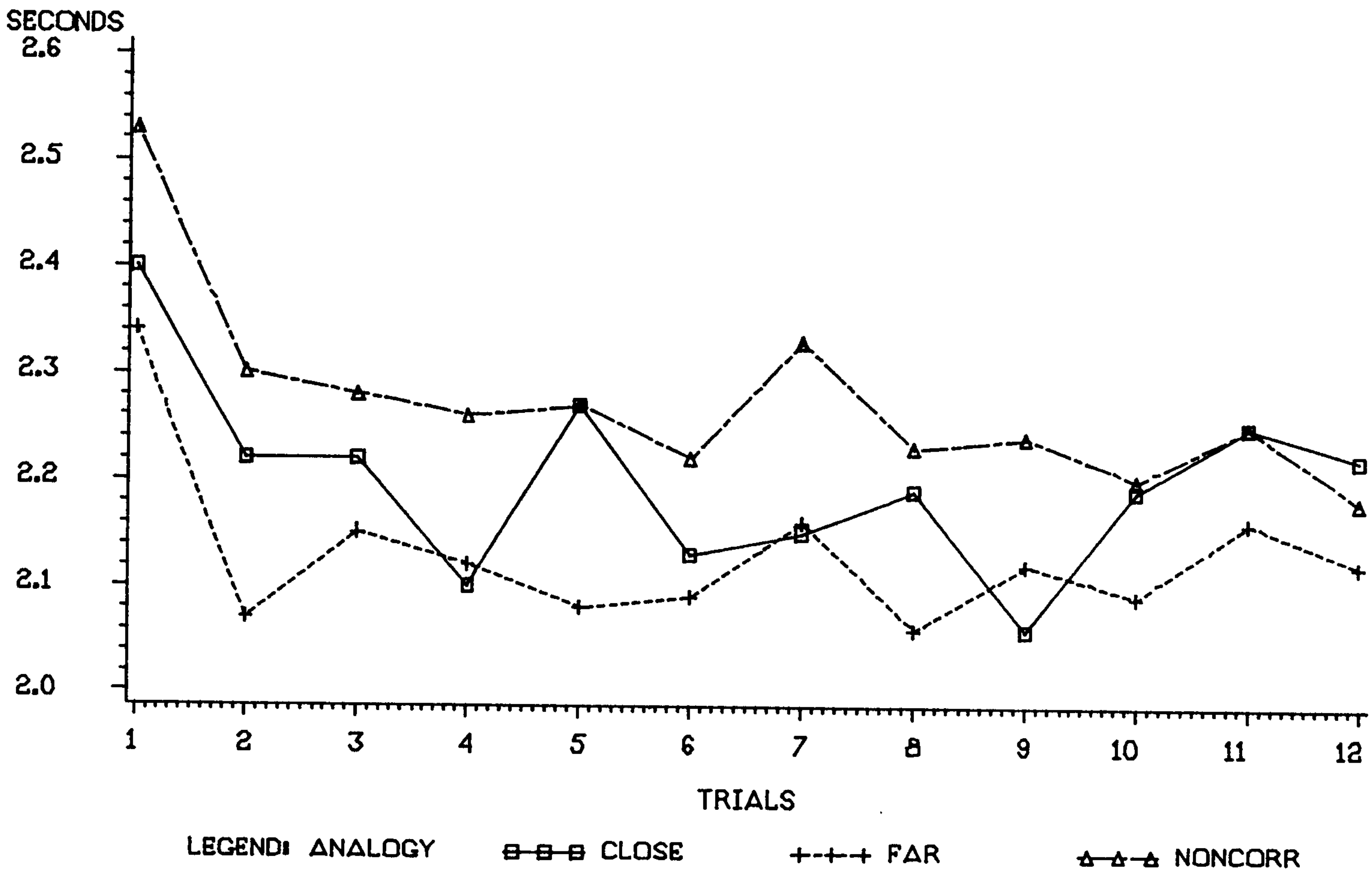

FIGURE 6: MEAN RESPONSE TIMES FOR ANALOGY CONDITIONS BY TRIALS

Another two way interaction, Blocks X Trials (Figure 7), was significant ($p < .05$). On the basis of pairwise comparisons (Appendix H), it can be seen that this interaction is mostly attributable to the fact that, on certain trials (1, 8, 11, and 12), block 2 differs reliably from block 4 while it only differs from block 3 on trial 9. Since no systematic pattern could be detected from the data, no detailed interpretation of this interaction will be attempted.

The only significant effect which involved the between-group factor was the Analogy X Trials X Groups interaction. This interaction is presented in Figures 8a and 8b. Pairwise comparisons (Appendix I) indicate that the interaction is mostly attributable to the slower response latencies obtained on the non-corresponding analogy condition with inconsistent items, especially on the early trials. This condition differs reliably from four other conditions on trial 1 and from one other condition on trials 2, 4, and 7. Within this condition, the latencies on trial 1 were reliably longer than latencies on other trials except for trials 2, 3, and 7. Since this is the only condition on which conflicting analogies were present on the same list, the results are consistent with the interpretation that a conflict was indeed produced on the first trial but that the subjects rapidly adopted techniques or strategies which allowed them to avoid the conflict. There is also an

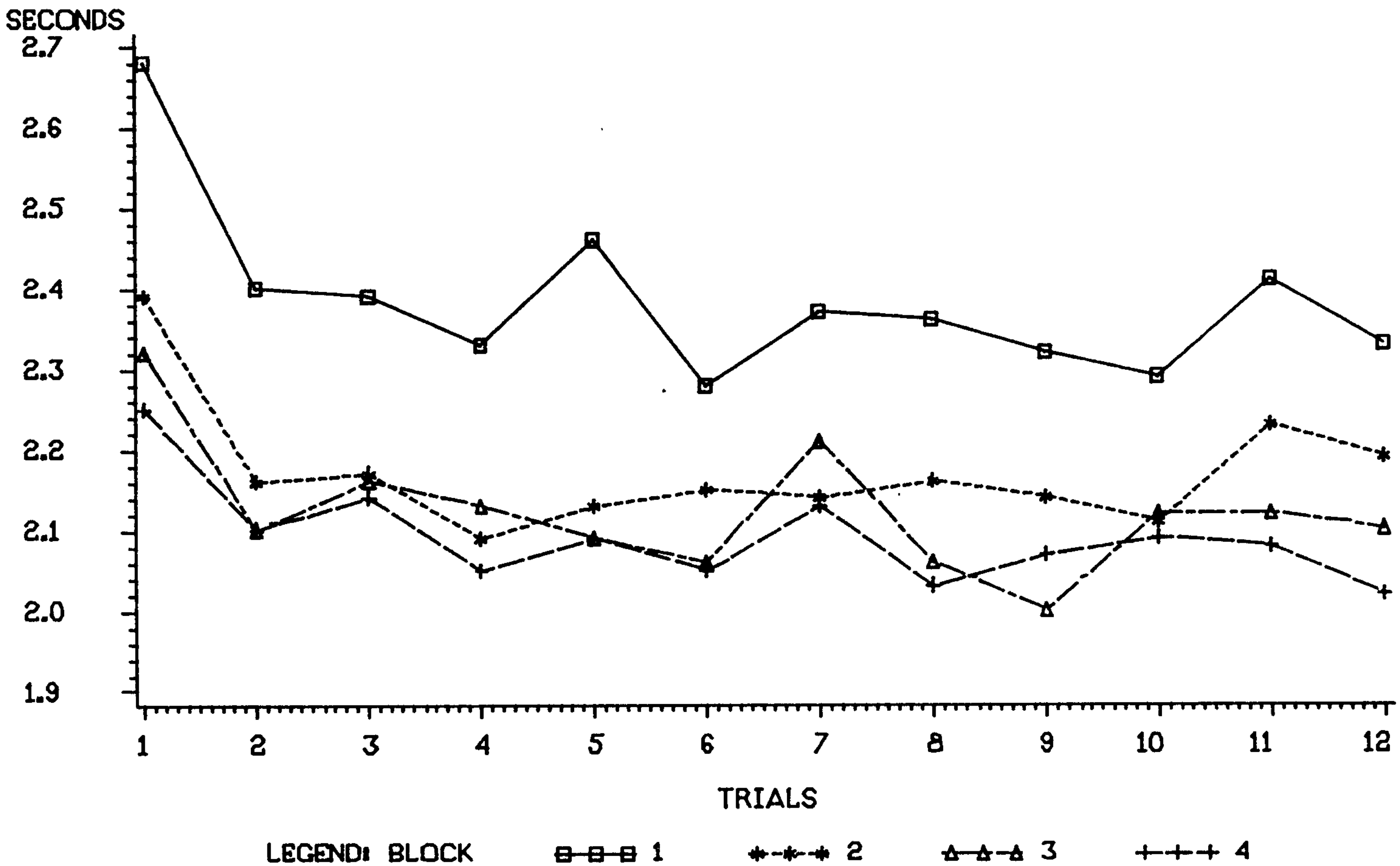

FIGURE 7: MEAN RESPONSE TIME FOR BLOCKS BY TRIALS.

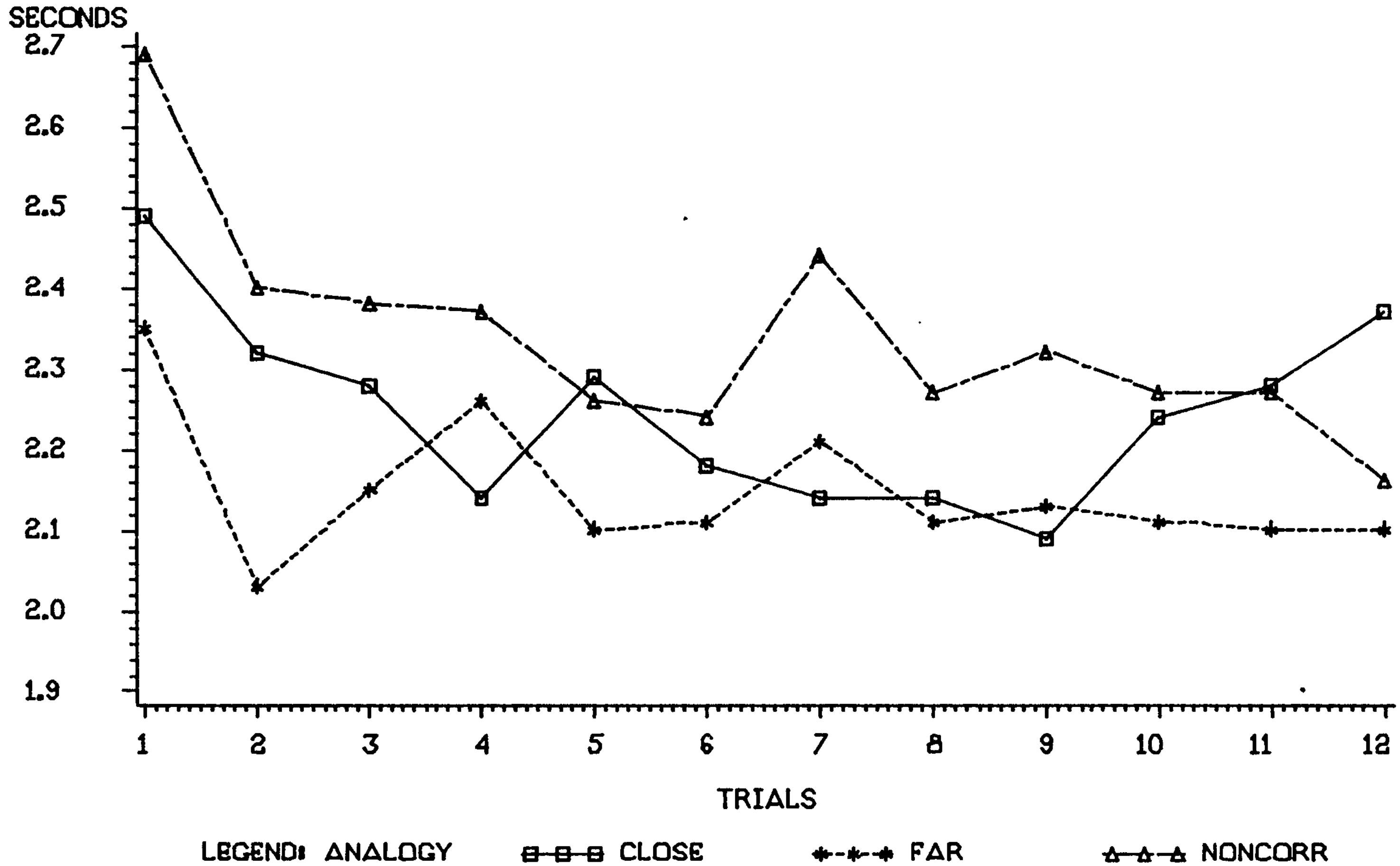

FIGURE 8A: MEAN RESPONSE TIMES FOR THE ANALOGY CONDITIONS ON INCONSISTENT ITEMS.

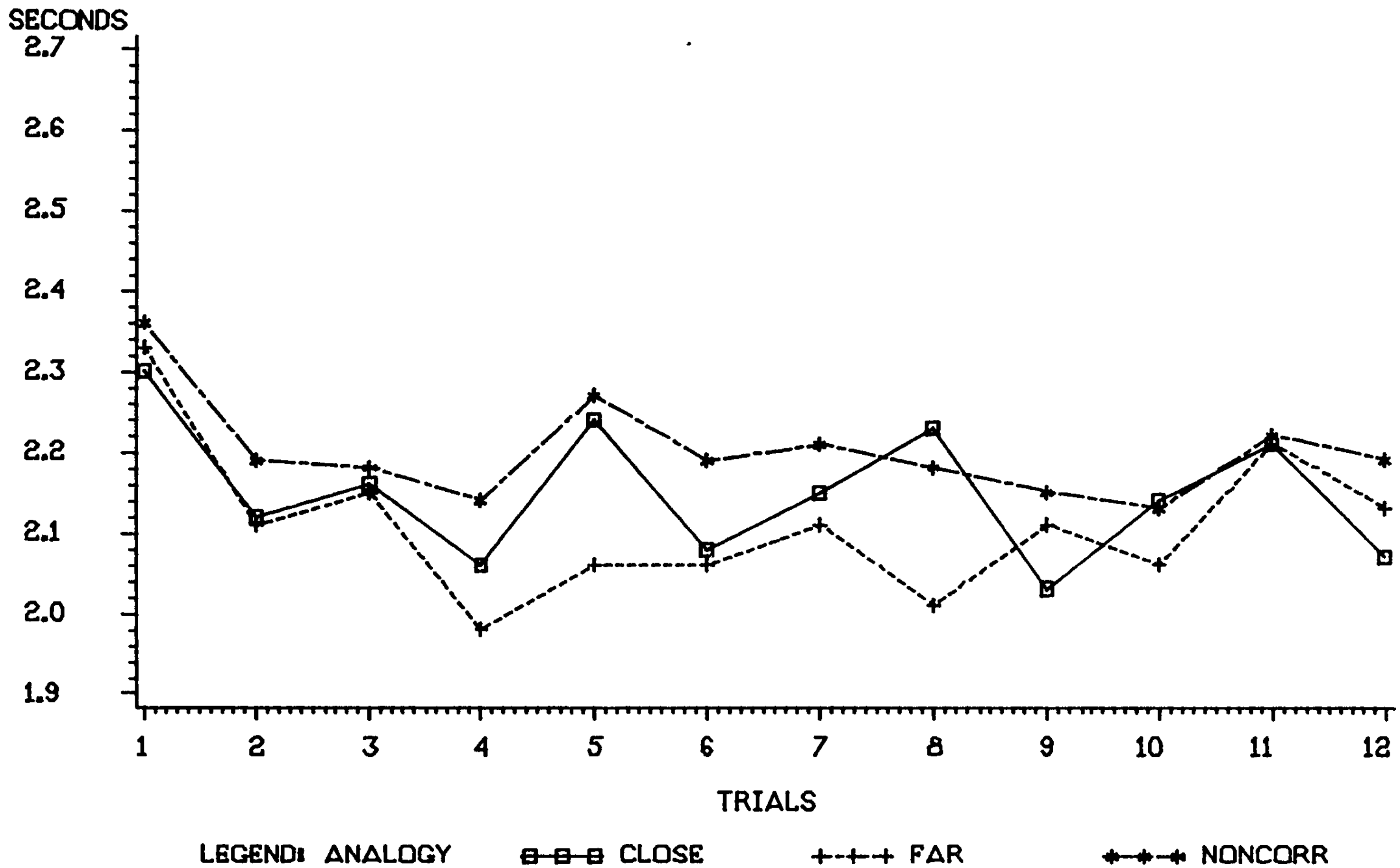

FIGURE 8B: MEAN RESPONSE TIMES FOR THE ANALOGY CONDITIONS ON CONSISTENT ITEMS.

indication that some learning over trials occurred with the use of inconsistent items in the close analogy condition since latencies on trial 1 are reliably longer than those on trials 4,7,8, and 9.

