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THE DEVELOPMENT OF DISCOURSE PRODUCTION: EXPLORING THE PROCESSING MECHANISM IN WRITING, TALKING AND READING

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ABSTRACT

THE DEVELOPMENT OF DISCOURSE PRODUCTION:
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The effect of practice -- in particular what accounts for the effect of practice on perceptual processing and lexical representation -- has been the focus in debates between abstractionist and episodic theories of cognition. Because of the relevancy of sensory input modality to both theories, the role of modality on repetition effects has been an issue in the study of lexical access and representation. Proponents of each view look at the variation of modality on repetition effects in perceptual processing. In support of episodic theories modality change usually reduces repetition benefits, especially in relatively data-driven tasks such as word naming, lexical decision, or tachistoscopic recognition. Despite the extensive investigation of the perceptual domain, analogous research on the production domain is largely absent from the literature of repetition effects. Furthermore, developmental data on the issue are completely lacking. This study examined the processing mechanism in text generation in writing and speaking by fourth graders and undergraduate students.

In Experiment 1 the effect of same and different modality -- writing and talking -- on the magnitude of repetition benefit was examined. Two-hundred and fifty-six subjects, half fourth graders and half undergraduates, learned a short passage and were then instructed to generate it from memory twice, either both times in writing, or in talking, or once in one modality and once in the other. A complete cross-modality transfer effect was observed in the performance of both fourth graders and adults. For both production tasks, whether written or spoken from memory, second production times were uninfluenced by whether the first production was written or spoken.

In Experiment 2 the effects of same- and cross-modality on repetition benefit was examined when text was copied by writing and when text was read aloud. Repetition benefits in the production tasks were much smaller than those in Experiment 1. However, the repetition effects that did occur were again uninfluenced by practice modality in either fourth graders or adults.

The findings support an abstractionist view of the effects of practice on writing and talking; repetition-based learning in such production tasks occurs in the "abstract" or "amodal" components of the semantic/lexical level of information processing.

To people who taught me the power of thought

In memory of

my grandparents and
my brother Gennadios

and

to my parents and my brother
Telemachos

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CHAPTER I

INTRODUCTION

Language perception and production are important processes for spoken and written language, and they can change with development and practice. The effect of practice -- and in particular what accounts for the effect of practice on perceptual processing and lexical representation -- has been the focus of substantial research in recent years. But despite the extensive investigation of the perceptual domain, analogous research on the production domain is largely absent from the literature of repetition effects. Furthermore, developmental data on the issue are completely lacking. The present study addresses the issue of the nature of the representations underlying repetition effects in two output modalities, such as writing and talking, and examines the representation of these processes from a developmental standpoint.

In this chapter, first the repetition effect in perception tasks is explained in terms of two competing theories: the abstractionist and the episodic. Then some predictions are made concerning the magnitude of repetition effects that derive from these two theories, focusing in particular on what ought to happen when sensory modality is changed between repetitions. This is followed by a summary of available results on the actual impact of changes in sensory modality on repetition effects. Finally, the rationale for a study to explore the question of repetition effects in production tasks in college students and fourth graders is described.

The second chapter presents a review of several studies that have investigated repetition effects in a variety of experimental paradigms. The first two sections focus on repetition effects and the role of sensory modality in normal and neurological individuals. The third section of the chapter describes a few studies of practice effects in speech production.

The third chapter presents information regarding the subject population and the method for the present experiments. In chapters four and five the results of the experiments are reviewed and discussed with particular reference to the level of the learning mechanism that supports repetition benefit in production tasks.

Repetition Effects in Perception

When a particular task is performed more than once, there is a substantial increase in both the speed and the accuracy of performance (Forbach, Stanners, and Hochhaus, 1974; Kirsner and Smith, 1974; Scarborough, Cortese, and Scarborough, 1977), even though considerable time--several hours or days--may have elapsed between the two occasions (Jacoby, 1983; Jacoby and Dallas, 1981; Tulving, Schacter, and Stark, 1982). This phenomenon is referred to as repetition priming or the repetition effect.

Repetition effects are ubiquitous in all forms of human behavior, including learning, perceptual and perceptual-motor skills, and memory skills (Brown and Carr, 1989; Ebbinghaus, 1885; Fitts and Posner, 1967; Keele, 1986; Kolers, 1975; MacKay, 1982; Newell and Rosenbloom, 1981). Repetition priming of the recognition and pronunciation of words has been studied intensively in recent years and has been observed in a variety of experimental paradigms. Such tasks include lexical decisions (Kirsner and Smith, 1974; Scarborough, Gerarld, and Cortese, 1979), word identification (Carrol and Kirsner, 1982; Feustel, Shiffrin, and Salasoo, 1983; Jacoby and Dallas, 1981; Morton, 1979), word fragment completion (Tulving, Schacter, and Stark, 1982), reading inverted text (Kolers, 1975, 1976), and free association (Kihlstrom, 1980).

Theoretical Explanations of Repetition Effects

The repetition effect in word perception has been the focus in current debates between "abstractionist" and "episodic" theories concerning the role of knowledge and experience in the processing of sensory information. These debates concern the way knowledge supports cognitive performances such as perceptual identification and categorization. According to the abstractionist position, the nature of this knowledge is essentially conceptual, consisting of general characteristics abstracted from past experiences. The episodic account, in contrast, holds that knowledge used to enhance performance consists of specific memories of past experiences or "episodes." Both perspectives regarding repetition effects are equally important and challenging for our purpose; therefore, a brief description of each perspective follows.

Under the "abstractionist" view, repetition effects are attributed to activation of pre-existing lexical representations, or knowledge structures, often called "logogens" (Morton, 1969, 1970, 1979; Carr & Pollatsek, 1985; Monsell, 1985), that correspond to each word in a person's vocabulary. Each logogen is equal to a word prototype which is activated by general sensory patterns produced by stimulus instances of the word it represents. A logogen is responsible for recognizing the occurrence of a word both in context and in isolation. Each logogen has an associated threshold value which determines how much activation is necessary for the logogen to "fire" (respond), causing its word to be recognized or made available for production. The idea is that repeated use facilitates the activation of a logogen either by lowering the threshold level of activity required for the logogen to fire or by raising the logogen's resting level of activation (Rumelhart and McClelland, 1981) and therefore making it easier to perceive or produce that word on subsequent occasions. The more frequently a logogen has been activated, the less the evidence required to "fire" that logogen and therefore the more easily it can be activated in the future.

The activation process may be fast or slow depending on the various contexts in which words occur, but the important thing is that the same abstract logogen is activated each time. It is "abstract" in the sense that the representation does not retain concrete information about individual instances of the referents, such as surface features of the stimulus; rather, it corresponds to a prototype abstracted from past encounters with individual stimuli. In other words, the abstract generic lexical representations respond to any instance of a word regardless of its context or the particular script or typeface in which it is written. Repetition effects are believed to be associated with mental structures representing abstract lexical knowledge (Morton, 1979; Allport & Funnell, 1981).

Morton's (1969) influential "logogen model" of word recognition as well as other abstractionist models are characterized by the preceding description. Because of its popularity, and hence its theoretical importance, additional information concerning Morton's model will be presented for better understanding of how the model can handle current data of repetition effects. Of particular interest is the way the model treats the possibility of cross-modality facilitation effects. Therefore, it is also important for this study which deals with repetition effects in two modalities.