DISCUSSION OF THE RESULTS FROM THE REPEATED LIST EXPERIMENTS.

In summary, the results of this analysis support the conclusion that an increase in similarity within a list leads to an increase in response times. This is seen in the slower response times of the close analogy conditions relative to the far analogy conditions. The subjects also appear to have more difficulty with the non-corresponding analogy condition on the first trial. This evidence is partially consistent with the activation-synthesis model since a conflict appears to have been produced on the first presentation of the non-corresponding analogy list. However, the activation-synthesis model has difficulty with the direction of the difference found between the far analogy condition and the close analogy condition. It is possible that the list presentation format leads to interference due to the high similarity of the items. Such an effect might not be observed when the items are presented one at time as is done in priming paradigms.

Hence some support for the activation synthesis model was provided by these two experiments. However, it appears that subjects can very rapidly learn to avoid the conflict which was produced in the non-corresponding analogy conditions or that the nature of the task is drastically altered for the subsequent trials. It may well be that with the list presentation format, the subjects rapidly learn that the major task is to gather enough information to distinguish pairs of similar items. One of the best ways to achieve this would be to distinguish between the initial consonants of each pair of items. Hence the subjects would not be generating a new response each time an item is encountered but, instead, they would simply be selecting one item from within a set of highly activated items. The process on which this selection is based could be very different from the usual word pronunciation process. However, on the first trial when the subject has to generate responses, something akin to the activation-synthesis process could be occurring.

Since the activation of inconsistent information and the subsequent conflict may only be produced when a response has to be generated from scratch, it could be very informative to examine how regular and exceptional information will generalize to or interfere with the pronunciation of pseudowords. Since Glushko (1979a) has found that inconsistent pseudowords are pronounced with the exceptional pronunciation on approximately 15% of the trials, it might be possible to decrease or increase the number of exceptionally pronounced pseudowords by manipulating the type of priming to which the pseudowords are submitted.

CHAPTER 5: THE PRIMING EXPERIMENTS

It was mentioned earlier that there are potentially two simple ways of controlling which information will become activated and, subsequently, to examine the role that this activated information can play in word pronunciation. The first manipulation consisted in repeatedly presenting a short list of items so that the response to each item should become highly activated. The results from such a manipulation provided partial support for the activation-synthesis model of word pronunciation while some of the data could be considered as evidence against the model.

Since the data from the previous experiments showed a possible conflict on the first trials of the non-corresponding analogy condition, it suggests that something akin to activation-synthesis may be occurring when responses are generated on their first presentation. Hence, these results provided further impetus for using the priming paradigm which has already been used quite extensively in lexical decision studies. Glushko (1979a) also used the same procedure in a word pronunciation task. Such a paradigm could indicate what phonological knowledge a reader can use to transfer to subsequent novel items.

By having the subject pronounce a word immediately before he has to pronounce a very similar pseudoword, it might be possible to influence the pronunciation emitted for the pseudoword. A simple extension of the activation-synthesis model would predict that pre-activated exceptional information should be just as efficient in determining the pronunciation of a pseudoword as pre-activated regular information. This extension is based on Glushko's claim that the regular-irregular distinction is not useful. In his view, the only difference between regular items and irregular items is in the fact that one class includes more members than the other.

The following two experiments focussed on priming of pseudoword pronunciation in undergraduates, and third grade students, respectively.

ADULT PRIMING EXPERIMENT.

The first priming experiment was designed to verify whether exceptional primes would be just as effective as regular primes in resolving the conflict produced by the presentation of an inconsistent pseudoword.

MATERIALS. Five types of priming relationships were included. An inconsistent pseudoword (BINT) could be preceded by a regularly pronounced word (MINT), or by a exceptionally pronounced word (PINT). A consistent pseudoword (BINK) could be preceded by two types of regularly pronounced words (MINK or PINK). The two types of regular words were included in the last condition in order to control for similarity to both exceptional and regular primes in the inconsistent condition. One of them, PINK followed by BINK, was labelled the exceptional control priming condition since it constitutes a regular priming condition which attempts to match the degree of similarity observed between PINT and BINT, the exceptional priming condition.

Eighteen pairs of 4-letter target pseudowords were selected. Within each pair one item contained an inconsistently pronounced letter pattern while the other item contained consistently pronounced letter patterns. All such pairs had the same initial consonant but differred in one of the other three letter positions. Three pairs differred on consonants in the fourth position; six pairs differred on the consonant in the third position; and, two pairs differred on the vowel in the second position.

All priming words differed from their target items in initial consonants only. Attempts were made to match the priming words which were to be used with both types of pseudowords. Fifteen regular inconsistent words shared their initial consonants with the corresponding regular consistent word. Ten exceptional words shared their initial consonants with the exceptional-control consistent words. For three consistent items, the same word was used as the regular prime and the exceptional-control prime. The words and pseudowords used in the experiment are presented in Table 2.

Two other conditions were included, one in which a pseudoword could precede itself (repetition), and the other in which the pseudoword could be preceded by three words which differed from it by at least two letters. (On later verification it was found that, in one instance, a word, which was three positions away from a given pseudoword, shared three letters-in-position with it.) The last two priming relationships were to serve as baseline conditions so that estimates of maximum and minimum amounts of priming could be obtained. However, because of the overlap which was allowed between the letters of consecutive items, the last condition does not constitute a proper 'no-priming' condition.

The experiment was also designed to avoid the paired presentation format which has been used often in priming experiments. It was believed that, if list construction is too obvious, the subject can adopt a strategy of responding on the basis of item pairs. Such a strategy might only be due to the experimental procedure and, as such, would severely limit the generalizability of the results. A lag manipulation was introduced so that each of the priming

TABLE 2. Items used in the two priming experiments.

Inconsistent items			Consistent items		
Regular primes	Except. primes	Targets	Regular primes	Control for Except. primes	Targets
gull	pull	vull	gulp	pulp	vulp
mint	pint	bint	mink	pink	bink
gush	bush	vush	gust	bust	vust
mead	head	kead	meal	heal	keal
rome	come	vome	robe	lobe	vobe
loot	soot	doot	loop	loop	doop
seen	been	heen	seem	deem	heem
rove	love	bove	rope	lope	bope
band	wand	kand	bend	wend	kend
rant	want	fant	rent	went	fent
comb	bomb	gomb	romp	pomp	gomp
tone	done	wone	tote	dote	wote
post	cost	wost	colt	colt	wolt
gild	wild	pild	hilt	hilt	pilt
five	give	tive	fife	life	tife
hear	bear	kear	heat	beat	keat
hose	lose	fose	hole	sole	fole
leaf	deaf	peaf	ream	team	peam

relationships could occur between adjacent items or between items which were separated by one or two other items.

Three lists of 84 4-letter items (Appendix J) were constructed . Any one list allowed for 2 instances of each priming relationship at each of the three lags. Although there were 4 instances of regular priming in the consistent word conditions, two instances constituted the regular priming relationship and the other two constituted the exceptional-control condition. Each list differed from the two others on the basis of the type of priming relationship which was present for any particular target item. For example, if BINT was primed by PINT on list 1, it would be primed by MINT on list 2 and would be primed by itself on list 3. In this last case, the first appearance of the pseudoword constituted the 'no-prime' condition while the second appearance constituted the repetition condition. Two versions of each list were constructed so that the order of the items would not be constant across all subjects. Half the subjects received the first ordering of a list while the other half received the second ordering.

The presentation order of the three experimental lists was counterbalanced across subjects.

PROCEDURE. Twenty four McMaster undergraduates participated in the experiment in exchange for course credits. When a subject showed up in the experimental room, he or she was seated in front of a television screen on which the items were to be displayed. Four dots were then displayed on the screen by an APPLE II microcomputer. The subject was told that whenever he pressed a button, the dots would be replaced by a word. He was asked to pronounce each item as rapidly as he could. A microphone was then adjusted so that it would be immediately in front of the subject's mouth and within two inches from it. The microphone permitted the microcomputer to measure response latencies via a voice-activated relay. It also allowed recording of the subject's responses so that they could later be scored for correctness and regularity of pronunciation.

A practice list consisting of 2-syllable English words was then presented to the subject. After presentation of the practice list, the subject was told that, for the next three lists, four letter items would appear on the screen whenever he pressed the button. Some of these items would be words but most of them would be nonword letter strings which should be quite easy to pronounce. The subject was then told that he should attempt to pronounce each item as rapidly as possible with the first response that came to mind.

RESULTS. Two dependent variables were analyzed: the number of irregular pronunciations and the latency between item presentation and initiation of the vocal response. The results based on the number of irregular pronunciations will be presented later, when the results of the second priming experiment are analyzed.

A first step consisted in verifying whether the pattern of results obtained by Glushko (1979a) had been replicated. By collapsing across items, lags, and lists, one score per subject was obtained for each of the following conditions : unprimed inconsistent pseudowords, unprimed consistent pseudowords, consistent words, and inconsistent words. For pseudowords, the subjects could produce both regular and exceptional pronunciations. The following analysis is based on regular pronunciations only in order to approximate more closely the analysis done by Glushko. Table 3 permits a comparison of the present results with Glushko's main results.

A randomized block factorial analysis of variance (Kirk, 1968) with two factors (wordness and consistency) revealed that both main effects were significant. The summary table for this analysis is presented in Appendix K. On average, consistent items were 40 milliseconds faster than inconsistent items and words were faster than pseudowords by about 84 milliseconds. When inconsistent words are broken down further into regular and exceptional words (Table 4), there was a highly unreliable 20 msec. advantage for regular words (MINT) over exceptional words (PINT). Hence, the basic pattern of results reported by

TABLE 3. Comparison of pronunciation latencies in terms of wordness and consistency.

(Milliseconds)

Wordness	Consistency	Current Priming Experiment	Glushko Exp. 1
Words			
	Consistent	662	598
	Inconsistent-exceptional	702	618
	Difference	40	20
Pseudowords			
	Consistent	747	618
	Inconsistent	787	646
	Difference	40	28

TABLE 4. Comparison of pronunciation latencies in terms of regularity of words containing inconsistent letter groups.

(Milliseconds)

Regularity	Current Priming Experiment	Glushko Exp. 3
Regular (MINT)	692	546
Exceptional (PINT)	712	550
Difference	20	4
T-test	0.777	Not reported

Glushko was replicated.

The mean response latencies for the pseudoword conditions as a function of lag are presented in Table 5. These latencies are based on both regular and exceptional pronunciations of the pseudowords. Responses where incorrect pronunciations occurred, that is, pronunciations which are not encountered in English for that particular letter group, or responses where the voice-activated relay failed to operate on the subject's first attempt at responding, were excluded from the analysis.

The response latencies for the primed pseudoword conditions were submitted to a three-way analysis of variance (consistent versus inconsistent; lags 0, 1, or 2; regular, exceptional, or repetition priming). They were first collapsed across lists and items. Appendix L shows that all main effects were highly significant ($p < 0.01$). Figure 9 shows that inconsistent pseudowords were responded to more slowly than consistent pseudowords. Figure 10 shows that the fewer items inserted between the prime and the target, the faster was the response to the target (Appendix M for pairwise comparisons). Figure 11 shows that repetition was faster than regular priming which, in turn, was faster than exceptional priming (Appendix N for pairwise comparisons).

Two of the two-way interactions were statistically significant ($p < 0.01$): the Consistency X Type of priming

TABLE 5. Mean response latencies for the pseudoword conditions.

(Milliseconds)

		Type of priming			
Items	Lags	Exceptional	Regular	Repeated	Unprimed
Inconsistent					
	0	817	714	671	802
	1	806	757	724	
	2	764	795	775	
Consistent					
	0	709	675	653	747
	1	709	728	731	
	2	699	746	722	

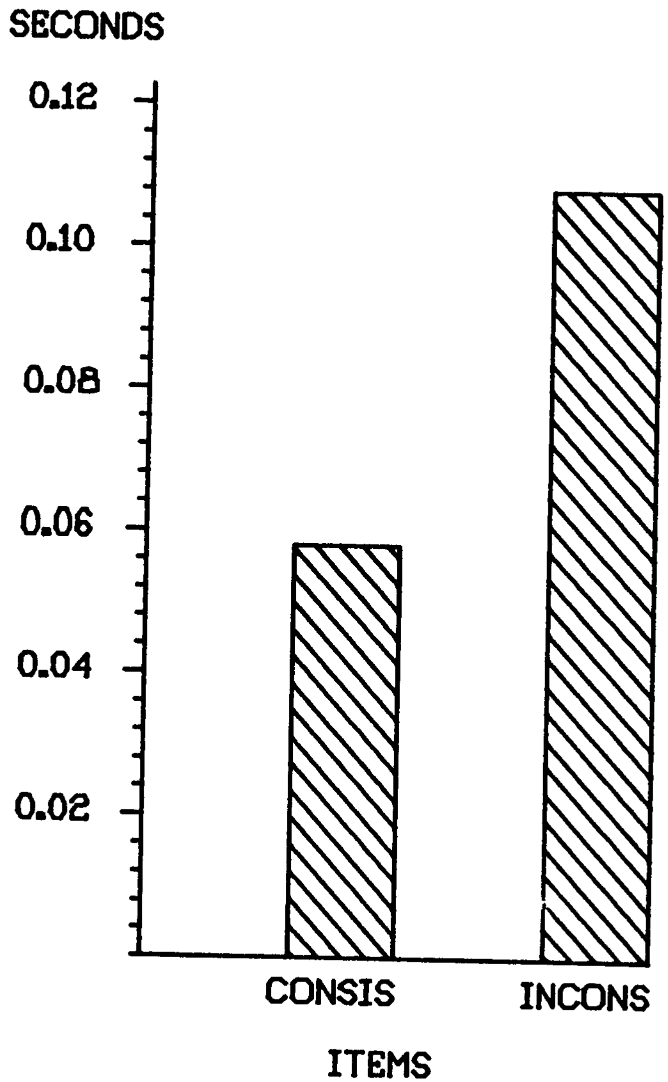

FIGURE 9: MEAN RESPONSE LATENCY FOR DIFFERENT TYPES OF ITEMS

(0.650 SUBTRACTED FROM EACH SCORE)

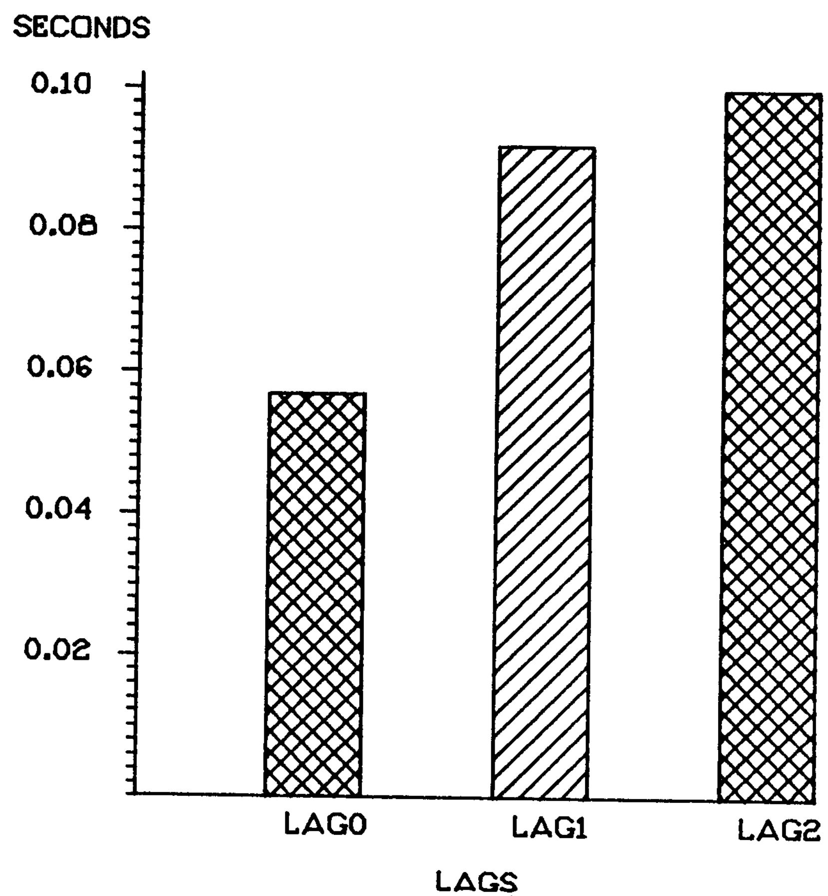

FIGURE 10: MEAN RESPONSE LATENCY FOR DIFFERENT LAGS.

(0.650 SUBTRACTED FROM EACH SCORE)

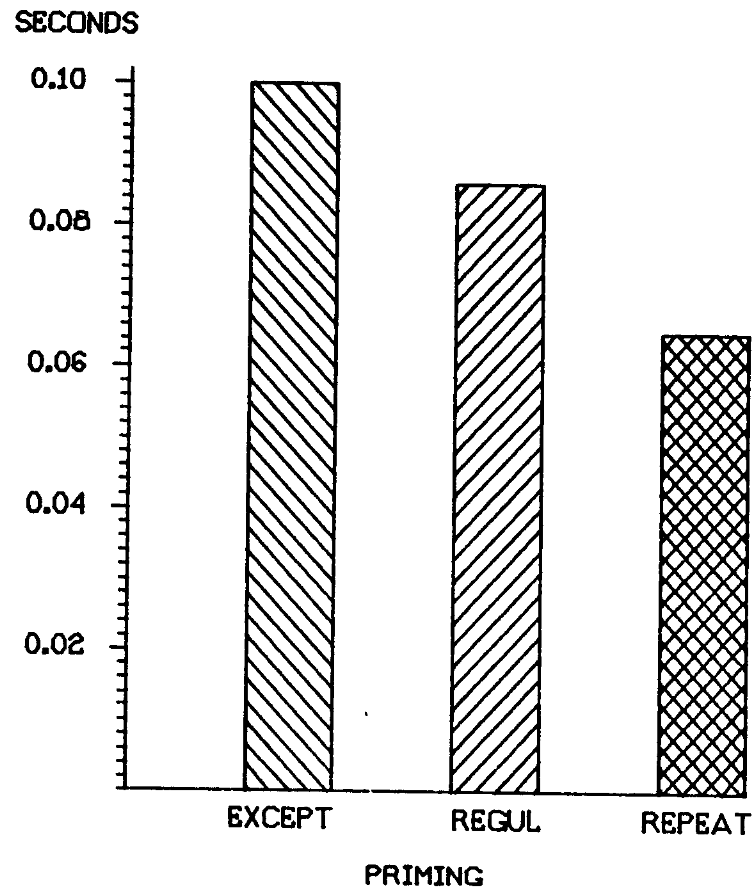

FIGURE 11: MEAN RESPONSE LATENCY FOR DIFFERENT PRIMING CONDITIONS

(0.650 SUBTRACTED FROM EACH SCORE)

interaction (Figure 12) and the Type of priming X Lag interaction (Figure 13). Care has to be exercised in the interpretation of the first interaction since the exceptional condition used with the consistent items is in reality a regular priming condition. This condition was included to partially control for similarity between primes and targets across consistency of items and to permit symmetry of design.

The first interaction then indicates that the slow responding to the exceptionally primed inconsistent items cannot be fully attributed to the differential effects of initial consonants (Appendix O for pairwise comparisons). Indeed, the performance on one set of consistent pseudowords is equivalent to that of the other set of consistent pseudowords independently of whether its priming word shares its initial consonant with a regular word or with an exceptional word. Hence the degree of visual similarity between the prime and the target does appear to be the major factor in producing the pattern of results observed here. Although PINT is a true exceptional prime and PINK is a regular prime, they both share the same degree of visual similarity with their respective target pseudowords BINT and BINK. Since they produce substantially different amounts of priming, it appears that regularity and not similarity is the important factor in producing priming. What the interaction indicates then, is that all the regular primes

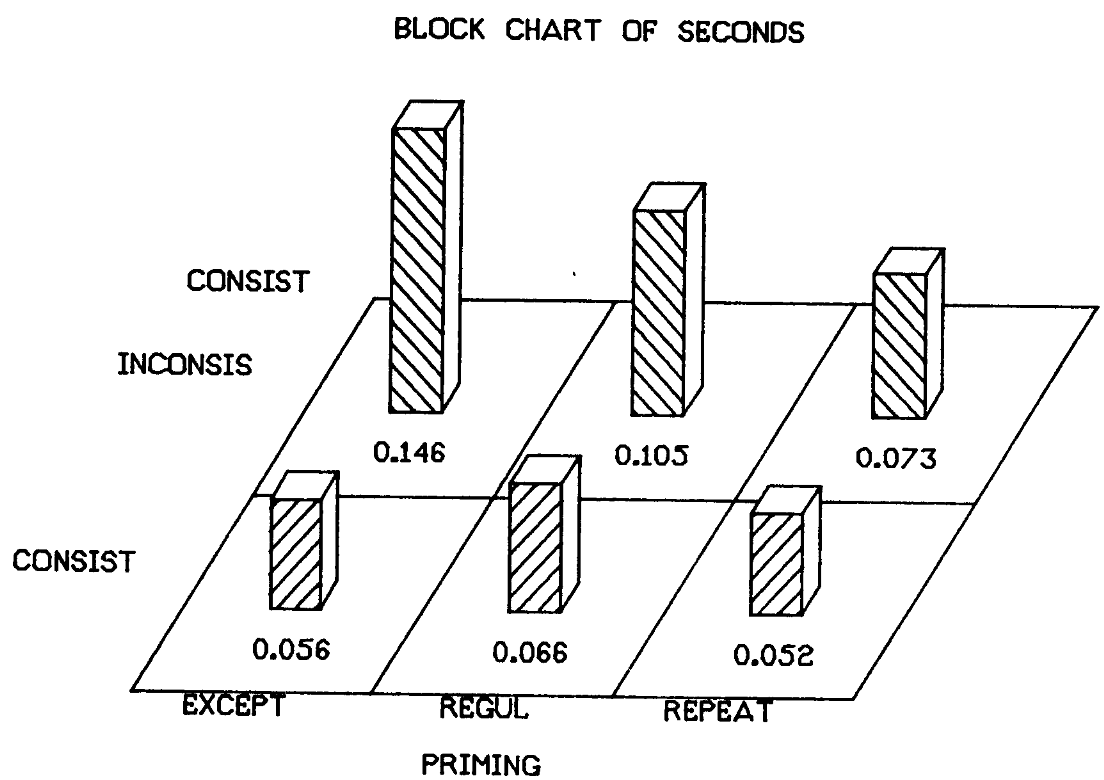

FIGURE 12: MEAN RESPONSE LATENCY FOR CONSISTENCY BY PRIMING

(0.650 SUBTRACTED FROM EACH SCORE)

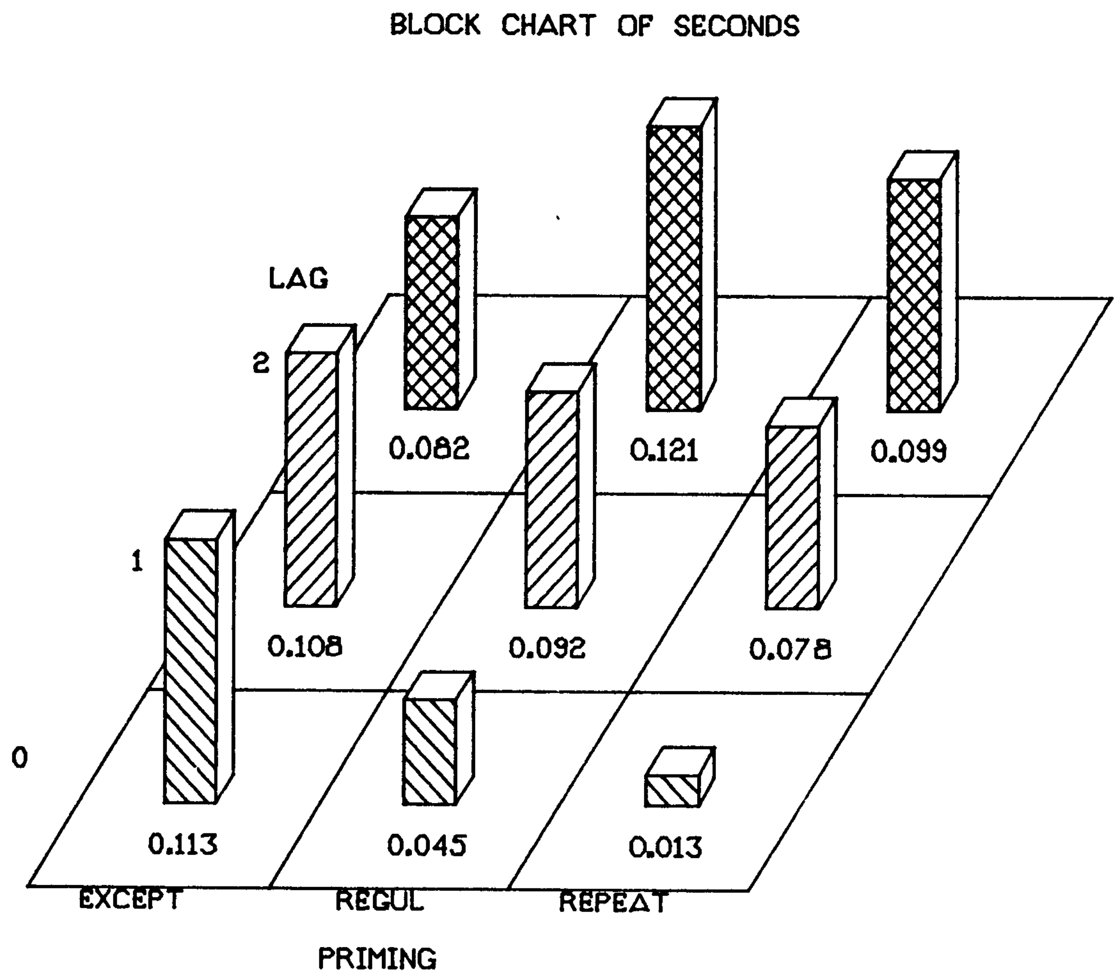

FIGURE 13: MEAN RESPONSE LATENCY FOR LAG BY PRIMING

(0.65 SUBTRACTED FROM EACH SCORE)

(MINT-BINT, MINK-BINK, and PINK-BINK) are quite effective while the exceptional primes (PINT-BINT) are clearly not as effective in speeding up the pronunciation response.

The second interaction is the one between Type of priming and Lags. The pairwise comparisons are presented in Appendix P. It shows that, with regular priming and with repetition, the lag 2 latencies are longer than both lag 1 and lag 0 latencies. With the exceptionally primed inconsistent items an unreliable reversal of the lag affect is observed.

An analysis based on only the regular pronunciations of the primed pseudowords (Appendix Q) revealed the same general pattern as the one just described. The mean pseudoword pronunciation latencies for the different conditions are presented in Table 6. The same main effects and interactions were statistically significant (all at $p < 0.01$). The greatest difference was a reduction of about 14 milliseconds in the inconsistent pseudoword conditions. There was no change in the consistent items since these were all pronounced regularly.

On the basis of this apparent reduction in speed of responding for exceptional pronunciations, a number of comparisons were conducted between regular and exceptional pronunciations conditionalized on the type of priming present for any given item. In order to eliminate carry over effects between lists within the experimental session, only

TABLE 6. Mean response latencies for the regular pronunciations of pseudowords in the different priming conditions.

(Milliseconds)

Items	Lags	Type of priming		
		Exceptional	Regular	Repeated
Inconsistent				
	0	827	710	664
	1	770	743	722
	2	766	797	764
Consistent				
	0	709	675	653
	1	709	728	731
	2	699	746	722

items encountered on the first priming list were considered. Since there were four priming conditions (no-priming, exceptional priming, regular priming and repetition) and two types of target items (consistent and inconsistent) and since inconsistent pseudowords could be pronounced exceptionally or regularly, each subject's first-list latencies were broken down in twelve cells. Table 7 presents the mean response latency for each cell along with the number of subjects who produced a score for that cell.

A first analysis compared regular pronunciations of inconsistent items to their exceptional pronunciation across three priming conditions: no-priming, exceptional priming and repetition. It was not possible to include the regular priming condition since no subject produced exceptional pronunciations of regularly primed pseudowords. The mean response latencies for each of the six conditions are presented in Figure 14.

Since the number of observations varied between cells and since this variation was probably related to the independent variables, a two factor least-squares analysis of variance (Kirk, 1968) was selected. There were two levels of the Pronunciation factor (regular or exceptional) and three levels of the Priming factor (no-priming, exceptional priming and repetition). The summary table of the analysis of variance is presented in Appendix R.

The Priming main effect and the Priming X

TABLE 7. Mean response latencies in the different priming conditions conditionalized on the type of item (Number of subjects in brackets).

(Milliseconds)

Items	Pronunc.	Excep. prime	Regul. prime	Repet.	Unpri.
Consistent:					
	Regular	794	692	664	754
		(22)	(24)	(24)	(24)
Inconsistent:					
	Regular	942	677	626	812
		(14)	(24)	(19)	(24)
	Exceptional	865	-	734	957
		(17)	(0)	(10)	(13)

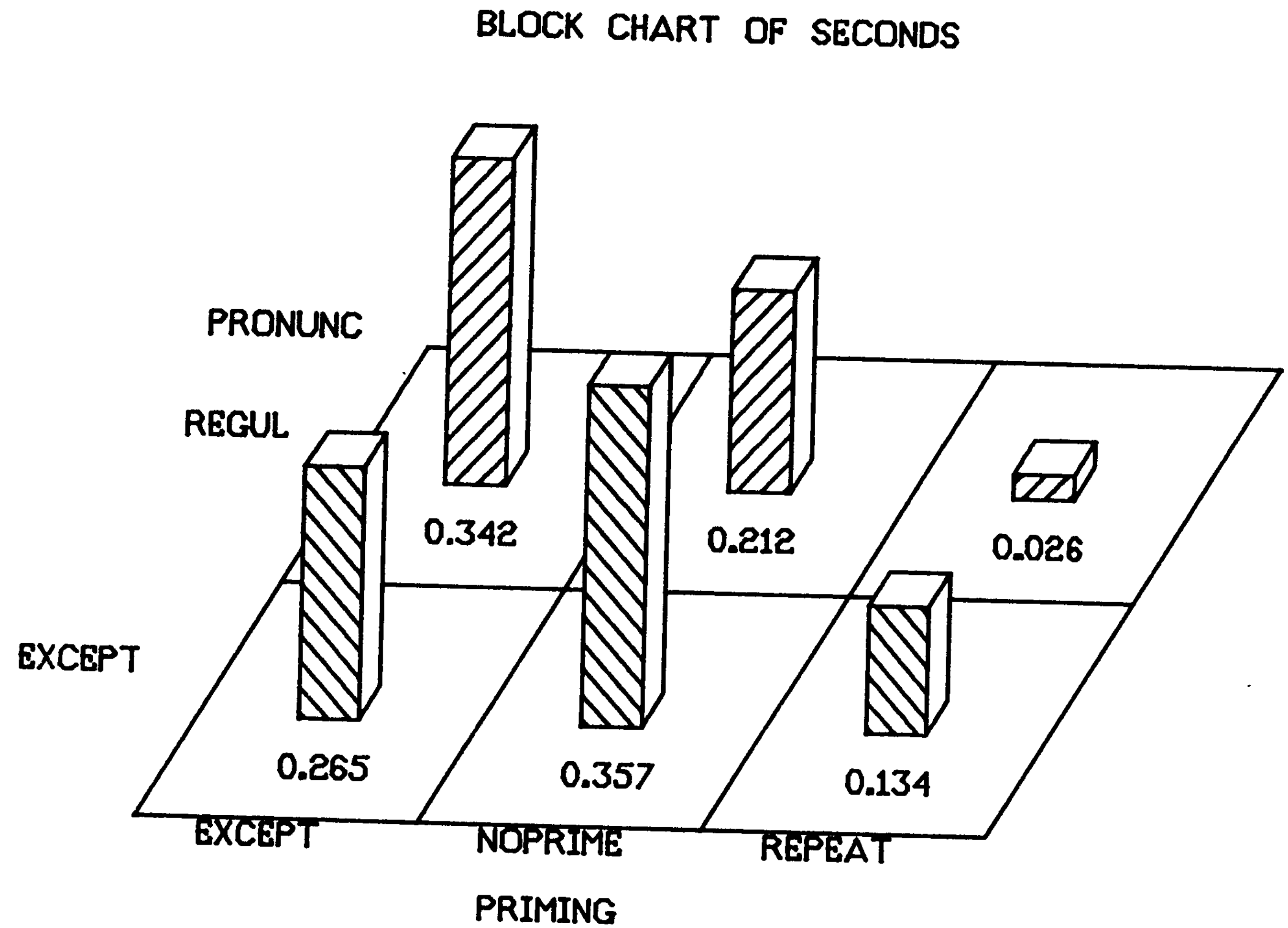

FIGURE 14: MEAN RESPONSE LATENCY FOR PRONUNCIATION BY PRIMING

(0.600 SUBTRACTED FROM EACH SCORE)

Pronunciation interaction were both statistically reliable. The main effect (Figure 15) was due to the reliably longer latencies observed in the no-priming and the exceptional priming conditions over the repetition condition (Pairwise comparisons are presented in Appendix S). The interaction (Appendix T) is attributable to the fact that with regular pronunciations both the no-priming and the exceptional priming condition showed longer latencies than the repetition condition while with exceptional pronunciations only the no-priming condition showed longer latencies than the repetition condition. Hence exceptional pronunciations of exceptionally primed items are not reliably faster than the exceptional pronunciations of unprimed items.