The model was based on a categorization system (logogen system) and was originally created on the premise that the production of a single word response should be mediated by the same element irrespective of the origin of the information which led to the response. For this reason, according to Morton (1969), a logogen takes information from both auditory and visual sensory analysis and from the cognitive system. The results of visual and auditory analyses of verbal material are fed into the same system where they interact with contextual (semantic) information from the cognitive system. When the amount of information arises above threshold value, the logogen responds; and the corresponding response is available. The model required that whenever a logogen "fired," there would be subsequent facilitation of the appropriate word. The same effect should be found irrespective of the source of the information which led to the response.

One important aspect of Morton's hypothesis (1969, 1970) is that a logogen for a particular word is not tied to a specific sensory modality but rather sums relevant information in all forms: auditory, visual, pictorial, contextual (Morton, 1970, pp 205 - 206). Logogens were held to be multimodal devices with respect to both input and output.

In contrast to the abstractionist stance and the logogen model, the "episodic" view (Jacoby, 1978, 1983; Jacoby and Brooks, 1984; Kolers and Roediger, 1984) suggests that the representation underlying repetition effects is not an abstract (prototypic) entity, but it is a more concrete entity associated to specific episodes or instances of past experiences in which the stimulus was encountered. The present occurrence of the stimulus acts as a memory cue to retrieve these past experiences, and recognition is made on the basis of the content of the retrieved episodes. Because an episode or a specific instance of a concept is remembered, memory is always tied to context. Within the episodic view repetition of the same word or the same text facilitates the retrieval process by increasing the number of relevant memories available for retrieval. However, because retrieval is sensitive to the similarity of memory cue and the stored memories, perceptual recognition is sensitive to surface form and context.

According to Jacoby and Brooks (1984), Jacoby and Hayman (1987), and Whittlesea and Brooks (1988), the more similar the task performances, the context, and surface form of the repeated stimulus to its previous occurrence, the easier it is to retrieve that occurrence and therefore the greater the resulting repetition benefit. Based on this similarity principle, any variation in both stimulus form and task processing should influence the degree of repetition effects by reducing the similarity between a current episode and a previous episode in which the stimulus was encountered. The more the context of the stimulus is changed, the more attenuated any repetition efects should be, because the second encounter will be less likely to cue retrieval of an episodic trace of the first encounter.

Given these two theoretical differences concerning the representation underlying the repetition effect and its generalizability, one can make some straightforward predictions about the magnitude of repetition effects as a function of stimulus properties and attributes. On any strong version of the episodic account, changes between the first and second stimuli in modality of presentation or other aspects of perceptual format or surface form such as typefont for visual stimuli or tone and voice for auditory stimuli, should reduce the benefits that result from repeating the same stimulus. Strong versions of the abstractionist account, on the other hand, would predict that changes in modality or typefont should matter little or not at all to the magnitude of repetition benefit. This last position (modality-independent representation) was adopted by Morton (1969) in his original logogen model.

The predictions derived from these two theoretical positions concerning the magnitude of repetition effects are fascinating and apparently straightforward. The pattern of current data concerning these predictions, however, is rather mixed. With respect to variations in visual surface form, changes in letter case between initial reading and later fragment completion tasks (Roediger and Blaxton, 1987) or changes from previously read normally oriented sentences to geometrically inverted sentences (Kolers, 1973, 1975) lead to a decrease in the amount of facilitation observed. On the other hand, complete transfer is observed across a change, for example, in writing systems for Hindi-Urdu bilinguals (Brown, Sharma, and Kirsner, 1984) and for changes from typed to handwritten surface form and vice versa for text reading (Carr, Brown, and Charalambous, 1989).

With respect to variations in modality, the pattern of current data concerning the previous theoretical predictions is again mixed. Because of the importance of modality and its relevancy to both abstractionist and episodic theories, the role of modality on repetition effects has been a favorite issue in the study of the nature of lexical access and representation. Several investigators who attempted to distinguish between modality-specific and modality-nonspecific components of lexical organization by examining the effect of auditory-visual modality shifts on the magnitude of repetition effect reported the following:

First, some investigators have found that the repetition effect occurs within but not across sensory modality; the facilitation effect is entirely modality-specific and involves an advantage of the same modality over the different modality. This has been demonstrated in word identification and lexical decision tasks (e.g., Clarke and Morton, 1983, experiment 2; Jacoby and Dallas, 1981, experiment 6; Monsell and Banich 1985; Morton, 1979; Winnick and Daniel, 1970).

Second, other investigators have found that the within-modality effect is greater than the cross-modality effect, yet significant facilitation is observed even across modality. This pattern of results has been observed by Clarke and Morton, (1983); Monsell and Banich, (1987), and Postman and Rosenzweig (1956). Interestingly, a persistent and striking "asymmetry" of the pattern of cross-modality facilitation has been found in some of the studies in which cross-modality transfer was significant: transfer from visual to auditory identification of words is larger than for the converse.

Repetition Effects in Production Tasks -- An Unexplored Question

Although these two sets of results reflect mainly the representation underlying repetition effects on the input or perceptual domain tasks (e.g., word recognition), one could ask similar questions about output or production domain tasks, such as writing and speaking.

Writing and speech, both language production processes, have been treated by some investigators as motor skills much more than they have been studied as an output media for communication. This is more true for writing which has been strangely neglected until recently. This neglect has occurred despite the fact that writing is one of the first means used to generate, record, and communicate thoughts in time and space.

Very often writing skills have been believed to be closely parasitic upon speech. A common proposal by neuropsychologists is that in order to write a word you must first say it to yourself, then translate that internal string of sounds into a string of letters, and then write those letters (Dejerine, 1914; Luria, 1970).

One cannot deny the existence of some differences between writing and speaking, but probably similarities derived from some shared mechanism underlying these two processes are more than might be expected. Planning to write probably utilizes the same production processes as speech production, though writing tends to have its own vocabulary and style. Also, writing is less interactive than natural speaking but still affords more opportunities for editing; it probably diverges from speech at the point where word spelling must be accessed.

Given these similarities and differences between Speaking and Writing, the question then arises how these processes are represented in our brain? How, for example, do skilled speakers and writers retrieve from memory the sounding or the spelling of familiar words? And how is the repetition effect reflected in these two modalities? Is, for instance, the benefit from repetition larger in one modality than in the other modality? Are the practice effects modality-specific or do we have cross-modality effects as an analogy derived from the logogen model would suggest? The exploration of these questions is not only of great theoretical importance but of great value in in any general learning situation and in disciplines such as education, psychology, and speech - language pathology.

The purpose of this study is to focus on repetition effects in text generation (production) tasks. The text generation in handwriting and speaking is examined in individuals at two age levels: undergraduate students and fourth graders. The study includes two experiments.

Experiment 1 examines the effects of modality and modality change on the magnitude of repetition benefits, both when written text is being generated from memory and when spoken text (discourse) is being generated from memory. The study looks at the following:

1. The effect of repetition: Does skill in writing or talking increase as a function of practice?
2. What is the magnitude of repetition benefit in writing compared to that of talking?
3. Cross-modality facilitation: Does the effect of practice in writing modality have any facilitation on modality of talking and vice versa?
4. Does repetition effect change developmentally, and if so, how?