The other analysis compared the regular pronunciations of consistent pseudowords to those of inconsistent pseudowords. Again a two factor least-squares analysis of variance was selected. There were two levels of Items (consistent or inconsistent) and four levels of Priming (no-priming, exceptional priming, regular priming and repetition). A graphical representations of the eight cell means is presented in Figure 16. The summary table for the analysis of variance is presented in Appendix U. Only the Priming main effect was reliable. Pairwise comparisons (Appendix V) indicated that the exceptional priming and the no-priming conditions both led to longer response latencies than the regular priming and the repeated condition.

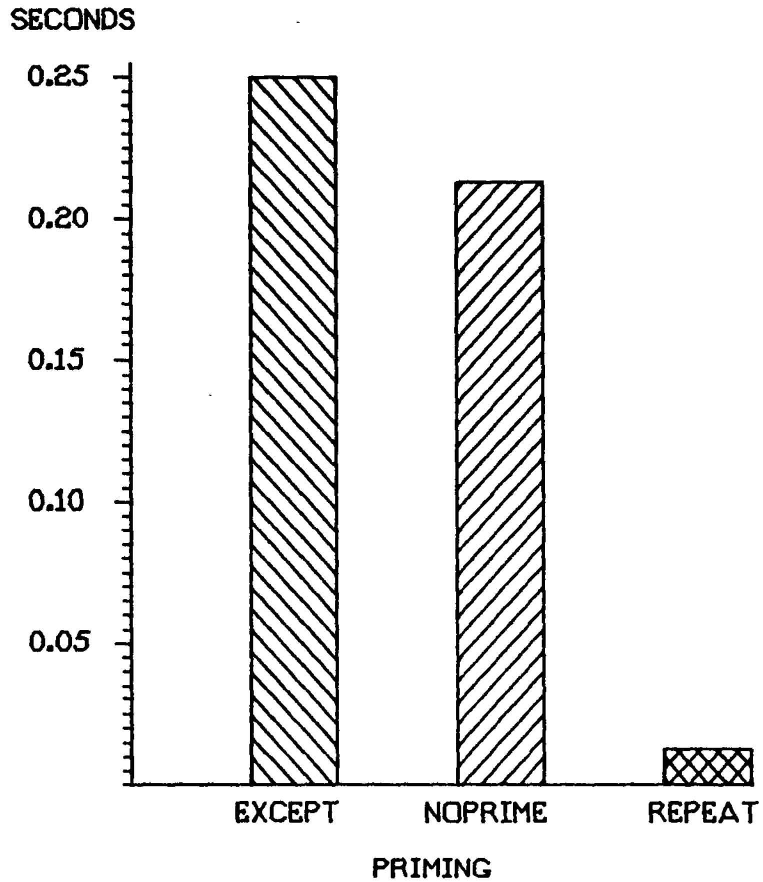

FIGURE 15: MEAN RESPONSE LATENCY FOR DIFFERENT PRIMING CONDITIONS

(0.650 SUBTRACTED FROM EACH SCORE)

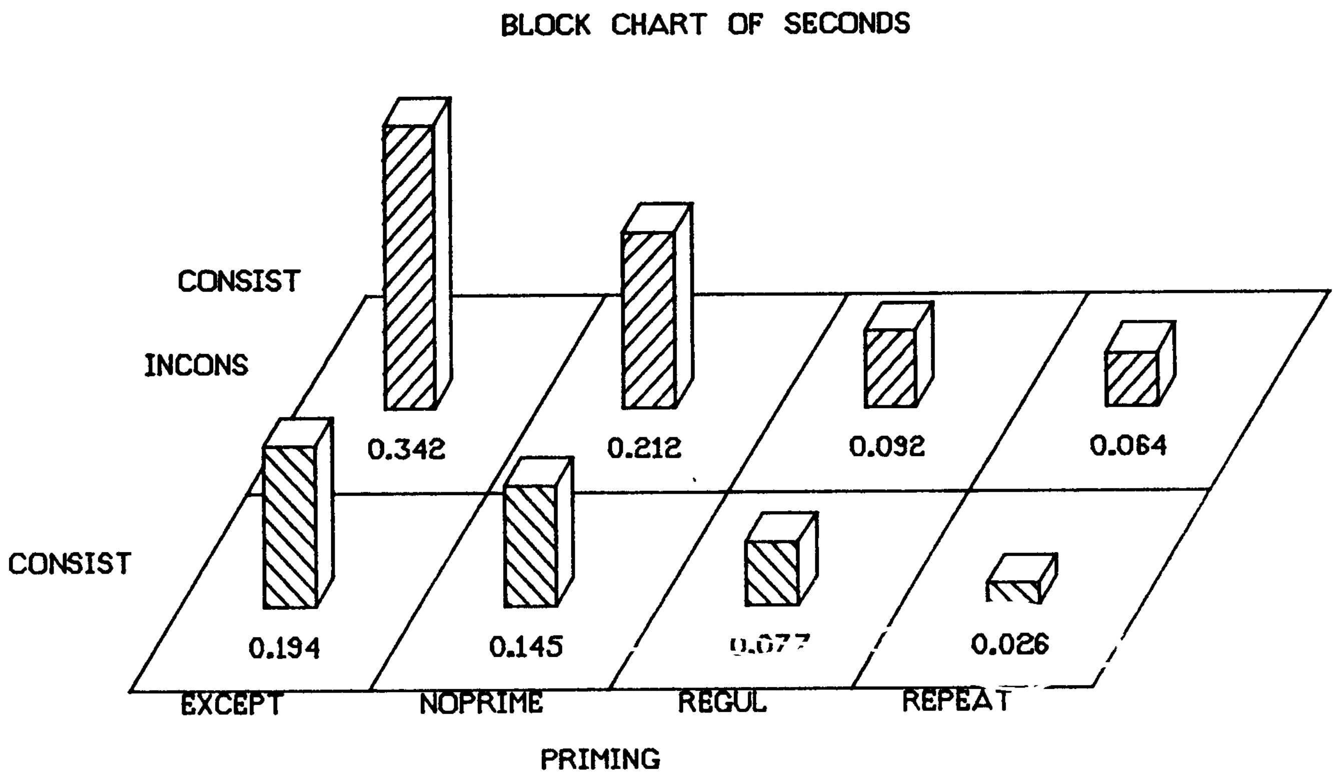

FIGURE 16: MEAN RESPONSE LATENCY FOR CONSISTENCY BY PRIMING

(0.600 SUBTRACTED FROM EACH SCORE)

Finally, a comparison was done between regular and exceptional pronunciations for the cases where the target pseudowords were pronounced in the way suggested by the prime, that is, between the regular pronunciations of regularly primed pseudowords and the exceptional pronunciations of exceptionally primed pseudowords. The 188 millisecond advantage of regular pronunciations over exceptional pronunciations was found to be highly reliable ($t=4.196$ with 39 degrees of freedom, $p < .001$). From this result it is clear that symmetry of priming effects is not observed between exceptional priming and regular priming.

Because a number of studies have found substantial individual differences in word pronunciation tasks, a number of comparisons were conducted to verify whether such differences could be observed in the present study. The slow and fast subjects did not differ in their pattern of results (Table 8). Similarly, slow and fast responders did not differ in the number of exceptional responses they produced (Table 9). These results are consistent with the conclusion that both groups of subjects used the same type of underlying process in the current task.

DISCUSSION. The general conclusion which can be made on the basis of these results is that regular priming has a different status than exceptional priming. Regular priming leads to faster response times relative to the exceptional

Table 8. Comparison of fast and slow responders on their response latencies to unprimed consistent and inconsistent pseudowords. (Milliseconds)

Subject number	Mean latency	Rank	Incon-sistent	Consis-tent	Diff.
Fast subjects					
1	643	7	642	646	- 2
3	668	9	686	650	+ 36
8	558	2	563	552	+ 11
9	642	6	668	616	+ 52
14	617	5	634	599	+ 35
15	599	3	614	584	+ 30
19	691	10	721	660	+ 61
20	605	4	636	575	+ 61
21	664	8	677	647	+ 30
22	536	1	550	523	+ 27
23	707	12	772	641	+132
24	707	11	724	670	+ 54
Mean difference (inconsistent - consistent)					+ 44
Slow subjects					
2	772	16	772	771	+ 1
4	737	14	792	682	+110
5	978	24	1024	927	+205
6	819	19	847	783	+ 64
7	807	17	831	781	+ 50
10	810	18	815	813	+ 2
11	939	23	1042	836	+206
12	740	15	751	731	+ 20
13	845	20	821	868	- 57
16	933	22	952	937	+ 15
17	730	13	763	698	+ 65
18	851	21	899	802	+ 97
Mean difference (inconsistent - consistent)					+ 56

T (on difference scores) = -0.552 ($p > .50$)

Table 9. Comparison of fast and slow responders on their number of exceptional responses to inconsistent pseudowords.

Subject number	Type of priming: Except.	Repeated	Regular	Total
Fast subjects				
1	5	3	1	11
3	2	2	0	7
8	3	2	2	9
9	6	4	1	16
14	7	4	2	16
15	4	2	0	8
19	7	2	2	13
20	6	1	1	9
21	4	4	0	12
22	4	2	0	7
23	7	2	1	14
24	3	3	2	11
Mean	4.8	2.6	1.0	11.1
Slow subjects				
2	4	2	0	7
4	3	2	0	6
5	4	3	1	12
6	5	1	0	7
7	4	3	2	12
10	5	2	1	8
11	7	6	4	22
12	4	3	0	11
13	5	1	0	7
16	4	3	0	9
17	5	3	0	11
18	0	0	0	0
Mean	4.2	2.4	0.7	9.3
T-test	0.962	0.320	0.771	0.993

priming condition. Hence, Glushko's conclusion that there is only need for one mechanism of pronunciation, which applies equally to words and nonwords, and to regular or exceptional items is not supported. If one assumes that there are two components in the priming effect, one visual and the other phonological, the results can even be construed to show that interference is produced when priming is done with an exceptionally pronounced word. The phonological interference would cancel out the visual priming.

PRIMING EXPERIMENT WITH GRADE THREE READERS.

This final experiment was designed to find out whether the results which had been obtained with adult subjects had any relationship to the results that would be obtained with children who are at the early stages of learning to read. Grade three subjects were selected because it was assumed that they already had quite a bit of experience with the regularities and irregularities of English pronunciation. It was also hoped that they had developed sufficient fluency for response latency differences to show up.

MATERIALS AND PROCEDURE. The same three experimental lists were used. The practice list was changed to words found in texts used in grade three. Twenty four grade three students were selected from two Hamilton public schools. Each of the three teachers involved were instructed to designate the better readers in their respective class. It was originally intended to compare good readers with weak readers.

With the first two subjects, it was noticed that they had difficulty with the button pressing required to initiate item presentation. From that point on, the experimenter operated the button so that a comfortable pace could be maintained. An interval of a few seconds was inserted between the subject's response and the subsequent button press.

RESULTS. The mean response latencies across the different conditions were all quite slow relative to the adult response latencies and there was very little variation between them. In addition, the variances were quite large so that no reliable differences in response latencies could be detected (Table 10).

Table 11 presents the number of exceptional pronunciations produced by both the adults and the grade three subjects for the relevant conditions. These do not include responses which are not encountered for that particular letter group in English. A between-group (adults versus grade three) analysis of variance was done on the number of exceptional pronunciations of pseudowords. Three

TABLE 10. Mean response latencies and standard deviations produced by the grade 3 subjects.

(Seconds)

Condition	Average	Standard deviation
Inconsistent pseudowords		
Unprimed	1.09	0.27
Repeated	1.05	0.37
Regular priming	1.16	0.34
Exceptional priming	1.08	0.24
Consistent pseudowords		
Unprimed	1.10	0.30
Repeated	1.05	0.38
Regular priming	1.10	0.31
Inconsistent words		
Regular	1.06	0.45
Exceptional	0.97	0.22
Consistent words		
Regular	1.02	0.27

TABLE 11. Mean number of exceptional pronunciations for both groups.

GROUP	TYPE OF PRIMING		
	Irregular	No-priming	Regular
Adults	4.50	2.50	.88
Grade 3	3.88	2.46	1.75

conditions were compared: the exceptionally primed inconsistent pseudowords, the regularly primed inconsistent pseudowords, and the unprimed pseudowords. The summary table for the analysis of variance is presented in Appendix W. It indicates that there was a significant main effect of Type of Priming. (Pairwise comparisons are presented in Appendix X.) The exceptional priming condition produced the highest number of exceptional pronunciations followed by the unprimed condition and then the regularly primed condition. The Subject X Type of Priming interaction was also significant. This interaction appears to be attributable mostly to the fact that grade 3 subjects produced more exceptional pronunciations in the regular priming condition than the adult subjects while no reliable difference between the two groups was observed in the two other conditions (Appendix Y).

DISCUSSION. Two general conclusions can be drawn from this experiment. First, it appears that pronunciation latency is not an appropriate dependent variable with children in this age group. This could be due to a lack of concentration on the task, a lack of preoccupation with speeded performance, or a strong preoccupation with success at the expense of speed.

In terms of number of irregular pronunciations, the children's performance reflects to a great extent the same phenomenon that was observed with the adults. Although to a lesser degree, the children are sensitive to priming in the phonological domain. Consequently, grade three children appear to be responding on the basis of visual similarity between words. The possible basis of whatever generalization or abstraction mechanism is operative with adult readers could be already present to some extent in grade three readers. Such a result suggests that some of the performance differences which are manifesting themselves with grade three children are quite easy to measure with adults.

However, the fact that the children produced more exceptional pronunciations of regularly primed pseudowords than did the older subjects suggests that they have not yet fully developed the type of processing which is used by more fluent readers. Additionally, the children seem to have more difficulty in limiting the potentially interfering effect of generalization from exceptional knowledge. This in itself was unexpected since it was believed that young children have more experience with the regular words while their encounters with exceptional words would have been somewhat limited.

GENERAL CONCLUSIONS FOR THE PRIMING EXPERIMENTS.

On the basis of the results obtained in these two priming experiments, three general conclusions can be drawn. First, knowledge associated with regular pronunciations apparently enjoys a different status than knowledge associated with exceptional pronunciations. Whether this regularity effect is due to generalized knowledge in the form of implicitly abstracted general rules, or to the existence of two types of item-specific learning, is not presently determinable on the basis of the present data. Secondly, whatever form or structure this knowledge takes, it is highly sensitive to context effects. If a model base on rule-governed pronunciation is to be used, then the notion of context sensitive rules, or rules which show generalization gradients, deserves to be considered seriously. Thirdly, young readers show this sensitivity to context effects, although not to the same extent as adult readers. They do not appear to be able to block exceptional pronunciations to the same extent that adults do. Hence, studying pronunciation mechanisms in adult readers may well provide useful information for designing initial reading programs.

In general, the results indicate that correspondence of similarity relationships across the visual and phonological domains probably play an important role in determining the processes and knowledge structures which a fluent reader has developed.

CHAPTER 6: ARGUMENTS FOR AN ALTERNATIVE MODEL.

It was argued earlier that simple models of word pronunciation based on single processes are insufficient to account for the data which is available concerning word and pseudoword pronunciation. A model which proposes that word pronunciation occurs only through the application of spelling-to-sound correspondence rules will have difficulty with the continued existence of exceptionally pronounced words in English. Similarly, models based only on item specific knowledge will have difficulty with the demonstrated ease with which users of English pronounce pseudowords and novel items.

Because of the inappropriateness of simple models of word pronunciation, some consideration has been given to dual process models. For example, it is possible to complement a rule-of-correspondence model with a secondary process which allows for retrieval of item specific knowledge in the case of exceptional words. Alternatively, it is possible to complement the item specific model with a generalization process based on rules of correspondence for the pronunciation of pseudowords. Both of these models predict that all pseudowords should be pronounced regularly and that there should be no difference in response times between pseudowords containing consistently pronounced letter patterns and those containing inconsistently pronounced letter patterns.

However, Glushko (1979a) has shown in his experiments that longer pronunciation latencies are observed with words and pseudowords which contained inconsistently pronounced letter patterns than with items which contained only consistently pronounced letter patterns. In addition, when he controlled for certain aspects of item similarity, he found no difference in the pronunciation latencies of exceptional and regular words or pseudowords when both types of items contained inconsistently pronounced letter groups. On the basis of those results, he argued that it would be possible to replace the exceptional-regular distinction by the consistent-inconsistent distinction. He then proposed the activation-synthesis model of pronunciation to account for the pattern of results he had obtained.

In a subsequent communication, Glushko (1979b) identified four major characteristics of the model:

1- the activation of phonological information is assumed to be an automatic process which results from the presentation of any written item;

2- the same process is operative for all type of items: regular words, exceptional words and pseudowords;

3- the interference which results from activation of inconsistent information will produce decrements in speed of responding and in accuracy;

4- only specific information, and not abstract information, can become activated.

On the basis of these claims, two main extensions of the activation-synthesis model were proposed here. The first extension was concerned with the possible manipulation of the degree of conflict which could be produced. It was assumed that the full activation of inconsistent information by the repeated presentation of a word list would produce a high level of conflict. It was further assumed that the presentation of lists which contained rhyming item pairs would produce facilitation relative to lists which did not contain analogous pairs, independently of whether the items used were regular or exceptional, and, independently of whether or not they were consistent within the context of the whole language as long as they were consistent within the list.

The second extension was concerned with the generalizability of activated knowledge to novel items in the form of pseudowords. Here, it was predicted that exceptional priming of pseudoword pronunciations would be just as efficient as regular priming. In addition, it was expected that the inconsistency effect would still be observed.

Results in agreement with both extensions of the model would have provided strong support for the activation-synthesis model and the claims it makes relative to the uniqueness of the pronunciation process. Such results would eliminate the need for models based on differences in the processes required for the pronunciation of regular and exceptional words. They would also decrease the necessity for a model based on different processes for the pronunciation of words and the pronunciation of pseudowords.

RESULTS CONSISTENT WITH ACTIVATION-SYNTHESIS

Some of the results from the two sets of experiments are consistent with the activation-synthesis model proposed by Glushko (1979a, 1979b). A number of specific results can be mentioned:

1- the overall inconsistency effect was maintained in the adult priming experiment. Both words and pseudowords containing inconsistent letter groups showed longer pronunciation latencies than words containing consistent letter groups only. Hence, Glushko's results are replicated in a different setting using different equipment and presentation parameters. As such, they provide evidence for the robustness of the inconsistency effect.

2- in the repeated list experiments, it was possible to obtain some evidence for the presence of a conflict resulting from activation of inconsistent pronunciation knowledge. On the early trials of each block, the list containing non-corresponding analogies (PULL/GULL) were pronounced more slowly than lists containing corresponding analogies (PILL/GILL). Although the level of formal similarity within the word pairs was identical, the non-corresponding analogy condition was slower. The fact that the reliability of the effect is only established for the first trial may suggest that this type of conflict is only present when a response has to be generated rather than being retrieved from short term memory. On subsequent presentations of the same list, the responses to all the individual items may remain highly activated so that the task becomes one of selecting the appropriate response from the activated set. Hence, on subsequent trials, the subject would not be submitted to the same type of conflict that is proposed by the activation-synthesis model.

3- the preactivation of word pronunciations can influence which response will be emitted to subsequent items which are similar to it. This was shown by the increase in the number of exceptional responses with exceptional priming and in the number of regular responses with regular priming. Such a result points to a strong generalization mechanism for word pronunciation. The increase in the number of regular pronunciations and the increase in speed of responding observed with regular priming does not a priori permit to determine whether this generalization is attributable to instance-based knowledge or to rule-based knowledge. Rules of pronunciation could be sensitive to context and hence susceptible to priming. However, the increase in the number of exceptional priming with exceptional priming is much more suggestive of generalization on the basis of item specific knowledge.

RESULTS INCONSISTENT WITH ACTIVATION-SYNTHESIS

Other results from the two sets of experiments reported here are inconsistent with the predictions derived from the activation-synthesis model. A number of specific results can be mentioned:

1- lists containing close analogies are slower than lists containing far analogies. This result was obtained with both regular items and exceptional items. It was expected that the activation of the knowledge required to pronounce an item would facilitate the pronunciation of its consistent orthographic neighbor. However, at no time did the close analogy condition lead to reliably faster response times than the far analogy condition, not even on the first trial. It is possible that the presentation format is responsible for this result. Since both items of an analogy pair could be both simultaneously present in the visual field, it is possible that some parallel processing of the items occurred. This could result in some competition or interference between the responses which are becoming activated. The subjects' task would then become one of selecting the appropriate response between competing alternatives.

2- the first priming experiment showed that although it was possible to considerably accelerate the regular pronunciation of inconsistent pseudowords by priming, it was not possible to do as much for its exceptional pronunciation. Whenever the target was pronounced in the way suggested by the prime, initiation of exceptional responses required more time on average than initiation of regular responses. Also, when both regular and exceptional pronunciations of inconsistent pseudowords are considered, there was a large interaction effect between lags and types of priming. For regular priming of inconsistent pseudowords, the closer the prime was to the target, the more facilitation was observed. With exceptional priming, no reliable lag effect was observed.

The difference in response latencies observed between regular and exceptional priming constitutes the most damaging evidence against the current formulation of the activation-synthesis model. This is because the model proposed to do away with the regular-exceptional distinction. The present results clearly provide evidence of performance differences between regular and exceptional words. However, an interpretation of this lack of facilitation with exceptional priming is somewhat complex because of the fact that although exceptional priming does not appear to increase speed of responding, it does appear to partially determine which pronunciation will actually be emitted. This indicates that some generalization of activated exceptional knowledge does occur as is predicted by the model. Although this exceptional knowledge apparently generalizes sufficiently to produce the inconsistency effect and to determine, in part, which pronunciation will be generated, it does not generalize sufficiently to result in an increase in speed of responding as is observed with regular priming.

POTENTIAL EXPLANATIONS OF THE DIFFERENTIAL EFFECTS OF REGULAR AND EXCEPTIONAL PRIMING

A number of potential explanations of the performance differences observed between regular and exceptional words can be discarded. One such partial explanation would be that exceptional words require more time because of the articulatory movements associated with them. This explanation can be rejected on the basis of a lack of difference observed between regular and exceptional inconsistent words. When inconsistent words are compared, there is no difference in their response latencies although one set of words contains the exceptional sounds and the other set does not.

Alternatively, it could be argued that the exceptional words differed from regular words in terms of the frequency with which they appear in the language. In general, high frequency words are processed faster on a number of tasks than low frequency words. If exceptional items were lower in frequency, they would be processed more slowly and the knowledge associated with them might not be as available for generalization to other items as is the knowledge associated with regular words. In the priming experiments reported here, the regular and irregular words were not matched for word frequency since it was desired, instead, to control for word similarity and for initial consonant. However, when the words were analyzed for frequency (Kucera and Francis, 1967), it was found that in general the exceptional words used had an average frequency count which was more than double the average frequency count of regular words. Still, the high frequency exceptional words did not lead to faster response times or to a greater amount of priming. Rather, no reliable priming was observed with the high frequency words while substantial amount of priming was observed with the lower frequency regular words. Hence the difference observed in priming does not appear to be attributable to the greater availability of the response components of the high frequency items.

Thirdly, it is not possible to explain the difference observed between exceptional and regular priming of pseudowords in terms of differences in the latencies associated with the initial consonants. Every individual pseudoword was used in all priming conditions. In addition, the inconsistent pseudowords and the consistent pseudowords were also matched completely in terms of their initial consonants. As a result, the inconsistency effect was observed across pseudowords which shared initial consonants. In addition, with the inconsistent items, differential priming effects were observed not only when the pseudowords shared the initial consonant but also when the same pseudoword was used in the different priming conditions. Hence the argument based on the differential latencies associated with the initial consonants would not hold.

It might be possible to argue that the degree of similarity between the prime and the target differed across the regular priming condition and the exceptional priming condition. However, such an explanation is unlikely since most of the exceptional priming words shared initial consonants with one set of the regular priming words (the exceptional control priming condition) where a substantial amount of priming was observed. However, since complete matching of initial consonants was not possible, this explanation remains viable.

It is also possible to counter the argument that the facilitation which was observed in these experiments is attributable to visual processing only and not to phonological processing. It could be expected that the visual processing of a word like PINK would facilitate the visual processing of a subsequent pseudoword like BINK which shares with it three letters-in-position. However, this argument is very weak since there was a lack of facilitation in the exceptional priming condition and the presence of such facilitation in the exceptional-control priming condition. There was approximately the same degree of formal visual similarity between the prime and the target across both conditions. Similarly, the PULL/GULL list required longer pronunciation time on the first trial than the PILL/GILL list required. Here the degree for formal similarity between the item pairs is identical. If there was a component of visual priming in all the conditions which showed reliable priming, it would then imply that some interference (possibly phonological) was present in the exceptional priming condition since the pronunciation latencies in this condition did not reliably differ from the pronunciation latencies of the unprimed inconsistent pseudowords. This could have been obtained if the visual priming is cancelled out by the phonological interference. Such an interpretation would only provide additional support for the claim that the effect observed here can be attributed to the lack of correspondence between the written and spoken forms of the words and that exceptional words are exceptional because they do not conform to the most common correspondence rules.

Certain explanations of the pattern of results in terms of individual differences between subjects can also be rejected. It was found that the fast responders did not differ from slow responders in terms of the number of exceptional pronunciations they emitted. This result would be inconsistent with an explanation which would propose that subjects relying on one type of mechanism produced the slow exceptional pronunciations of pseudowords while subjects relying on another type of mechanism produced fast response times to primed regular pseudowords.

Finally, with the repeated lists experiments, it was not possible to reject an explanation based mostly on item similarity. As was discussed earlier, most of the results obtained in the repeated list experiment could be attributable to visual similarity within lists. The two lists which contained P and B as initial consonants were slower than the two equivalent lists which contained G and H as initial consonants. Because of the increased similarity and because the task may be simply one of selecting between highly activated items, it could take longer to distinguish BILL from PILL (or BULL from PULL) than to distinguish GILL from HILL (or GULL from HULL). However, the priming experiments almost completely controlled for visual similarity between regular and exceptional words. In this case, it is unlikely that the results can be fully attributed to visual similarity since approximately equivalent levels of similarity produce differential results dependent on whether regular or exceptional words are used as primes.

MODIFICATION OF THE ACTIVATION-SYNTHESIS MODEL

Since it appears that the exception effect is additive to the inconsistency effect, either the activation-synthesis model should be rejected or some aspects of the model need to be modified to account for the results reported here. One modification would be to assign precedence to the regular information in the resolution of the conflict produced by the inconsistency of the activated information. This could be done by assuming that a regular pronunciation is first attempted before the irregular pronunciation is attempted. To explain the lack of lag effect obtained with exceptional priming, it would be sufficient to propose that the activation of exceptional information inhibits somewhat the activation of competing regular information which still has to be used first in the attempt to resolve the conflict. Exceptional priming would result in increased response latencies because it slows down the whole fixed sequence for conflict resolution. Regular priming at short lags would result in decreased pronunciation latencies because it makes more immediately available the information required in the early phase of conflict resolution.

There remains one problem with this explanation in that exceptional priming leads to an increase in the number of exceptional responses which are produced. According to the modified model, there would be no reason to expect such a difference since in both cases the regular solution should be attempted first. Hence, even with exceptional priming, all or at least most of the exceptionally primed pseudowords should be pronounced regularly. This was not the case in these experiments.

Alternatively, it is possible that resolution of the conflict is highly dependent on both the identity and the number of orthographic neighbours which become activated. The definition of exceptionality which was used by Glushko and which was adopted for the current experiments assures that inconsistent items will have a greater number of regular neighbours than exceptional neighbors. Hence regular priming would generally provide more information in support of the majority of the neighbours which will become activated while exceptional priming would provide information in support of the minority pronunciation. In the first case it could speed up the resolution of the conflict by increasing the amount of activated information which is in agreement with the regular pronunciation (the majority position). In the second case, it would tend to equalize the activation of both pronunciations and to possibly increase the conflict. Hence no increase in speed of responding would be observed in the case of exceptional priming while there would be a possible increase in the number of exceptional pronunciations. In addition, a reversed lag effect would not be unexpected within this formulation since the closer the prime is to the target the more strongly the exceptional information can contribute to the conflict. There is one potential problem for this explanation. The exceptional primes used in the current experiments were words of higher frequency of occurrence than were the regular primes. The exceptional primes should then be highly available items so that the knowledge associated with them should be easily activated when orthographic neighbours are presented. If such were the case, exceptional priming should not greatly increase the conflict since the knowledge associated with the prime already has a high likelihood of being activated independently of whether the prime is presented or not. Still, this explanation cannot be completely rejected without a better specification of orthographic neighborhoods and their effects.

AN ALTERNATIVE MODEL

However, before adopting such modification of the activation-synthesis model, I would prefer to argue for a different model of word pronunciation. Some support for this new model can be based on the fact that exceptional words differ from regular words in one important way. The difference is that, in general, exceptional words tend to negate the trend observed concerning word frequency data. High frequency words are generally processed faster and with more ease than low frequency words. In the case of priming, however, the high frequency words do no lead to response facilitation while the lower frequency words lead to such facilitation. In addition, within the inconsistent words, the high frequency words are pronounced with the same speed as the lower frequency regular words.

The fact that many exceptional words are high frequency words (Hunnicutt, 1976) may partially explain their persistence in a language where substantial generalization of phonological knowledge can be observed. Since they are used very often they could have associated with them an extremely high degree of item specific learning or highly available information so that the generalized process would not be required or would not have time influence response production. In conjunction with this item specific information or high availability, resistance to generalization to other items and/or resistance to the generalized process used for regular words may be built into the knowledge used to pronounce them. Otherwise, the generalized process should exert pressure for regularization, especially if it is viewed as an automatic and an implicit process as suggested by Glushko (1979b). Other models, such as the interactive activation model (Rumelhart and McClelland, 1981), which are based on the automatic activation of orthographic neighbors and response selection on the basis of the majority position, also predict the quite rapid elimination of exceptions from the language unless they allow the exceptional words to be isolated from the generalized process. Exceptional words appear to be protected from this pressure towards regularization, at least within short spans of the evolution of the language.

Another possibly important source of information comes from the apparent unawareness of exceptions demonstrated by the subjects when they were debriefed after the experiment. A number of subjects expressed surprise at the presence of exceptionally pronounced words in the lists they had just seen. For some of them it was as if they had just realized that HULL and BULL did not rhyme. Although these observations were not quantified systematically, they indicate that at least some subjects can process exceptional words without being aware that they are processing a special case. This lack of awareness of exceptions does not fit in very well with the notion of conflict which is demonstrated in a Stroop task. Hence, some of the introspective reports seem to be more related to the notion of independence of the knowledge bases than to the notion of a conflict arising from the activation of different sources of information.

The model which will be proposed is one which assumes that the inconsistency is encoded within the representation of certain letter patterns. Inconsistently pronounced letter groups or patterns would be identified as such by a special inconsistency detection mechanism. Once the inconsistency cue is recognized, the system could proceed with a modified pronunciation generation or retrieval process which would allow access to two types of knowledge. One type of knowledge would correspond to the standard information which is used to pronounce regular and consistent items. The other type of knowledge would be specific to exceptions. It would only become activated if a specific cue indicated that it might be useful for the pronunciation of the present item.

With the presentation of a consistent word, the activation of its internal representation could occur as is proposed in the interactive activation model (McClelland and Rumelhart, 1981; Rumelhart and McClelland, 1981). Their detailed model proposes that the presentation of a letter string results in the activation of letter nodes which then feed in to the nodes of words which contain those letters. Through a system of feedback between the nodes from different levels, the node of one particular word becomes more highly active. Under normal conditions, the node of the presented word would be the most highly activated one and the phonological knowledge associated with it would become available.

With the presentation of an inconsistent word, there would first be tripping of the inconsistency detector which would allow activation to occur for the two or more types of knowledge (one regular and one or more exceptional). Here also, under normal conditions, the presented word would generally become the most highly activated node. However, the tripping of the inconsistency detector and/or the parallel processing within the different knowledge bases would entail a reduction in speed of responding. This would correspond to the inconsistency effect with words first demonstrated by Glushko (1979a).