Experiment 2 asks the same questions as Experiment 1, but subjects were asked -- instead of generating text -- to copy a passage in the writing condition or to read it aloud in the reading condition. Hence, Experiment 2 examines the effects of same- and cross- modality conditions in the magnitude of repetition benefits both when text is copied by handwriting and when text is read aloud.

CHAPTER II

REVIEW OF LITERATURE

In the following section a review of several studies that have investigated repetition effects in a variety of experimental paradigms will be presented. These paradigms include perceptual identification, lexical decision, and word fragment completion.

The repetition effect, as mentioned earlier, refers to the enhancing effect of a single presentation of a stimulus on a second or subsequent test of the same stimulus item. This enhancement is usually substantial and is evident by a decrease in both latencies and errors for the subsequent test with the item (Forbach, Stanners, and Hochhaus, 1974; Scarborough, Cortese, and Scarborough, 1977).

Repetition effects can be long-lasting (over hours or even weeks) for words but short-lived for non-words (Jacoby, 1983; Jacoby and Dallas, 1981; Scarborough et al., 1977). They can occur equally for physically identical repetitions of a word and for the same word repeated by a speaker of the opposite sex, or printed in script vs type, or in different case (Scarborough et al., 1977; Morton, 1979). The particular conditions that determine how long they last and how widely they generalize over such departures from exact repetitions are very important to understanding how repetition achieves its impact.

Before the main body of this review begins, two definitional explanations of two main paradigms used in repetition studies will be made.

1. Perceptual identification experiments: On perceptual identification tests -- also referred to as word identification or tachistoscopic identification (Feustel, Shiffrin, and Salasoo, 1983; Jacoby and Dallas, 1981) -- a stimulus item, e.g., a string of letters, is exposed for a brief time (typically tens of milliseconds) and the subject is asked either to identify it or to choose the target item from a set of alternative responses. The priming effect is indicated by a decrease of the exposure time necessary to identify the items or by an increase in the accuracy of identifying items that have been recently exposed relative to new items.

2. Lexical decision tests: On lexical decision tasks (Forbach, Stanners, and Hochhaus, 1974; Scarborough, Gerard, and Cortese, 1979) subjects are presented with a sequence of strings of letters and are required to decide as quickly as possible whether the string constitutes a real word or not; priming is reflected by a decreased latency in making the lexical decision on the second presentation relative to the first and by a decrease of errors. This technique has proved useful in exploring the storage and retrieval of

vocabulary (Morton, 1981).

Repetition Effects and the Role of Sensory Modality

The literature on relevant modality effects can be divided into two "unequal" subgroups. The first (smaller) group includes studies showing repetition effects within but not across modality. The repetition effect is absent, for example, when the repetition is from written to spoken or from spoken to written presentations. This pattern of results has been interpreted as implying a phenomenon which depends on a modality-specific lexical code (Allport and Funnell, 1981).

One example of a study in which facilitation was found only within sensory modality was an early study conducted by Winnick and Daniel (1970). In particular, in their second experiment these researchers used two modes of priming responses in tachistoscopic recognition of words. In the first stage, subjects were presented either with the picture of the objects denoted by the word, with the definition of the word, or with the word itself presented in cards. In each case, the subjects were instructed to pronounce the appropriate word as each card was presented. This was followed by a free recall test which required the subjects to name all the words that served as responses in the first stage. Later, the subjects were exposed to a tachistoscopic naming of the words seen in the previous conditions, without any indication that the same words would be used. Threshold measures were compared with thresholds for words actually seen and for control words not used at all in the first stage.

The recall data indicated that the words corresponding to previously seen pictures and definitions were better recalled than were the words seen in printed form. The tachistoscopic identification of typed words, however, yielded a different result. Items presented initially as printed words were recognized with lower (better facilitation) tachistoscopic threshold than words from picture and definition conditions. Thus, if a subject had seen and named the picture of a "butterfly" without having seen the word in the training session (first phase) there was no facilitation of the word BUTTERFLY in the test phase. Explaining these findings, Winnick and Daniel (1970) attributed the word priming to an "advantage where words to be recognized appear in the same form on both initial familiarization trials and subsequent recognition tests." They concluded that there "appeared to be a sensitization effect accruing from previous viewing of printed words that did not occur where verbal responses had been evoked by pictures or by definitions."

This differential facilitation in favor of printed words shown in Winnick and Daniel's results had some serious implications for Morton's logogen model. In its original form the logogen model (Morton, 1969) would have predicted cross-modality facilitation on tachistoscopic word recognition. Accordingly, the same logogen should be involved whether a word is being produced in response to a picture, a definition, or its written form; all three forms would be equivalent primers in eliciting a vocalized response.

Given the Winnick and Daniel's data, Morton felt that the original logogen model had to be reconsidered. This led him and his co-workers in a series of experiments dealing with cross-modality facilitation in tachistoscopic word recognition. Clarke and Morton (1983) wanted to replicate the results of Winnick and Daniel's study and to further investigate the notion of "perceptual sensitization." They looked at whether repetition benefit was based on the exact visual form or whether it was related to some more abstract representation.

In their first experiment they tested whether word priming shown by Winnick and Daniel was due to the precise correspondence of pre-training and recognition of stimuli. Clarke and Morton used the same conditions (typed words and definitions), but they omitted the picture condition since they had evidence that it produced qualitatively similar results to definition condition (Morton, 1979). A new condition was also introduced in which the pretraining was a handwritten version of a word later to be seen in typewritten form. In the first phase subjects were presented with a list of words of similar recognition threshold, and they were required to pronounce quickly the appropriate word as each word was presented. In the recall condition, the subjects were asked to remember as many of the words they had just spoken, taking as long as they wanted. In the final phase, the recognition stage, the subjects were presented with a random sequence of recognition cards with items from the four conditions equally distributed through the list and were asked to name them. Tachistoscopic exposure started with 10 ms and increased until the correct response was produced.

Results replicated the Winnick and Daniel finding that words corresponding to previously seen definitions are better recalled than the words seen previously printed. There was no difference between the typed and handwritten conditions. The recognition results showed that a handwritten word appears to be as effective a prime as a typewritten word. In other words, the transfer from reading a handwritten word was not significantly different from that produced by a typewritten word in the pretraining. This led to the conclusion that any visual presentation of a word leads to the same facilitation effect as opposed to Winnick and Daniel's supposition that the basic identity facilitation effect is due to visual correspondence.

Instead, it was hypothesized that the input logogen system must be abstract to a certain extent and does not differentiate among specific visual forms of stimulus words.

Clarke and Morton continued their studies by addressing the question of cross-modality facilitation. In experiment two they investigated the effects of auditory priming on subsequent visual word recognition. The pretraining was either auditory or visual, whereas the recognition phase was always visual. In addition, another variable was added in the pretraining and that was the nature of the response. This consisted of the "word opposite" and "auditory opposite," and they were to confirm that facilitation was dependent only upon the stimulus and not upon the response as well. Subjects were presented alternatively with single spoken words from a tape recorder and words typed on cards at the rate of 1 item per sec. They were instructed either to repeat the word, to read the word, or to pronounce the opposite of the displayed word. Two minutes after the training procedure, the recognition phase was carried out using the same procedure as in Experiment 1.

Results showed no significant transfer from auditory presentation to subsequent visual recognition, although the means indicated a slight trend in that direction. This was interpreted to mean that the auditory and visual inputs could not be regarded as equivalent. In addition, the production of an opposite seemed to have no significant effect on the priming of either auditory or visual stimuli.

The data reported from Winnick and Daniel's study as well as from Clarke and Morton's experiment lead to the conclusions that neither the naming of pictures nor the completion of definitions have any effcet upon visual recognition. Presenting a word in the visual modality facilitates later recognition in the same modality, but saying the word or hearing it has no such priming effect. That is, there is no cross-modal facilitation.

Morton (1979) has interpreted these kinds of results in terms of repetition priming in modality-specific logogens. In light of these data, a separation of the visual input system from the phonological lexicon and from the auditory input system was demanded (Clarke and Morton, 1983): A "visual input logogen system" for recognizing written words, an "auditory input logogen system" for recognizing spoken words, and an "output logogen system" for producing spoken words. By this account, the cause of the repetition effect can be considered, but an experience of a word will prime a later experience only if the two accounts activate the same internal logogen system.

The modality-specific nature of repetition effect was further supported by Ellis (1982) and Gipson (1984). These researchers have reported experiments in which hearing a word facilitated later auditory recognition, although reading the word did not facilitate auditory recognition. A significant within-modality transfer was found but not between modality transfer from visual study to auditory perceptual identification at all.

Ellis (1982) wanted to replicate the claim that repetition priming is a modality-specific phenomenon. Subjects in his study were pretrained on experimental words by matching each word to one of three definitions that they had read silently. The pretrained words were presented in one of three conditions: conventionally spelled; phonically but not conventionally spelled; or auditorily (containing only the definitions). The same words were later shuffled randomly with new filler words and presented auditorily for recognition in a background of white noise.

Analysis of the results showed a significant interaction between condition and type of word (experimental vs. fillers). Only the auditory pretraining condition led to significantly improved auditory recognition of the experimental words when compared with the recognition scores of a control group that was given no pretraining of any sort. The finding that identification of a word was facilitated by having recently heard that word but not by having read it confirms, as Ellis noted, the modality-specific nature of repetition effect.

This pattern of results -- that is, repetition effect within-modality but not across modality -- has also been obtained in lexical decision studies (Scarborough, Gerard, and Cortese, 1979) and word identification studies (Jacoby and Dallas, 1981). Jacoby and Dallas (1981) in a series of experiments investigated the effects of study on perceptual identification performance. The results of these experiments revealed that study of a word influences perceptual identification even when 24 hours intervene between study and test.

In experiment six Jacoby and Dallas (1981) investigated the effect of perceptual similarity between the study and test version of a word. The importance of physical information was tested by manipulating the modality of presentation between study and test. They had subjects study words in either visual or auditory modality and then try to identify visually degraded words. It was found that there was substantial priming on the visual test for visually studied words but not for auditorily studied words.

Though a number of studies fall into the category first described in which priming is restricted entirely to the within-modality situation, a more common pattern of results in studies of repetition effects is to observe a "gradient" of priming. That is, there is more repetition effect within a modality than across modalities, but there is significant priming even across modalities.

Postman and Rosenzweig (1956) investigated the effects of training on the visual and auditory perceptual recognition of verbal stimuli. Specifically, they wanted to see how specific the effects of repetition are to the sense-modality used during the training (i.e., what is the degree of transfer from visual training to auditory recognition and vice versa).

Four experimental groups (25 subjects in each group) were presented with nonsense syllables in the training phase and then tested for recognition of these syllables and other three letter English words. A different group was assigned for each of the four experimental conditions of training and testing. Subjects receiving visual training wrote down each of the stimuli projected on a screen for 1 sec., whereas subjects receiving auditory training repeated each word aloud that was presented from a tape recorder. For the visual recognition test, the test-items were presented seven times tachistoscopically under different intensities of illumination and recognition thresholds. For the auditory test, the items were presented six times in conjunction with different degrees of masking noise. During the recognition test, all groups made their responses in writing.

Analysis of threshold data demonstrated that frequency of past experience is a significant determinant of both visual and auditory recognition and transfer effects across modalities. When the same sense-modality was involved in both training and test, the effects of practice were more pronounced than when there was a change in modality. Interestingly, the transfer-effects were not symmetrical:

there was more transfer from visual training to auditory perceptual recognition than conversely. The visual test following the auditory training showed only small and insignificant differences in threshold. The advantage of transfer from visual study to auditory recognition was interpreted as the result of a possible mediating mechanism suggested by the fact that subjects tend to say the visually presented words to themselves during study.

Priming effects within and across modalities were the focus of a series of experiments Monsell carried out in collaboration with Banich (Monsell and Banich, 1982; Monsell, 1985).

In two of their experiments (5 and 6) subjects were presented with four types of priming trials which all involved visual display of a number of incomplete sentences. The sentences were either rote-proverb type phrases or quasi definitions. In the first two conditions the subjects were required to indicate whether a visual or auditory word presented one second after the displayed sentence belonged in the sentence or not. On the other two conditions (write and say) the subjects generated the missing word blind or spoke the missing word. The priming phase was immediately followed by a visual lexical decision for experiment 5 and auditory lexical decision for experiment 6. The lexical decision words included new words and words already used during the priming phase.

In experiment 7 the same procedure was used as in experiment 6 except that instead of "saying" the missing word, subjects were required to "mouth" it completely silently. The experimental task was auditory lexical decision.

Monsell and Banich reported a "strong" cross-modal priming effect for auditory lexical decision but none for visual lexical decision. Priming effect in the visual lexical decision task was significant only when tested words had been previously presented visually (read), but the effect in the other cross modality conditions was close to zero. In contrast, auditory lexical decision time was significantly facilitated by any modality, even writing; the effects observed of hearing or saying the words were significantly greater than seeing or writing it.

The other interesting finding was that silently mouthing the word had a strong facilitative effect on later auditory lexical decision (just as much as saying the word out loud). The writing effect also had a significant effect though it had significantly weaker effects than the within modality (auditory) condition.

In summary, Monsell and Banich showed facilitation of auditory lexical decision by prior generation of the word to complete sentence, whether the word was mouthed silently, spoken aloud or written blind. Monsell and Banich in contrast to Morton argued that priming may take place in a phonological processing system used in both the perception and production of words.

Clarke and Morton (1983) in their third experiment examined auditory-to-visual priming in a way that would reduce the contribution of "sophisticated guessing." In the priming phase of the experiment the subjects were presented with words and were asked to rate their imaginability on a five point scale. Half of the words were presented visually and half auditorily, the two modalities alternating. In the test phase subjects were presented with experimental words on a tachistoscope. Of these words, one third had been presented auditorily in the priming phase, one third had been presented visually, and the last third constituted the control stimuli (neither seen nor heard). The subjects were strongly encouraged not to guess their responses. The test stimuli were presented at a tachistoscopic exposure duration that was adjusted to give a performance level of about 40% correct.