With the presentation of consistent pseudowords, the generation or synthesis of a response from the activated information would have to be added to the sequence. Since, in this case, no word node would usually become fully active, some transformation of the most highly activated information would occur to produce a pronunciation for the pseudoword. This additional processing would entail the longer pronunciation times observed with pseudowords relative to words.

Similarly, the presentation of inconsistent pseudowords would result in an increase in response times due to both the inconsistency detection and to response synthesis. The determination of which response would be emitted would depend on whether a regular or an exceptional word node achieved the highest level of activation. Again, the synthesis of a response would be mostly based on the phonological knowledge associated with the most highly activated node. If the most highly activated node was a regular word, then from this point on the process would be similar to that of consistent pseudowords. If the most highly activated node was an exceptionally pronounced word, then there would be a further delay in response production since the exceptional knowledge would be somewhat resistant to generalization to other items.

With the priming paradigm used here, the preceding presentation of a word would serve to determine which word node would be the most highly activated one when the pseudoword is presented. Hence, regular priming would increase the speed of responding to the pseudoword because it would speed up the process of activating a word node in the regular knowledge base. The closer the regular prime would be to the target, the higher would be its activation when the target is presented. It would rapidly reach a level where it would determine the pronunciation of the pseudoword. Consequently a lag effect would be observed.

In the case of exceptional priming, the presentation of the exceptional word would also lead to a high activation level of its node when the subsequent pseudoword is presented. However, the synthesis of a response from the exceptional information would be a slow process and it would tend to mask the facilitation of prior presentation of the prime. Consequently, exceptional priming could partly determine which pronunciation will be emitted for the pseudoword without producing a decrease in response time.

There is one potential problem with this interpretation in that exceptional pronunciations of exceptionally primed pseudowords do not require more time than regular pronunciations of exceptionally primed pseudowords. However, this could be due to the fact that although the regular word node becomes dominant in the second case, it still has to overcome the activation resulting from the exceptional prime. Hence, the advantage which should result through synthesis of regular knowledge would be cancelled by the competition from the activated exceptional knowledge.

Another potential problem for the model results from the fact that no lag effect is observed with exceptional priming. This could possibly be related to the resistance to generalization which is associated with exceptional words. However, it remains as one of the issues which the model will have to address.

The new formulation which is being proposed has some similarity with one of the the dual process models in that it proposes the existence of two types of knowledge for word pronunciation, one for the pronunciation of regular words and another for the pronunciation of exceptional words. It differs from it in that it proposes a mechanism for the detection of inconsistency cues instead of proposing a mechanism for the identification of exceptional words. In the new model, both regular and exceptional words can activate the secondary process if the inconsistency cue is present. In the previous dual process model, only exceptional words could activate the secondary process.

It also has some similarity with the Baron (1979) proposal of transformation on an analogy for the pronunciation of pseudowords. A major difference lies in the proposal of two types of knowledge and the easier generalization from one source than from the other.

The new model differs from Glushko's formulation principally in that it maintains the existence of two types of phonological knowledge. Also, it proposes that the inconsistency effect does not result from a conflict within the activated information but rather from the activation of the inconsistency detection mechanism and the switching in of some form of parallel processing.

The proposal of such an inconsistency mechanism raises immediately the question of what are the cues which indicate that a word contains inconsistently pronounced letters. An examination of the lists of words generated for the present experiments and for Glushko's experiments reveals that P and B may be important components of inconsistency cues. These letters appear to be over-represented as initial consonants in the set of exceptional words that were generated for all these experiments. It is also possible to generate a high number of exceptionally pronounced words which start with the letter W (WAS, WAND, WANT, WHERE, WERE, WHO, and WARD). If these letters constitute the inconsistency cue, then words containing them, such as PEACH and WALL, may be responded to more slowly than words from which they are absent, such as REACH and HALL. However, because of the lack of difference found between the two types of consistent words used in the priming experiments, such results appear unlikely since one of the two sets of consistent words generally used the same initial consonant as the exceptional words but resulted in faster response latencies. Further, such an identification of individual letters as indicators of inconsistency may be difficult to substantiate since it would ultimately lead to an inevitable confounding of the slowness of processing the inconsistency detector with the slowness of a specific articulatory component. It would not be possible to differentiate whether a particular symbol is slow in activating the voice key because it contains a particular articulatory component or because it is an inconsistency cue. In other words, a particular symbol cannot be at the same time a consistency cue and an inconsistency cue. Hence, measures of response latencies could not be obtained independently of whether the symbol is used as a consistency cue and as an inconsistency cue.

The search for inconsistency cues should probably focus instead on multiletter patterns. Independent frequency tabulations of the letter patterns found in regular and in exceptional words might permit to identify certain combinations of letters which could be good candidates for inconsistency cues. Hence the letter P in presence of certain other letters may constitute an indication of inconsistency. In the absence of these other letters, it would not activate the inconsistency detectors.

POTENTIAL EXTENSIONS

Possibly the best way to validate the inconsistency encoding model would be to identify certain letter patterns which can function as inconsistency cues. Depending on what type of letter patterns which could be identified, it might be possible to test whether the presence of these patterns always leads to slower pronunciation latencies, even in the case of words classified as consistent according to the criterion used in Glushko's experiments and in the present experiments.

It is assumed that the inconsistency encoding process would have developed because of the high degree of surface inconsistency which is found in the letter-to-sound correspondences of the English language. Since French and English differ in the degree of surface inconsistency they show in their respective letter-to-sound correspondences, the users of each language may have developed differential processing mechanisms and structures associated with phonological knowledge. A striking result would be to find that users of French do not show substantial amounts of priming since they can rely much more extensively on rules of correspondences. This could indicate that the priming observed in English may be the result of reliance on more global information in order to detect inconsistent letter groups.

The identification of differences in the mechanisms for pronunciation between the two language might permit to predict the type of errors and difficulties that the user of one language will encounter when learning the second language. This could lead to training programs which might prevent some errors of pronunciation and reduce the "having an accent" phenomenon.

By adopting the inconsistency encoding framework, it also becomes possible to cast new light on the question of the type of manipulations which could lead to adult type of performance earlier than is currently being done. For example, it might be better to explicitly teach the inconsistencies in the rules of correspondence from the written to the spoken language. Hence, a child would be taught the basic rule and the exceptions: the letters ULL are pronounced as in HULL except in the words PULL and BULL. Such a strategy would focus the attention of the learner on the inconsistency itself. In view of the number of exceptional pronunciations produced by the grade three children in the regular priming condition, there appears to be some need for them to learn to isolate exceptional words from interfering with the pronunciation of novel items.

Another strategy which has been advocated extensively by the proponents of spelling reforms has been to teach only the regular words at first so that the learner can become aware of the regularity of the language. The exceptional words would only be introduced in a second phase. Such a strategy might put too much emphasis on the development of a generalized process for word pronunciation and not enough on the subsequent development of the inconsistency detection mechanism to handle the exceptional words.

Another important reason to teach the exceptional words very early would be to allow the development of wholistic processing in the early phase of reading since such processing would be an important component required for the generalization process. This would be especially relevant if the generalization process is assumed to operate on the basis of item specific knowledge. With the new framework, the emphasis is on the sequencing of two different types of learning rather than on the determination of which type of learning is more appropriate.

The type of processing which is suggested here, may be occurring in many domains where there are a number of rules of thumb to guide behavior but which also include a number of special cases. These cases are special because they do not agree with the rules of thumb and cannot be handled by them. It is my impression that often when we consult an expert it is because the domain includes a number of such special cases which are not at all obvious to somebody new to the field where rules of thumbs are available. Hence, through extensive experience, the expert may have developed an inconsistency encoding process which allows him to rapidly identify the special case. In other words, the rule would be maintained in the knowledge base without eliminating the special case. In addition, the special case would not intrude unduly in the application of the rules in their everyday use. This seeming independence between the two types of knowledge needs to be considered in models of expertise. The studies of categorization and rule-governed behavior have not paid sufficient attention to the processing of special cases.

The results obtained in the present set of experiments also reveal some of the constraints which are present in the phonological domain. Since a number of current theories call upon recoding processes or assume certain phonological properties of words, the results obtained here have some implication for the type of processes which can be assumed to occur in lexical decision tasks, and other such tasks. For example, it may be more difficult to make a lexical decision with words which contain inconsistent letter groups since two types of knowledge or two pronunciation mechanisms are activated and, consequently, it would take longer for the accrual of sufficient information to arrive at a decision.

Similarly, models such as the interactive activation model of word recognition will have to address the question of differential generalization effects observed between regular and exceptional words. Rumelhart and McClelland (1981) have suggested that the activation of phonological knowledge could be integrated in the model. They referred to Glushko's results with the pronunciation of pseudoword and his subsequent model as being consistent with the spirit of the interactive activation model. The new results from the current priming experiments impose severe limits on the type of automaticity which can be assumed in such models.

The results also point out the differential roles that similarity of items can play in different tasks. In the repeated list experiments, evidence was obtained which strongly suggests that item similarity is detrimental when the task requires the subject to select a response from a set of highly activated alternatives. In the priming experiments, it was observed that item similarity can facilitate response production. Hence, similarity of items can lead to both response facilitation and response interference depending on their mode of presentation.

The experiments reported here required the subjects to pronounce isolated words presented individually or in lists. Consequently, the type of processing which is suggested by the results may not be a major component of the silent reading of connected discourse. The nature of the experimental task may have been such that it encouraged a type of processing or responding which would not be habitually observed with more meaningful material. Such processing could be specific to the experimental condition.

It is quite probable that the reading of connected discourse is less dependent on item specific knowledge since top-down processes can facilitate word identification. However, this limitation applies equally to models of pronunciation based on rules of pronunciation and models based on generalization from item-specific knowledge.

On the other hand, the more artificial experimental situation may be particularly useful in that it can provide clues as to what mechanisms and structures are available to the readers when top-down processing is faulty. In the current experiments, generalization of highly item-specific knowledge was observed in the case of expceptional priming of pseudowords. If such generalization is possible with items which constitute special cases, it is quite possible that the same type of generalization also occurs with regular items. It is with those items that the process would be most useful since, on average, most novel words that the reader will encounter should be regular and not special cases.

In summary, the following model is proposed for word pronunciation. After a user of the English language has had extensive practice with the language, he somehow has learned to respond differentially to consistent and inconsistent letter groups. Certain letter patterns would act as inconsistency cues and their presence in a word would be sufficient to activate inconsistency detectors. These, in turn, would then switch in a different type of processing. This new processing would allow a second type of knowledge, which would be resistant to generalization, to become activated and to possibly play a role in determining the pronunciation of the pseudoword. The regular knowledge, on the other hand, would be easily generalizable to other items.

This model can account for most of the findings concerning word pronunciation. It predicts the inconsistency effect even with regular priming since the activation of the inconsistency detectors and the switching in of the secondary process should require some time and possibly some processing resources. In the case of consistent words, the system would allow as many sources of information as possible to become activated since each of them should result in information which would be useful for response production. In addition, exceptional pronunciations of pseudowords would be slower because of some inhibition of generalization would be associated with exceptional responses and would have to be overcome before an exceptional response can be produced to the target pseudoword. This exceptional knowledge would not be easily generalizable. On the other hand, the information required for regular inconsistent words would be easily generalizable once it became activated. This would account for the increase in speed of responding with the regular priming of consistent and inconsistent pseudowords and the lack of such facilitation with exceptional priming of inconsistent pseudowords.

Whether the new model can be validated or not, one important result will have to be considered by alternative or replacement models. These models will have to explain why exceptional priming can partly determine which pronunciation will be produced for a subsequent pseudoword but does not lead to an increase in speed of responding. The explanation which is proposed here is that exceptional knowledge (or knowledge associated with special cases) is generally isolated from the more regular knowledge. For this exceptional knowledge to become active, some special processing has to be switched in. This allows for the persistence of special cases in domains where extensive generalization is observed.

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APPENDICES

APPENDIX A: Summary table for the preliminary analysis of variance on lists A, B, D, and E from the first repeated list experiment.

Source	Sum of Squares	DF	Mean Square	F	Prob.
Subjects	20411.72	7	2915.96	15.61	<.01
Consonants	4584.03	1	4584.03	24.53	<.01
Analogy	1638.78	1	1638.78	8.77	<.01
C*A	101.53	1	101.53	.54	>.25
Residual	3923.91	21	186.85		
Total	30659.97	31			

APPENDIX B. Summary table for the analysis of variance on the response times obtained on the P/B lists from both repeated-list experiments.

Source	Sum of Squares	Df	Mean Square	F	Prob.
Consistency	50577.21	1	50577.21	0.80	.388
Subjects	890145.11	14	63581.79		
Analogy	84966.00	1	84966.00	16.00	.001
C*A	2588.57	1	2588.57	0.49	.497
A*Subjects	74362.14	14	5311.58		
Blocks	182864.44	3	60954.81	22.32	.000
B*C	9902.63	3	3300.88	1.21	.318
B*Subjects	114699.51	42	2730.94		
A*B	835.86	3	278.61	0.21	.892
A*B*C	1900.18	3	633.39	0.47	.707
A*B*Subjects	56905.09	42	1354.88		
Trials	57518.26	11	5228.93	3.93	.000
T*C	7882.24	11	716.57	0.54	.875
T*Subjects	204862.17	154	1330.27		
A*T	63025.39	11	5729.58	3.91	.000
A*T*C	11449.33	11	1040.85	0.71	.727
A*T*Subjects	225524.83	154	1464.45		
B*T	30464.48	33	923.16	1.16	.258
B*T*C	26930.61	33	816.08	1.02	.438
B*T*Subjects	369140.58	462	799.01		
A*B*T	40398.31	33	1224.19	1.48	.044
A*B*T*C	32286.99	33	978.39	1.18	.225
A*B*T*Subjects	381471.32	462	825.70		

APPENDIX C. Summary table for the analysis of variance on the response times obtained from both repeated-list experiments.

Source	Sum of Squares	Df	Mean Square	F	Prob.
Consistency	46458.21	1	46458.21	0.69	.422
Subjects	949440.45	14	67817.18		
Analogy	74938.31	2	37469.16	11.38	.000
C*A	10107.78	2	5053.89	1.53	.133
A*Subjects	92211.70	28	3293.28		
Blocks	295119.43	3	98373.14	41.11	.000
B*C	10241.30	3	3413.77	1.43	.249
B*Subjects	100502.53	42	2392.96		
A*B	6988.80	6	1164.80	1.00	.430
A*C*C	7737.91	6	1289.65	1.11	.364
A*B*Subjects	97711.27	84	1163.22		
Trials	120328.88	11	10938.99	8.46	.000
T*C	17195.57	11	1563.23	1.21	.286
T*Subjects	199218.24	154	1293.63		
A*T	30696.54	22	1395.30	1.99	.006
A*T*C	39780.47	22	1808.20	2.58	.000
A*T*Subjects	216082.03	308	701.57		
B*T	31663.22	33	959.49	1.64	.016
B*T*C	22820.84	33	691.54	1.18	.229
B*T*Subjects	270353.18	462	585.18		
A*B*T	45439.51	66	688.48	1.16	.191
A*B*T*C	29914.67	66	453.25	0.76	.920
A*B*T*Subjects	550086.33	924	595.33		

APPENDIX D. Pairwise comparisons between the analogy conditions.

Calculations for comparisons among analogy conditions.

Mean square for the error term	3293.28
Number of observations for each mean	768
Critical value for Tukey's HSD test:	
at p .05, HSD =	6.855
at p .01, HSD =	8.533

Differences among means

	Mean	A1	A2	A3
A1 = Far analogy	213 :	-	7 *	16 **
A2 = Close analogy	220 :		-	9 **
A3 = Non-corresponding analogy	229 :			-

* $p < .05$
** $p < .01$

APPENDIX E. Pairwise comparisons between the block conditions.

Calculations for comparisons among blocks.

Mean square for the error term	2392.28
Number of observations for each mean	576
Critical value for Tukey's HSD test:	
at p .05, HSD =	7.398
at p .01, HSD =	8.967

Differences among means

	Mean	B4	B3	B2	B1
B4 = Block 4	212 :	-	0	5	26 **
B3 = Block 3	212 :		-	5	26 **
B2 = Block 2	217 :			-	21 **
B1 = Block 1	238 :				-

** $p < .01$

APPENDIX F. Pairwise comparisons for the trials main effect.

Calculations for the comparisons among btrials.

Mean square for the error term = 1293.63
Number of observations for each mean = 192
Critical value for Tukey's HSD test:
at p .05, HSD = 11.994
at p .01, HSD = 13.733

Differences among trial means.

Mean	T9	T6	T4	T8	T10	T12	T2	T5	T7	T3	T11	T1
T9 = 214 :	-	1	2	2	2	3	6	7	7	8	8	28**
T6 = 215 :		-	1	1	1	2	5	6	6	7	7	27**
T4 = 216 :			-	0	0	1	4	5	5	6	6	26**
T8 = 216 :				-	0	1	4	5	5	6	6	26**
T10= 216 :					-	1	4	5	5	6	6	26**
T12= 217 :						-	3	4	4	5	5	25**
T2 = 220 :							-	1	1	2	2	22**
T5 = 221 :								-	0	1	1	21**
T7 = 221 :									-	1	1	21**
T3 = 222 :										-	0	20**
T11= 222 :											-	20**
T1 = 241 :												-

** $p < .01$

APPENDIX G. Pairwise comparisons for the Analogy by Trials interaction.

Calculations for the comparisons among trials.

Mean square for the error term = 898.92
Number of observations for each mean = 64
Critical value for Tukeys HSD test:
at p = .05, HSD = 17.33 *
at p = .01, HSD = 19.84 **

Differences among trials means on far analogy condition.

Mean	T8	T2	T5	T6	T10	T4	T9	T12	T3	T7	T11	T1
T8 = 206 :	-	1	2	3	3	6	6	6	9	10	10	28**
T2 = 207 :		-	1	2	2	5	5	5	8	9	9	27**
T5 = 208 :			-	1	1	4	4	4	7	8	8	26**
T6 = 209 :				-	0	3	3	3	6	7	7	25**
T10= 209 :					-	3	3	3	6	7	7	25**
T4 = 212 :						-	0	0	3	4	4	22**
T9 = 212 :							-	0	3	4	4	22**
T12= 212 :								-	3	4	4	22**
T3 = 215 :									-	1	1	19*
T7 = 216 :										-	0	18*
T11= 216 :											-	18*
T1 = 234 :												-

Differences among trial means on the close analogy condition.

Mean	T9	T4	T6	T7	T8	T10	T2	T3	T12	T11	T5	T1
T9 = 206 :	-	4	7	9	13	13	16	16	16	19*	21**	34**
T4 = 210 :		-	3	5	9	9	12	12	12	15	17	30**
T6 = 213 :			-	2	6	6	9	9	9	12	14	27**
T7 = 215 :				-	4	4	7	7	7	10	12	25**
T8 = 219 :					-	0	3	3	3	6	8	21**
T10= 219 :						-	3	3	3	6	8	21**
T2 = 222 :							-	0	0	3	5	18*
T3 = 222 :								-	0	3	5	18*
T12= 222 :									-	3	5	18*
T11= 225 :										-	2	15
T5 = 227 :											-	13
T1 = 240 :												-

Differences among trial means on non-corresponding analogy condition.

Mean		T12	T10	T6	T8	T9	T11	T4	T5	T3	T2	T7	T1
T12= 218	:	-	2	4	5	6	7	8	9	10	12	15	33**
T10= 220	:		-	2	3	4	5	6	7	8	10	13	31**
T6 = 222	:			-	1	2	3	4	5	6	8	11	29**
T8 = 223	:				-	1	2	3	4	5	7	10	29**
T9 = 224	:					-	1	2	3	4	6	9	28**
T11= 225	:						-	1	2	3	5	8	27**
T4 = 226	:							-	1	2	4	7	26**
T5 = 227	:								-	1	3	6	25**
T3 = 228	:									-	2	5	24**
T2 = 230	:										-	3	22**
T7 = 233	:											-	19*
T1 = 253	:												-

Calculations for the comparisons among the analogy conditions.

Mean square for the error term = 842.52
Number of observations for each mean = 64
Critical value for Tukey's HSD test:
at p = .05, HSD = 12.02 *
at p = .01, HSD = 14.96 **

Differences among analogy conditions at trial 1.

	Mean		A1	A2	A3
Far	= 234	:	-	6	19 **
Close	= 240	:		-	13 *
Non-corresponding	= 253	:			-

Differences among analogy conditions at trial 2.

	Mean	A1	A2	A3
Far	= 207 :	-	15 **	23**
Close	= 222 :		-	8
Non-corresponding	= 230 :			-

Differences among analogy conditions at trial 3.

	Mean	A1	A2	A3
Far	= 215 :	-	7	13 *
Close	= 222 :		-	6
Non-corresponding	= 228 :			-

Differences among analogy conditions at Trial 4.

	Mean	A2	A1	A3
Close	= 210 :	-	2	16 **
Far	= 212 :		-	14 *
Non-corresponding	= 226 :			-

Differences among analogy conditions at trial 5.

	Mean	A1	A2	A3
Far	= 208 :	-	19 **	19 **
Close	= 227 :		-	0
Non-corresponding	= 227 :			-

Differences among analogy conditions at trial 6.

	Mean		A1	A2	A3
Far	= 209	:	-	4	13 *
Close	= 213	:		-	9
Non-corresponding	= 222	:			-

Differences among analogy conditions at trial 7.

	Mean		A2	A1	A3
Close	= 215	:	-	1	18 **
Far	= 216	:		-	17 **
Non-corresponding	= 233	:			-

Differences among analogy conditions at trial 8.

	Mean		A1	A2	A3
Far	= 206	:	-	13 *	17 **
Close	= 219	:		-	4
Non-corresponding	= 223	:			-

Differences among analogy conditions at trial 9.

	Mean		A2	A1	A3
Close	= 206	:	-	6	18 **
Far	= 212	:		-	12
Non-corresponding	= 224	:			-

Differences among analogy conditions at trial 10.

	Mean	A1	A2	A3
Far	= 209 :	-	10	11
Close	= 219 :		-	1
Non-corresponding	= 220 :			-

Differences among analogy conditions at trial 11.

	Mean	A1	A2	A3
Far	= 216 :	-	9	9
Close	= 225 :		-	0
Non-corresponding	= 225 :			-

Differences among analogy conditions at trial 12.

	Mean	A1	A3	A2
Far	= 212 :	-	6	10
Non-corresponding	= 218 :		-	4
Close	= 222 :			-

APPENDIX H. Pairwise comparisons for the Blocks by Trials interaction.

Calculations for the comparisons among trials.

Mean square for the error term = 762.30
Number of observations for each mean = 48
Critical value for Tukeys HSD test:
at p = .05, HSD = 18.43 *
at p = .01, HSD = 21.11 **

Differences among trials means at block 1.

Mean	T6	T10	T9	T4	T12	T8	T7	T3	T2	T11	T5	T1
T6 = 228 :	-	1	4	5	5	8	9	11	12	13	18	40**
T10= 229 :		-	3	4	4	7	8	10	11	12	17	39**
T9 = 232 :			-	1	1	4	5	7	8	9	14	36**
T4 = 233 :				-	0	3	4	6	7	8	13	35**
T12= 233 :					-	3	4	6	7	8	13	35**
T8 = 236 :						-	1	3	4	5	10	32**
T7 = 237 :							-	2	3	4	9	31**
T3 = 239 :								-	1	2	7	29**
T2 = 240 :									-	1	6	28**
T11= 241 :										-	5	27**
T5 = 246 :											-	22**
T1 = 268 :												-

Differences among trial means at block 2.

Mean	T4	T10	T5	T7	T9	T6	T2	T8	T3	T12	T11	T1
T4 = 209 :	-	2	4	5	5	6	7	7	8	10	14	30**
T10= 211 :		-	2	3	3	4	5	5	6	8	12	28**
T5 = 213 :			-	1	1	2	3	3	4	6	10	26**
T7 = 214 :				-	0	1	2	2	3	5	9	25**
T9 = 214 :					-	1	2	2	3	5	9	25**
T6 = 215 :						-	1	1	2	4	8	24**
T2 = 216 :							-	0	1	3	7	23**
T8 = 216 :								-	1	3	7	23**
T3 = 217 :									-	2	6	22**
T12= 219 :										-	4	20*
T11= 223 :											-	16
T1 = 239 :												-

Differences among trial means at block 3.

Mean	T9	T6	T8	T5	T2	T12	T10	T11	T4	T3	T7	T1
T9 = 200:	-	6	6	9	10	10	12	12	13	16	21*	32**
T6 = 206 :		-	0	3	4	4	6	6	7	10	15	26**
T8 = 206 :			-	3	4	4	6	6	7	10	15	26**
T5 = 209 :				-	1	1	3	3	4	7	12	23**
T2 = 210 :					-	0	2	2	3	6	11	22**
T12= 210 :						-	2	2	3	6	11	22**
T10= 212 :							-	0	1	4	9	20*
T11= 212 :								-	1	4	9	20*
T4 = 213 :									-	3	8	19*
T3 = 216 :										-	5	16
T7 = 221 :											-	11
T1 = 232 :												-

Differences among trials at block 4.

Mean	T12	T8	T4	T6	T9	T11	T5	T10	T2	T7	T3	T1
T12=202 :	-	1	3	3	5	6	7	7	8	11	12	23**
T8 = 203 :		-	2	2	4	5	6	6	7	10	11	22**
T4 = 205 :			-	0	2	3	4	4	5	8	9	20*
T6 = 205 :				-	2	3	4	4	5	8	9	20*
T9 = 207 :					-	1	2	2	3	6	7	18
T11= 208 :						-	1	1	2	5	6	17
T5 = 209 :							-	0	1	4	5	16
T10= 209 :								-	1	4	5	16
T2 = 210 :									-	3	4	15
T7 = 213 :										-	1	12
T3 = 214 :											-	11
T1 = 225 :												-

Calculations for the comparisons among blocks.

Mean square for the error term = 735.83
Number of observations for each mean = 48
Critical value for Tukey's HSD test:
at p = .05, HSD = 14.23 *
at p = .01, HSD = 17.25 **

Differences among blocks at trial 1.

	Mean	B4	B3	B2	B1
Block 4 =	225 :	-	7	14	43 **
Block 3 =	232 :		-	7	36 **
Block 2 =	239 :			-	29 **
Block 1 =	268 :				-

Differences among blocks at trial 2.

	Mean	B4	B3	B2	B1
Block 4 =	210 :	-	0	6	30 **
Block 3 =	210 :		-	6	30 **
Block 2 =	216 :			-	24 **
Block 1 =	240 :				-

Differences among blocks at trial 3.

	Mean	B4	B3	B2	B1
Block 4 =	214 :	-	2	3	25 **
Block 3 =	216 :		-	1	23 **
Block 2 =	217 :			-	22 **
Block 1 =	239 :				-

Differences among blocks at trial 4.

	Mean	B4	B2	B3	B1
Block 4 =	205 :	-	4	8	28 **
Block 2 =	209 :		-	4	24 **
Block 3 =	213 :			-	20 **
Block 1 =	233 :				-

Differences among blocks at trial 5.

	Mean	B4	B3	B2	B1
Block 4 =	209 :	-	0	4	37 **
Block 3 =	209 :		-	4	37 **
Block 2 =	213 :			-	33 **
Block 1 =	246 :				-

Differences among blocks at trial 6.

	Mean	B4	B3	B2	B1
Block 4 =	205 :	-	1	10	23 **
Block 3 =	206 :		-	9	22 **
Block 2 =	215 :			-	13
Block 1 =	228 :				-

Differences among blocks at trial 7.

	Mean	B4	B2	B3	B1
Block 4 =	213 :	-	1	8	24 **
Block 2 =	214 :		-	7	23 **
Block 3 =	221 :				16 *
Block 1 =	237 :				-

Differences among blocks at trial 8.

	Mean		B4	B3	B2	B1
Block 4 =	203	:	-	3	13	33 **
Block 3 =	206	:		-	10	30 **
Block 2 =	216	:			-	20 **
Block 1 =	236	:				-

Differences among blocks at trial 9.

	Mean		B3	B4	B2	B1
Block 3 =	200	:	-	7	14	32 **
Block 4 =	207	:		-	7	25 **
Block 2 =	214	:			-	18 **
Block 1 =	232	:				-

Differences among blocks at trial 10.

	Mean		B4	B2	B3	B1
Block 4 =	209	:	-	2	3	20 **
Block 2 =	211	:		-	1	18 **
Block 3 =	212	:			-	17 *
Block 1 =	241	:				-

Differences among blocks at trial 11.

	Mean		B4	B3	B2	B1
Block 4 =	208	:	-	4	15 *	33 **
Block 3 =	212	:		-	11	29 **
Block 2 =	223	:			-	18 **
Block 1 =	241	:				-

Differences among blocks at trial 12.

	Mean	B4	B3	B2	B1
Block 4 =	202 :	-	8	17 *	31 **
Block 3 =	210 :		-	9	23 **
Block 2 =	219 :			-	14
Block 1 =	233 :				-

APPENDIX I. Pairwise comparisons for the Analogy by Trials by Consistency interaction.

Calculations for the comparisons among the analogy by consistency means.

Mean square for the error term = 917.55
Number of observations for each mean = 32
Critical value for Tukey's HSD test:
at p = .05, HSD = 25.73 *
at p = .01, HSD = 29.96 **
Label abbreviations : A1 = Far analogy,
A2 = Close Analogy,
A3 = Non-corresponding analogy,
C1 = Consistent items,
C2 = Inconsistent items

Differences among analogy by consistency means at trial 1.

	Mean	A2C1	A1C1	A1C2	A3C1	A2C2	A3C2
A2C1	= 230 :	-	3	5	6	19	39 **
A1C1	= 233 :		-	2	3	16	36 **
A1C2	= 235 :			-	1	14	34 **
A3C1	= 236 :				-	13	33 **
A2C2	= 249 :					-	20
A3C2	= 269 :						-

Differences among analogy by consistency means at trial 2.

	Mean	A1C2	A1C1	A2C1	A3C1	A2C2	A3C2
A1C2	= 203 :	-	8	9	16	29 *	37 **
A1C1	= 211 :		-	1	8	21	29 *
A2C1	= 212 :			-	7	20	28 *
A3C1	= 219 :				-	13	21
A2C2	= 232 :					-	8
A3C2	= 240 :						-

Differences among analogy by consistency means at trial 3.

	Mean	A1C1	A1C2	A2C1	A3C1	A2C2	A3C2
A1C1	= 215 :	-	0	1	3	13	23
A1C2	= 215 :		-	1	3	13	23
A2C1	= 216 :			-	2	12	22
A3C1	= 218 :				-	10	20
A2C2	= 228 :					-	10
A3C2	= 238 :						-

Differences among analogy by consistency means at trial 4.

	Mean	A1C1	A2C1	A3C1	A2C2	A1C2	A3C2
A1C1	= 198 :	-	8	16	16	28 *	39 **
A2C1	= 206 :		-	8	8	20	31 **
A3C1	= 214 :			-	0	12	23
A2C2	= 214 :				-	12	23
A1C2	= 226 :					-	11
A3C2	= 237 :						-

Differences among analogy by consistency means at trial 5.

	Mean	A1C1	A1C2	A2C1	A3C2	A3C1	A2C2
A1C1	= 206 :	-	4	18	20	21	23
A1C2	= 210 :		-	12	16	17	19
A2C1	= 224 :			-	4	5	7
A3C2	= 226 :				-	1	3
A3C1	= 227 :					-	2
A2C2	= 229 :						-

Differences among analogy by consistency means at trial 6.

	Mean	A1C1	A2C1	A1C2	A2C2	A3C1	A3C2
A1C1	= 206 :	-	2	5	12	13	18
A2C1	= 208 :		-	3	10	11	16
A1C2	= 211 :			-	7	8	13
A2C2	= 218 :				-	1	6
A3C1	= 219 :					-	5
A3C2	= 224 :						-

Differences among analogy by consistency means at trial 7.

	Mean	A1C1	A2C2	A2C1	A3C1	A1C2	A3C2
A1C1	= 211 :	-	3	4	10	10	33 **
A2C2	= 214 :		-	1	7	7	30 **
A2C1	= 215 :			-	6	6	29 *
A3C1	= 221 :				-	0	23
A1C2	= 221 :					-	23
A3C2	= 244 :						-

Differences among analogy by consistency means at trial 8.

	Mean	A1C1	A1C2	A2C2	A3C1	A2C1	A3C2
A1C1	= 201 :	-	10	13	17	22	26 *
A1C2	= 211 :		-	3	7	12	16
A2C2	= 214 :			-	4	9	13
A3C1	= 218 :				-	5	9
A2C1	= 223 :					-	4
A3C2	= 227 :						-

Differences among analogy by consistency means at trial 9.

	Mean	A2C1	A2C2	A1C1	A1C2	A3C1	A3C2
A2C1	= 203 :	-	6	8	10	12	29 *
A2C2	= 209 :		-	2	4	6	23
A1C1	= 211 :			-	2	4	21
A1C2	= 213 :				-	2	19
A3C1	= 215 :					-	17
A3C2	= 232 :						-

Differences among analogy by consistency means at trial 10.