Results showed a significant cross-modality transfer. The facilitation from prior auditory experience of a word to subsequent visual recognition was significant, but it was small compared to visual-visual facilitation.

A partial transfer effect (or intermediate) under intermodality conditions has been reported in the literature. Kirsner and Smith (1974) compared intramodality (IM) and cross-modality facilitation effects using auditory and visual presentation of isolated words in a lexical decision task. They wanted to see whether the degree of the processing involved in reading a visually presented word was specifically visual or whether it was shared with auditory word recognition. To do this, Kirsner and Smith examined transfer from one modality to the other in a lexical decision task by repeating a word either in the same modality (visual - visual) or in different modality (auditory - visual). The subjects were presented with two-syllable nouns (half of which were common English words) for word/nonword categorization. Each item was presented twice for 0.5 sec. with a rate of presentstion of 4 sec/item either in the same as its original presentation or in a different modality. The decision task was to decide accurately and quickly whether each stimulus was an English word.

Kirsner and Smith reported an "intermediate" repetition effect under intermodality conditions. The results showed that cross-modality repetition did facilitate processing but not as much as within-modality repetition. Repetition facilitation was greater in the intramodality conditions for both words and nonwords, whereas facilitation was reduced in the cross-modality condition for words and was absent from this condition for nonwords. As the authors noted, their results suggest a substantial degree of specialization by modality in the encoding mechanisms for word recognition.

Repetition Effects in Amnesic Patients

The issue that has been raised by several investigators as to whether across-modality repetition effect is a modality specific phenomenon (Clarke and Morton, 1983; Scarborough et al., 1979) has been explored in studies of amnesic patients as well.

Studies on new learning capabilities in amnesic patients of various etiologies have provided considerable evidence that this population preserves not only the capacity for learning perceptual-motor skills (Brooks and Baddeley, 1976; Cohen and Squire, 1980) and cognitive skills (Squire and Frambach, 1990) but also the capacity for repetition priming as well (Shimamura, 1986; Tulving and Schacter, 1990). Interestingly, amnesic patients exhibit normal priming effects despite being severely impaired on tests of recognition memory; that is, their performance on word completion tests or other word identification tests can be facilitated by prior exposure to test words in the same way as in normal subjects (Graf, Squire, and Mandler, 1984; Graf, Shimamura, and Squire, 1985; Jacopy and Whitherspoon, 1982; Weiskrantz, 1968, 1970, 1974). In addition, in some studies -- and in particular in Graf, Shimamura, and Squire's study -- the amnesic patients showed priming effects in both within and across sensory modalities.

Graf, Shimamura, and Squire (1985) addressed the question as to whether amnesic patients with Korsakoff syndrome demonstrate normal priming effect when there is no or little overlap of sensory and perceptual information between study stimulus and test cues. In their first experiment they compared priming effects in amnesic patients and control subjects under within - and cross-modality conditions in a word stem completion tasks. Subjects were presented twice with a study list of words, either visually or auditorily; and then they received both a free recall and a word completion test. On the word completion task subjects were shown the initial three letters of a word as cues (old or new words) and were asked to complete the cues with the first words that came to mind. Results showed that average free recall of words was lower for amnesics than for the controls; however, a similar percentage of words was recalled under within- and cross-modality conditions by each subject group.

On the word completion test the magnitude of priming was similar across all the subject groups indicating that amnesic patients exhibit normal priming effects, despite severe impairment in recall. All groups exhibited significant priming effect in both within and across modality conditions, but the magnitude of the effects was greater under the within modality condition. These priming effects -- as the authors indicated -- were consistent with the findings of other studies (e.g., Graf and Mandler, 1984; Kirsner, Milech, and Standen, 1983; Roediger and Blaxton, 1983).

Priming across sensory modalities has been considered by some investigators as an "artifact" mediated by subject's tendency to employ visual imaging strategy, for example oral presentation of study words. To rule out any possibility that subjects might image the test cues during presentation of the study list, Graf et al. carried out a second experiment in which they assessed priming for category exemplars (e.g., apple, orange). The experiment was designed to essentially exclude any sensory and perceptual overlap between study items and test cues. In this experiment the subjects received two study-test trials, each of which involved the presentation of single words followed by a word production test and a free recall test. For the word production test the subjects were provided with category names as test cues (e.g., fruit), and they were asked to produce the first exemplars that came to mind.

Results showed that amnesic and control subjects exhibited equivalent and significant priming effects of category exemplars. These findings, as Graf et al. (1985) suggested, "strengthen the evidence for priming across sensory modalities by showing normal and significant priming effect in amnesic patients," even when there is no overlap in sensory/perceptual information between study lists and text cues. They concluded that the findings of their study, as a whole, indicated that amnesics preserve not only modality-specific sensory and perceptual processes, but they can also preserve capabilities that mediate the transfer of information across modalities.

Priming effects have also been found in amnesic patients for newly acquired materials such as unrelated paired associated (Graf and Schacter, 1985; Moscovitch, Winocur, and McLachlan, 1986), but not all amnesic patients showed priming for novel information (Cermak, Talbot, Chandler, and Wolbast, 1985; Diamond and Rozin, 1984). Moscovitch et al. (1986) conducted a study in which severe memory-impaired people with Alzheimer's disease and other neurological disorders, young people and elderly people served as subjects. Subjects were required to read sentences aloud as quickly as possible without making any mistakes and then to distinguish old sentences that they had read previously from new ones. The sentences were read in normal or in inverted script at initial presentation, 1 to 2 hour later, and 4 to 14 days later. The transformation involved a 180 rotation of each letter about its vertical axis which preserved a left-to-right direction in reading.

In general, all groups tested showed a similar pattern of improvement in reading transformed scripts; all groups read repeated old sentences faster than new sentences. Retention as measured by reading time paralleled recognition performance in that items that were read most quickly were recognized best. In people with memory disorders, however, a dissociation between these two tests was observed. Although this group demonstrated a reading time similar to that of the other groups, they could not distinguish old from new items even at short delays. Moscovitch et al. (1986)concluded that the fact that old sentences were read most quickly and that reading time of new sentences improved indicated retention of item specific information as well as the acquisition and retention of general skills in the impaired population.

Practice Effects in the Production of Speech and Handwriting.

Research on the practice effect in speech production -- the effect that can be defined as the increase in rate of producing a sentence as a result of practice (MacKay and Bowman, 1969) -- is rather limited as opposed to studies of other skills (e.g., perceptual skills). Some of the reasons for this limitation may be attributed to methodological difficulties and theoretical issues on the topic. Studies of practice effects in speech production have been concentrated for the most part on movement and muscle control in different types of skills, ignoring the underlying mental processes that are involved in the control of the muscle movements. As MacKay (1982) noted, however, the major effects of practice on the fluency of skilled behavior "are usually taking place at this mental level" rather than at the level of muscle movement.

MacKay and Bowman (1969) carried out several experiments that focused on the repetition effect in speech production at the phonological, syntactic, and semantic levels. German-English bilinguals were presented with sentences typed on an index card, and they had to produce each sentence as fast as possible. Following a 20 sec. pause, the sentence was presented again for a total of 12 repetitions of the same sentence. Half of the sentences were in English and half in German; there were three different types of material: normal sentences, scrambled sentences, and nonsense strings.

MacKay and Bowman found that practice had a significant effect for all three conditions. The rate of speech was 15% faster for the last four than the first four practice trials even though the subjects were always trying to speak at their maximum rate.

After practicing each sentence twelve times, the subjects received a transfer sentence condition in their other language, which they again produced at maximum rate. The transfer sentence was either a translation (with identical meaning but different word order and phonology from the original practiced sentence) or a nontranslation (unrelated to the original practiced sentence in meaning, syntax, and phonology; same word order). Results showed that subjects performed the translations significantly faster than the non-translations (2.24 sec. per sentence vs. 2.44 sec. per sentence). This finding, as the authors concluded, indicates an effect of practice at the lexical conceptual level and above in speech production.

MacKay (1981) investigated the effects of mental practice on skill in speech production, as reflected in the time to produce sentences at maximum rate. Bilingual subjects were presented with normal sentences one at a time, and they were required to produce a sentence as rapidly as possible either aloud or mentally (without making any lip movement).

The sentences differed across conditions for any given subject but were counterbalanced across subjects. Following a 20 sec. pause, the subjects repeated the same sentence mentally or overtly for a total of 12 repetitions of the same sentence at each condition. The subjects timed themselves for their own mental repetition trials by pressing a key as they began internal speech and another key as they finished it.

A transfer sentence phase followed immediately the practice phase. Transfer sentences were either a translation of the practice sentences or a non-translation of the practice sentence. During the transfer phase the transfer sentences for both practice conditions were produced out loud at maximal rate and repeated four times with about 20 sec. between repetitions.

Results for the practice phase showed that the rate of speech in both the physical (overt) and mental conditions became progressively faster as a function of practice, even though the subjects were always attempting to speak at their maximum rate. Production times were significantly shorter (faster speech) for the mental than the overt practice condition (by about 35% on the initial trial). This finding is in agreement with Anderson's (1982) results which also showed that covert verbal rehearsal was faster than overt verbal rehearsal when subjects repeated the alphabet, days of the week, and months of the year.

The rate of speech was significantly faster for translations than non-translations, and the degree of transfer for the mental and physical practice condition was equivalent. However, the transfer sentences (whether translations or non-translations) were produced faster following mental practice than following physical practice.

The facilitation effect was explained by MacKay under the mental <u>node</u> hypothesis that suggests that repetition at a mental level can facilitate the maximal rate of output. MacKay also concluded that the similarity of the practice and transfer effects for the physical and mental practice conditions suggests that physical and mental practice may "involve identical underlying components at some level in the system" (MacKay, 1981, p. 280).

Studies on writing are rarely represented in the literature of practice effect to date. One piece of research which is closely related to the present study is the study done by Brown et al. (1989). Their third experiment explored the resource organization of producing handwriting discourse. In particular, Brown et al. wanted to see whether the contribution of content practice of text and writing practice produced the same effects as does content practice alone.

In the first session of the experiment they asked subjects to copy four paragraphs, two in a legible condition and two in a speeded condition. The subjects were asked to practice two of the paragraphs while not practicing the other two. Half the subjects were told to practice the paragraphs each day by copying, whereas the other half were told to practice the paragraphs by reading them aloud. In the test condition for half the subjects test was the same as the first session. The other half were asked to copy the four paragraphs under the opposite instructions. So the paragraphs written and practiced with an emphasis on speed were now written legibly, and vice versa.

Writing times were measured with a stop watch and legibility ratings were taken for all groups. Results showed that subjects wrote faster in the second session than they had in the first session, but this was as true for unpracticed paragraphs as it was for practiced ones.

The Brown et al. study with its data and methodological procedures can be considered as a pilot piece of work on discource production via handwriting. The present study goes beyond that study. It addresses the issue of the nature of the representations underlying repetition effects in text generation tasks in two output modalities, writing and talking, and most importantly it examines the representation of these processes from a developmental standpoint. Hopefully, the pattern of the results of this study will suggest some kind of architecture of the mechanism involved in the process of writing and talking.

CHAPTER III

METHOD

In the present study two experiments were being conducted using undergraduate and fourth-grade students. The first experiment examined the effects of same modality and modality change in the magnitude of repetition benefits, both when written text is being generated and when spoken text is generated. Subjects were asked to generate a short passage from memory twice in these two modalities. The second genetation of the text was either in the same modality or in a different modality. This allowed for influences of changing in modality on second text generation time.

The second experiment examined the effects of same- and cross- modality in the magnitude of repetition benefits both when text is copied by writing and when text is read aloud. Subjects were asked to read aloud or to copy by writing a short passage twice. The second reading or writing was either in the same modality or in a different modality. In fact, the same subjects have participated in both experiments to facilitate comparisons of repetition effects across experiments. The order in which each subject participated in the Experiment 1 and Experiment 2 was counterbalanced--half the subjects were administered Experiment 1 first and the remaining subjects were administered Experiment 2 first.

The design, materials and procedures for the two experiments are almost identical, so they are described in one Method section.

EXPERIMENT 1

Subjects

A total of two-hundred and fifty-six subjects, half in fourth grade and half in undergraduate university classes, participated in the study. Of the 256 subjects 124 were males and 132 were females. The subjects consisted of 128 fourth graders and 128 adults from varied socioeconomic levels.

The two age levels included in this study were selected because they cover a wide range of writers, speakers and readers who differ considerably with respect to age, cognitive maturity, experience, and knowledge. Differences in these characteristics are generally assumed to account for differences in skill performance (Noble, 1978) and organization of mental operations (Kemler, 1983).

The adult subjects were college students recruited from undergraduate classes at Michigan State University. The fourth graders were normal-achieving children selected from elementary schools from the greater metropolitan area of Lansing, Michigan. The names of the children were generated from listings of students scoring between the 45 and 99 percentile on The California Test of Basic Skills, an achievement test given annually in the school district. All subjects were native English speakers with no evidence of neurological disorders, emotional problems, hearing or speech impairment including oral or motor deficit. The subjects also exhibited normal vision with or without correction. These determinations were made based on the school records, the teachers' consultation, and observations by the experimenter.

Materials

A total of four approximately short passages were used in the two experiments. Across subjects, each passage occurred in each condition of each experiment an equal nummber of times. For each subject in Experiment 1, two of the passages (henceforth identified as A and B) were selected as stimulus material for writing and speech generation. The passages were comparable in that they were matched in length (approximately 30 words), familiarity, and content difficulty to eliminate any possible confounding effects that could depend on these differential characteristics. The passages were expository and were appropriately reconstructed so that they are interesting to the subjects and at 3.5 grade reading level. The stimuli had been presented in a pilot study to guarantee successful generation of their content.

A prepared tape recorded set of the stimuli was spoken by an adult native English speaker. The set was used in preliminary presentations of each passage to be learned by the subjects prior to the main experimental task. For each of these memorized passages the subject first heard the whole passage from audiotape and then sentence by sentence and then was given a verbatim recall trial. The listening-recall trials were repeated with feedback and instruction until a criterion of 95% or more words correct was reached. After the passage had been learned to the criterion of 95% accuracy of verbatim recall, the main experimental task began.