	Mean	A1C1	A1C2	A3C1	A1C1	A2C2	A3C2
A1C1	= 206 :	-	5	7	8	18	21
A1C2	= 211 :		-	2	3	13	16
A3C1	= 213 :			-	1	11	14
A2C1	= 214 :				-	10	13
A2C2	= 224 :					-	3
A3C2	= 227 :						-

Differences among analogy by consistency means at trial 11.

	Mean	A1C2	A1C1	A2C1	A3C1	A3C2	A2C2
A1C2	= 210 :	-	11	11	12	17	18
A1C1	= 221 :		-	0	1	6	7
A2C1	= 221 :			-	1	6	7
A3C1	= 222 :				-	5	6
A3C2	= 227 :					-	1
A2C2	= 228 :						-

Differences among analogy by consistency means at trial 12.

	Mean	A2C1	A1C2	A1C1	A3C2	A3C1	A2C2	
A2C1	= 207 :	-	3	6	9	12	30	**
A1C2	= 210 :		-	3	6	9	27	*
A1C1	= 213 :			-	3	6	24	
A3C2	= 216 :				-	3	21	
A3C1	= 219 :					-	18	
A2C2	= 237 :						-	

APPENDIX J. The three lists of four letter items used in the two priming experiment.

List 1 used in the priming experiments.

GULL	LOPE
BINT	BOPE
BINT	FENT
VULL	LIRT
HEAL	GOMP
FOLE	FENT
KEAL	GOMP
VUST	TAST
FOLE	LOVE
VUST	BOVE
KEDE	FANT
LOBE	LIND
VOBE	GOMB
HEAD	FANT
FOSE	GOMB
KEAD	TASH
VUSH	TOTE
FOSE	WOTE
VUSH	COLT
KERE	LIFE
GULP	WOLT
BINK	HILT
BINK	TIFE
VULP	PILT
COME	TURL
VOME	TONE
LOOP	WONE
DEEM	POST
DOOP	GIVE
BALE	WOST
HEEM	GILD
PARL	TIVE
BEND	PILD
KEND	TURE
SOOT	REAM
BEEN	KEAT
DOOT	KEAT
BAVE	PEAM
HEEN	LEAF
PARN	KEAR
BAND	KEAR
KAND	PEAF

List 2 used in the priming experiments.

PINT	BEAT
PULL	KEAT
VULL	LOOP
BINT	KEDE
TASH	TEAM
KAND	DOOP
BOVE	PEAM
KAND	BACE
BUSH	HOLE
BOVE	FOLE
VUSH	ROME
ROBE	PILD
PILT	VOME
VOBE	WONE
WOTE	PILD
PILT	WONE
WOTE	LIND
LIRT	COST
COLT	KEAD
KEAL	KEAD
KEAL	WOST
WOLT	PARN
BEAR	TIVE
KEAR	TIVE
LOOT	RANT
KERE	SEEN
DEAF	FANT
DOOT	TURE
PEAF	HEEN
BAVE	BOMB
HOSE	GOMB
FOSE	PINK
PARL	PULP
TIFE	VULP
TIFE	BINK
RENT	TAST
SEEM	KEND
FENT	BOPE
TURL	KEND
HEEM	BUST
POMP	BOPE
GOMP	VUST

List 3 used in the priming experiments.

WAND	PEAM
VULL	PEAM
KAND	WOLT
VOME	MEAD
VULL	KEAD
VOME	COMB
DOOT	TASH
GUSH	LOSE
DOOT	GOMB
FIVE	FOSE
VUSH	BAVE
TIVE	WILD
PARN	PILD
MEAL	TURL
KEAL	HEEM
ROMP	HEEM
TAST	LIRT
SOLE	ROPE
GOMP	WENT
FOLE	BOPE
BACE	KEDE
HILT	FENT
PILT	MINK
TURE	BINK
HEEN	WOST
HEEN	PEAF
LIND	PEAF
ROVE	WOST
WANT	HEAR
BOVE	DONE
KERE	WONE
FANT	KEAR
MINT	WEND
BINT	VULP
DOOP	KEND
GUST	VOBE
DOOP	VULP
FIFE	VOBE
VUST	HEAT
TIFE	DOTE
PARL	WOTE
WOLT	KEAT

APPENDIX K. Summary table for the analysis of variance on the pronunciation latencies from the word and unprimed pseudoword conditions.

Source	Sum of Squares	DF	Mean Square	F	Prob.
Subjects	1288132.39	23	56005.75	11.17	
Wordness	170353.45	1	170355.45	33.97	<.001
Consistency	38240.11	1	38240.11	7.62	<.01
Interaction	.08	1	.08	.00	>.05
Residual	345942.84	69	5013.66		
Total	1842668.88	95			

APPENDIX L. Summary table for the analysis of variance on both exceptional and regular pronunciation latencies from the adult priming experiment.

Source	Sum of Squares	DF	Mean Square	F	Prob.
Subjects	6.0979	23			
Consistency	.2724	1	.2724	22.44	<.01
C*Subjects	.2793	23	.0121		
Priming	.1051	2	.0526	11.25	<.01
P*Subjects	.2150	46	.0047		
Lags	.1556	2	.0778	17.38	<.01
L*Subjects	.2060	46	.0045		
C*P	.0907	2	.0454	7.89	<.01
C*P*Subjects	.2646	46	.0058		
C*L	.0057	2	.0028	.70	>.25
C*P*Subjects	.1858	46	.0040		
P*L	.2086	4	.0522	8.95	<.01
P*L*Subjects	.5360	92	.0058		
C*P*L	.0309	4	.0077	1.58	>.10
C*P*L*Subjects	.4510	92	.0049		

APPENDIX M. Pairwise comparisons for the Lag main effect from the first priming experiment.

Calculations for the comparisons among lags.

Mean square for the error term	=	0.0045
Number of observations for each mean	=	120
Critical value for Tukey's HSD test:		
at p = .05, HSD	=	0.0202
at p = .01, HSD	=	0.0251

Differences among lags.

	Mean	Lag 0	Lag 1	Lag 2
Lag 0	= 0.707 :	-	.035 **	.043 **
Lag 1	= 0.742 :		-	.008
Lag 2	= 0.750 :			-

** $p < .01$

APPENDIX N. Pairwise comparisons for the Priming main effect from the first priming experiment.

Calculations for the comparisons among priming conditions.

Mean square for the error term	=	0.0047
Number of observations for each mean	=	120
Critical value for Tukey's HSD test:		
at $p = .05$, HSD	=	0.0209
at $p = .01$, HSD	=	0.0260

Differences among priming conditions.

Mean	Repet.	Regul.	Excep.
Repetition = 0.712 :	-	.024 *	.039 **
Regular = 0.736 :		-	.015
Exceptional= 0.751 :			-

* $p < .05$
** $p < .01$

APPENDIX O. Pairwise comparisons for the Consistency by Priming interaction from the first priming experiment.

Calculations for the comparisons among consistency conditions.

Mean square for the error term	=	0.0067
Number of observations for each mean	=	72
Critical value for Tukey's HSD test:		
at p = .05, HSD	=	0.0266
at p = .01, HSD	=	0.0349

Differences among consistency conditions with exceptional priming.

	Mean	Consistent	Inconsistent
Consistent	= 0.706 :	-	0.090 **
Inconsistent	= 0.796 :		-

Differences among consistency conditions with regular priming.

	Mean	Consistent	Inconsistent
Consistent	= 0.716	-	0.039 **
Inconsistent	= 0.755		-

Differences among consistency conditions with repetition.

	Mean	Consistent	Inconsistent
Consistent	= 0.702	-	0.021
Inconsistent	= 0.723		-

** $p < .01$

Calculations for the comparisons among priming conditions.

Mean square for the error term = 0.0044
Number of observations for each mean = 48
Critical values for Tukey's HSD test:
at p = .05, HSD = 0.0258
at p = .01, HSD = 0.0321

Differences among priming conditions with inconsistent items.

	Mean	Repet.	Regul.	Excep.
Repetition	= 0.723 :	-	0.032 *	0.073 **
Regular	= 0.755 :		-	0.041 **
Exceptional	= 0.796 :			-

Differences among priming conditions with consistent items.

	Mean	Repet.	Regul.	Excep.
Repetition	= 0.702 :	-	0.004	0.014
Exceptional	= 0.706 :		-	0.010
Regular	= 0.716 :			-

* p < .05
** p < .01

APPENDIX P. Pairwise comparisons for the Priming by Lag interaction from the first priming experiment.

Calculations for the comparisons among priming conditions.

Mean square for the error term = 0.0054
Number of observations for each mean = 48
Critical value for Tukey's HSD test:
at p = .05, HSD = 0.0351
at p = .01, HSD = 0.0437

Differences among priming conditions at lag 0.

	Mean	Repet.	Regul.	Excep.
Repetition	= 0.663 :	-	0.032	0.100 **
Regular	= 0.695 :		-	0.068 **
Exceptional	= 0.763 :			-

Differences among priming conditions at lag 1.

	Mean	Repet.	Regul.	Excep.
Repetition	= 0.728 :	-	0.014	0.030
Regular	= 0.742 :		-	0.016
Exceptional	= 0.758 :			-

Differences among priming conditions at lag 2.

	Mean	Excep.	Repet.	Regul.
Exceptional	= 0.732 :	-	0.017	0.039 *
Repetition	= 0.749 :		-	0.022
Regular	= 0.771 :			-

Calculations for the comparisons among lag conditions.

Mean square for the error term = 0.0054
Number of observations for each mean = 48
Critical values for Tukey's HSD test:
at p = .05, HSD = 0.0351
at p = .01, HSD = 0.0437

Differences among lags for the repetition condition.

	Mean	Lag 0	Lag 1	Lag 2
Lag 0	= 0.663 :	-	0.065 **	0.086 **
Lag 1	= 0.728 :		-	0.021
Lag 2	= 0.749 :			-

Differences among lags for the exceptional priming condition.

	Mean	Lag 2	Lag 1	Lag 1
Lag 2	= 0.732 :	-	0.026	0.031
Lag 1	= 0.758 :		-	0.005
Lag 0	= 0.763 :			-

Differences among lags for the regular priming condition.

	Mean	Lag 0	Lag 1	Lag 2
Lag 0	= 0.695 :	-	0.047 **	0.076 **
Lag 1	= 0.742 :		-	0.029
Lag 2	= 0.771 :			-

* p < .05
** p < .01

APPENDIX Q: Summary table for the analysis of variance on the regular pronunciation latencies for pseusowords from the adult priming experiment.

Source	Sum of Squares	DF	Mean Square	F	Prob.
Subjects	5.9885	23	.2602		
Consistency	.2042	1	.2042	15.52	<.01
C*Subjects	.3027	23	.0132		
Priming	.1037	2	.0518	7.36	<.01
P*Subjects	.3238	46	.0070		
Lags	.1355	2	.0678	8.32	<.01
L*Subjects	.3747	46	.0081		
C*P	.0856	2	.0428	5.20	<.01
C*P*Subjects	.3788	46	.0082		
C*L	.0238	2	.0119	1.19	>.25
C*P*Subjects	.2865	46	.0062		
P*L	.2416	4	.0604	9.06	<.01
P*L*Subjects	.6136	92	.0067		
C*P*L	.0223	4	.0056	.84	>.25
C*P*L*Subjects	.6122	92	.0067		

APPENDIX R. Least-square analysis of variance on the response latencies for the regular and exceptional pronunciations of inconsistent pseudowords.

Source	Sum of squares	DF	Mean square	F	Prob.
Response (adj.)	0.079	1	0.079	0.963	>.05
Priming (adj,)	0.900	2	0.450	5.488	<.01
R * B (adj.)	6.424	2	3.212	39.171	<.01
Within Cell	7.475	91	0.082		

APPENDIX S. Pairwise comparisons for the Priming main effect.

Calculations for the comparisons among priming conditions.

Mean square for the error term	=	0.082
Number of obs. for except. priming	=	31
Number of obs. for unprimed	=	37
Number of obs. for repeated	=	29

T-tests:

		Mean	Except.	Unprim.	Repeat.
Exceptional	=	.900	-	0.529	3.203 **
Unprimed	=	.863		-	2.817 **
Repeated	=	.663			-

** $p < .01$

APPENDIX T. Pairwise comparisons for the Priming by Pronunciation interaction.

Calculations for the comparisons among priming conditions.

Mean square for the error term = 0.082

Within regular pronunciations:

Number of obs. for except. priming = 14
Number of obs. for unprimed = 24
Number of obs. for repeated = 19

T-tests:

	Mean	Except.	Unprimed	Repeated
Exceptional =	.942 :	-	1.354	3.129 **
Unprimed =	.812 :		-	2.114 *
Repeated =	.626 :			-

Within exceptional pronunciations:

Number of obs. for unprimed = 17
Number of obs. for exceptional = 13
Number of obs. for repeated = 10

T-tests:

	Mean	Unprimed	Except.	Repeated
Unprimed =	.957 :	-	0.868	2.129 *
Exceptional =	.865 :		-	0.868
Repeated =	.734 :			-

* $p < .05$
** $p < .01$

Calculations for the comparisons among types of pronunciation.

Mean square for the error term = 0.082

Type of priming	Regular pronunc.	Exceptional pronunc.	T-test	Prob.
Exceptional	.942	.865	0.748	>.05
Unprimed	.812	.957	1.465	>.05
Repeated	.626	.734	0.946	>.05

APPENDIX U. Least-square analysis of variance on the response latencies for the regular pronunciations of consistent and inconsistent pseudowords .

Source	Sum of squares	DF	Mean square	F	Prob.
Consistency (adj.)	0.052	1	0.052	1.156	>.05
Priming (adj.)	1.052	3	0.351	7.800	<.01
C * P (adj.)	.207	3	0.069	1.533	>.05
Within Cell	7.545	167	0.045		

APPENDIX V. Pairwise comparisons for the Priming main effect.

Calculations for the comparisons among priming conditions.

Mean square for the error term = 0.045
Number of obs. for except. priming = 36
Number of obs. for unprimed = 48
Number of obs. for regul. priming = 48
Number of obs. for repeated = 43

T-tests:

	Mean	Except.	Unprim.	Regul.	Repeat.
Except.	= .852 :	-	1.553	3.574 **	4.271 ***
Unprim.	= .779 :		-	2.209 *	2.933 **
Regul.	= .684 :			-	0.822
Repeat.	= .647 :				-

* $p < .05$
** $p < .01$
*** $p < .001$

APPENDIX W: Analysis of variance on the number of exceptional pronunciations.

Source	Sum of Squares	DF	Mean Square	F	Prob.
Between subj.	179.660	47			
Groups	.174	1	.174	.04	>.25
Error	179.486	46	3.902		
Within subj.	300.667	96			
Priming	200.722	2	10.361	107.11	<.01
Interaction	13.722	2	6.861	7.32	<.01
B*Error	86.222	92	.937		
Total	480.326	143			

APPENDIX X. Pairwise comparisons for the Priming main effect.

Calculations for the comparisons among priming conditions.

Mean square for the error term = 0.937
Number of observations for each mean = 48
Critical value for Tukey's HSD test:
at $p = .05$, HSD = 0.463
at $p = .01$, HSD = 0.577

Differences among priming conditions.

		Mean	Except.	Unprimed	Regular
Exceptional	=	4.19 :	-	1.71 **	2.90 **
Unprimed	=	2.48 :		-	1.19 **
Regular	=				-

** $p < .01$

APPENDIX Y. Pairwise comparisons for the Groups by Priming interaction.

Calculations for the comparisons among priming conditions.

Mean square for the error term = 0.937
Number of observations for each mean = 24
Critical value for Tukey's HSD test:
at p = .05, HSD = 0.673
at p = .01, HSD = 0.847

Differences among priming conditions within adult group.

	Mean	Except.	Unprimed	Regular
Exceptional	= 4.50 :	-	2.00 **	3.62 **
Unprimed	= 2.50 :		-	1.62 **
Regular	= 0.88 :			-

Differences among priming conditions within grade 3 group.

	Mean	Except.	Unprimed	Regular
Exceptional	= 3.88 :	-	1.42 **	2.13 **
Unprimed	= 2.46 :		-	0.71 *
Regular	= 1.75 :			-

* p < .05
** p < .01

Calculations for the comparisons among groups.

Mean square for the error term = 1.925
Number of observations for each mean = 24
Critical value for Tukey's HSD test:
at p .05, HSD = 0.809
at p .01, HSD = 1.081

Type of priming	Adult mean	Grade 3 mean	Difference
Exceptional	4.50	3.88	0.62
Unprimed	2.50	2.46	0.04
Regular	0.88	1.75	-0.87 *

* $p < .05$