The memorization approach employed for handwriting and speech generation was thought to be the most appropriate for this study, as it has been used successfully in previous speech and handwriting production studies (Bock, 1982; Brown, McDonald, Brown, and Carr, 1988; Kelly, Bock, and Keil, 1985). In those studies subjects were required to reproduce content from memory rather to generate it naturally. The application of this approach--especially in a repetition study like this which deals with two output modalities--has two main advantages. First, the fact that all subjects have the chance to be equally exposed to the source material enhances the availability of the words and sentences to be written and spoken. Thus, the production process becomes easier. Second, the memory task allows a degree of experimental control over content of the produced text within- and cross-modality performance. This experimental control over content--vital for repetition studies-- could not be possible if subjects were just required to generate the passage naturally.

Procedure

The subjects were tested individually in one twenty minute session. Half the subjects were asked to generate a passage from memory twice in two modalities: either writing or speaking (within and across modality). The other half were asked to generate two passages once, either in writing or in speaking (within and across modality).

At the beginning of their text session the subjects were told that they were participating in a study of the organization and production of handwriting and speech. They were also informed that production times would be recorded during the experiment, and they were instructed to be as fast and as accurate as possible at each task. Each session began with the following instructions:

> This is a study in writing and speech, and I am interested in knowing how fast we can write and talk. I will ask you to write (or say) the passage you have just learned. When I say "ready-begin" you will start writing (or talking). You need to write (or talk) as quickly and as accurately as possible. Try not to leave words out or to use any extra words or sounds. When we write we often stop and go back to read it again. This time I would like you not to do this. If you made a mistake you can correct it just after you thought you made the mistake, but not before you start a new word. You also need not to abbreviate words when you write or talk; just write or say the whole word. I encourage you not to worry about spelling.

Speed and accuracy were given equal emphasis in the instructions. After these instructions were given, the first phase of the experiment began, followed by the second phase (repetition).

Design

A separate group design was used with the groups differing according the experimental conditions to which they were assigned. The experimental conditions will be referred to as W-W (first writing, second writing), T-T (first talking, second talking), W-T (first writing, second talking), and T-W (first talking, second writing). The W-W and T-T conditions will be designated as "within-modality" conditions; W-T and T-W, as "across-modality" conditions.

In each experimental condition there was one "experimental" group and one control group (16 subjects in each group) which only differed in terms of the stimulus relation (repeated non-repeated) they received. Thus, the experimental groups produced two repeated (R) passages in one of the following condition combinations: W_A W_A or W_B W_B; T_A T_A or T_B T_B; W_A T_A or W_B T_B; and T_A W_A or T_B W_B, whereas the control groups produced non-repeated passages (NR): W_B W_A or W_A W_B; T_B T_A or T_A T_B; W_B T_A or W_A T_B; and T_B W_A or T_A W_B).

Subjects were randomly assigned to one of the above combination groups. There were 16 subjects in each of the experimental groups and each of the control groups. In assigning subjects to different groups, the same percentage of male/female individuals were randomly assigned in each of the modality combination conditions.

Repeated Stimulus groups: In the W-W condition half of the subjects were required to write passage A once on a single page and then immediately after this to reproduce the exact passage by writing it on another page; the other half wrote passage B and then reproduced it. In the T-T condition, half subjects had to (recite) passage A and then to repeat it, whereas the other half received passage B to produce and repeat. In the W-T condition half of the subjects wrote first and then recited passage A, whereas the other half produced passage B in the same way. In the final condition, T-W, passage A was spoken first followed by its written version and passage B was produced in the same way.

Non-Repeated Stimulus groups: The same stimuli generation procedure was followed with respect to modality combination as in the experimental groups, except that now all the control subjects produced both passages A and B. In each of the conditions half of the subjects produced passage B first followed by passage A, and the other half produced passage A first followed by passage B. The control items provide the baseline against which any repetition effects are assessed. (See Table 1 with further explanations.)

Experimental Task

The experimental task was to produce each passage as quickly and accurately as possible. For all conditions, generation times were measured with a stop watch, and the talking mode of any condition combination was tape recorded. This allowed identification and scoring of production errors at a later time. The data of interest in the study were the absolute production speed for any passage and condition combination. Thus, response times were measured starting when the subjects began the passage and ending when subjects completed the passage. In fact, for estimating the magnitude of any repetition effect, the obtained measures fall into three categories for probe passages: a) measures for passages primed by an encounter in the same modality; b) measures for passages primed by an encounter in a different modality; and c) measures not encountered (control measures).

TABLE 1: Design of Experiment 1

Assignments of Passages to Experimental Conditions

ORDER OF LEARNING STIMULUS PASSAGES	MODALITY: SAME (a)		MODALITY: DIFFERENT (b)		STIMULUS RELATION
	W-W	T-T	W-T	T-W	
A,B	A A	A A	A A	A A	Repeated
B,A	B B	B B	B B	B B	Repeated
	(c_a)		(c_b)		
B,A	B A	B A	B A	B A	Non-Repeated
A,B	A B	A B	A B	A B	Non-Repeated

Assignment of Subjects to Experimental Conditions:
Eight college students and eight fourth graders were assigned to each of cell of the matrix of "Assignments of Passages to Experimental Conditions."

MEASURES OBTAINED:

a = repetition in same modality

b = repetition in different modality

c = non-repetition in same modality

c = non-repetition in different modality

INTERPRETATION:

Difference between (a) and (c_a) = within-modality effect.

Difference between (b) and (c_b) = across-modality effect.

EXPERIMENT 2

Experiment 2 examined the effects of same modality and modality change in the magnitude of repetition benefit both when text is copied by writing and when text is read aloud.

Subjects

Subjects were the same two-hundred and fifty-six students half in the 4th grade and half undegraduates who participated in Experiment 1. The within Experiment group structure was just like that in Experiment 1.

Material and Procedure

Each subject participated in one 10 minute session. The procedures were the same as in Experiment 1, except that now instead of generation from memory, copying of text or reading aloud was used. For each subject, the stimulus materials came from the two passages (henceforth designated D and E) that were not encountered in Experiment 1. Thus, half the subjects were asked to copy a passage (either D or E) from a typed page twice by writing or by reading it aloud. The other half were asked to write or read aloud two non-repeated passages (D and E). The second production of the text was either in the same modality or in different modality from the first production (see Table 2).

For the reading condition subjects were asked to read the passage aloud as quickly and as accurately as possible so that others would understand. For the writing condition instructions were the same as in Experiment 1. Subjects were informed again that production times would be recorded and that the spoken session would be tape recorded. They were also told that they could listen to their voices after they are finished.

The design used was the same as in Experiment 1. The experimental conditions were C-C (first copying, second copying) R-R (first reading, second reading), C-R (first copying, second reading), and R-C (first reading, second copying). The experimental groups copied or read two repeated passages in one of the follwing condition combinations: C_D C_D or C_E C_E; R_D R_D or R_E R_E; C_D R_D or C_E R_E; and R_D C_D or R_E C_E, whereas the control groups produced non-repeated passages (C_D C_E or C_E C_D; R_D R_E or R_E R_D; C_E R_D or C_D R_E; and R_E C_D or R_D C_E).

Reliability

During the administration of the experimental task, reliability measures were taken for response time. To measure reliability for timing the subjects' written and spoken passages, a second trained person independently timed 10% of experimental sessions at each age level.

Reliability was calculated on a point-to-point comparison basis. Interrater reliability for timing ranged from .93 to .99 with a mean of .96.

TABLE 2: Design of Experiment 2

Assignments of Passages to Experimental Conditions

ORDER OF LEARNING STIMULUS PASSAGES	MODALITY SAME (a) C-C	SAME (a) R-R	DIFFERENT (b) C-R	DIFFERENT (b) R-C	STIMULUS RELATION
D,E	D D	D D	D D	D D	Repeated
E,D	E E	E E	E E	E E	Repeated
	(c_a)		(c_b)		
E,D	E D	E D	E D	E D	Non-Repeated
D,E	D E	D E	D E	D E	Non-Repeated

Assignment of Subjects to Experimental Conditions:
Eight college students and eight fourth graders were assigned to each of cell of the matrix of "Assignments of Passages to Experimental Conditions."

MEASURES OBTAINED:

a = repetition in same modality

b = repetition in different modality

c = non-repetition in same modality

c = non-repetition in different modality

INTERPRETATION

Difference between (a) and (c_a) = within-modality effect.

Difference between (b) and (c_b) = across-modality effect.

CHAPTER IV

RESULTS

EXPERIMENT 1

Data Analysis

The production time data were analysed to examine the issues that have been addressed in the introduction of this paper:

1. Does skill in Writing or Talking increase as a function of repetition?
2. If there is repetition benefit, what is the magnitude of this benefit in Writing compared to that of Talking?
3. Does the effect of practice in Writing modality have any facilitation on modality of Talking and vice versa?
4. Does this repetition effect change developmentally, and if so, how?

The main analysis consisted of 2x2x2x2x2 Analysis of Variance (ANOVA). The analysis compared first and second writing and talking production times to establish the occurrence of repetition, target task modality, practice modality, and grade effects. For the ANOVA the between-subjects factors were grade level (College students or fourth graders), repetition (repeated stimulus passage or non-repeated), target task modality (Writing or Talking), and practice modality (same or different). The within subjects factor was trial (first production, second production).

Results

For the purpose of the issues addressed in this study, the effects of most interest are those that involve the influence of a variable on the magnitude of the repetition effect. The presentation of the results will begin with the main effects of all the variables manipulated in the study, simply to establish which ones were effective in an overall way.

Fisrt, there was a significant main effect of repetition, $F(1,239) = 55.205$, $p < 0.01$. That is, repeated stimulus passages ($M = 40.0$ sec) were produced faster than non-repeated (new) passages ($M = 46.0$ sec). Second, there was a significant main effect for target task modality (Writing or Talking), $F(1,239) = 835.848$, $p < 0.01$. Thus, production performance was slower in Writing ($M = 57.8$ sec) than in Talking ($M = 27.8$ sec). Third, a significant main effect for grade level was observed with fourth graders ($M = 55.0$ sec) spending more time on each production than college students ($M = 30.0$ sec), $F(1,239) = 594.877$, $p < 0.01$. Finally, the main effect for practice modality (whether same or different) was not significant, $F(1,239) < 1$, nor was the main effect of trial, $F(1,239) < 1$.

Though the main effect of Repetition is significant, it is important to note that the interaction between <u>repetition</u> and <u>trial</u> is the real index of the passage-specific repetition effects that are the focus of this study.

A significant interaction was observed between stimulus repetition and trial, $F(1,239) = 41.392$, $p < 0.01$. As shown in Figure 1, second trial times were reduced when a given passage was repeated, whereas they were actually increased when the passage was new (non-repeated). Thus, repeating a passage clearly helped production performance. The magnitude of this repetition effect changed developmentally as shown by the three factor interaction of grade level, repetition status, and trial, $F(1,239) = 6.751$, $p < 0.01$. This interaction is shown in Figure 2 where second trial times for both College students and fourth graders were reduced in repeated passages, whereas time was increased in the non-repeated passages. However, the size of these repetition effects was larger in the performance of the fourth graders.

As we have just seen, there is a repetition effect sensitive to developmental changes. Now the question arises

FIGURE 1: Mean performance Times (in seconds) in Experiment 1 as a Function of Repetition and Trial.

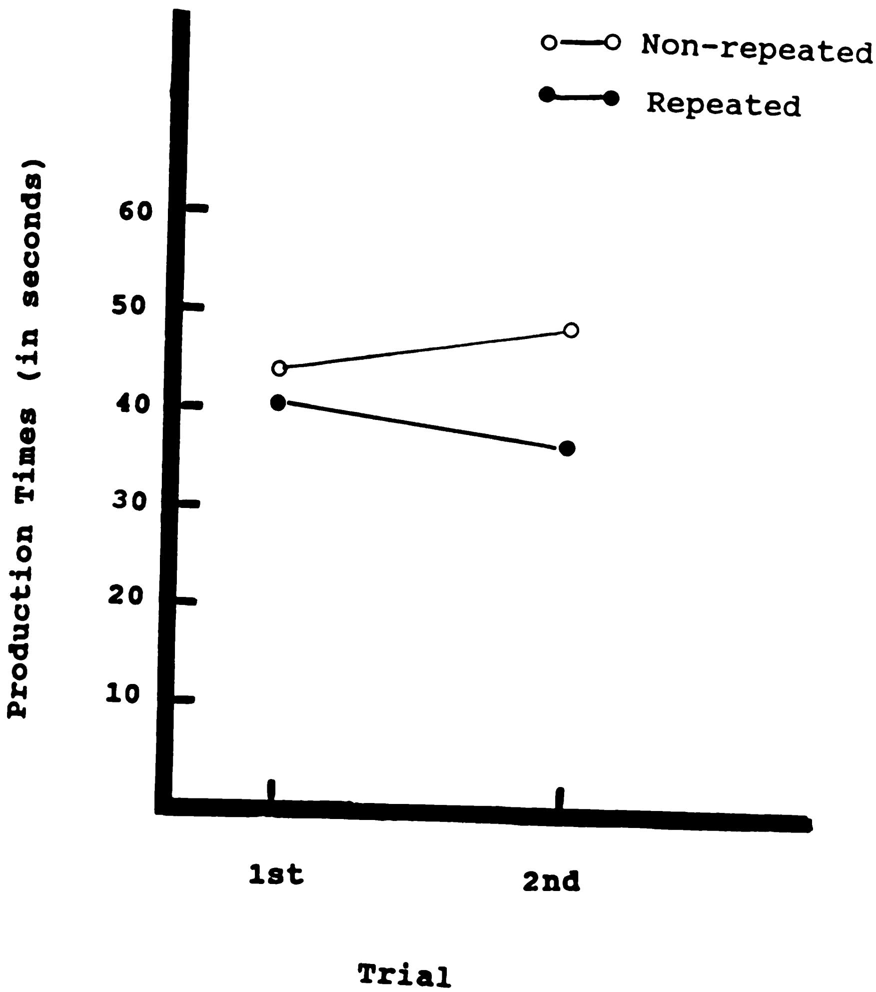
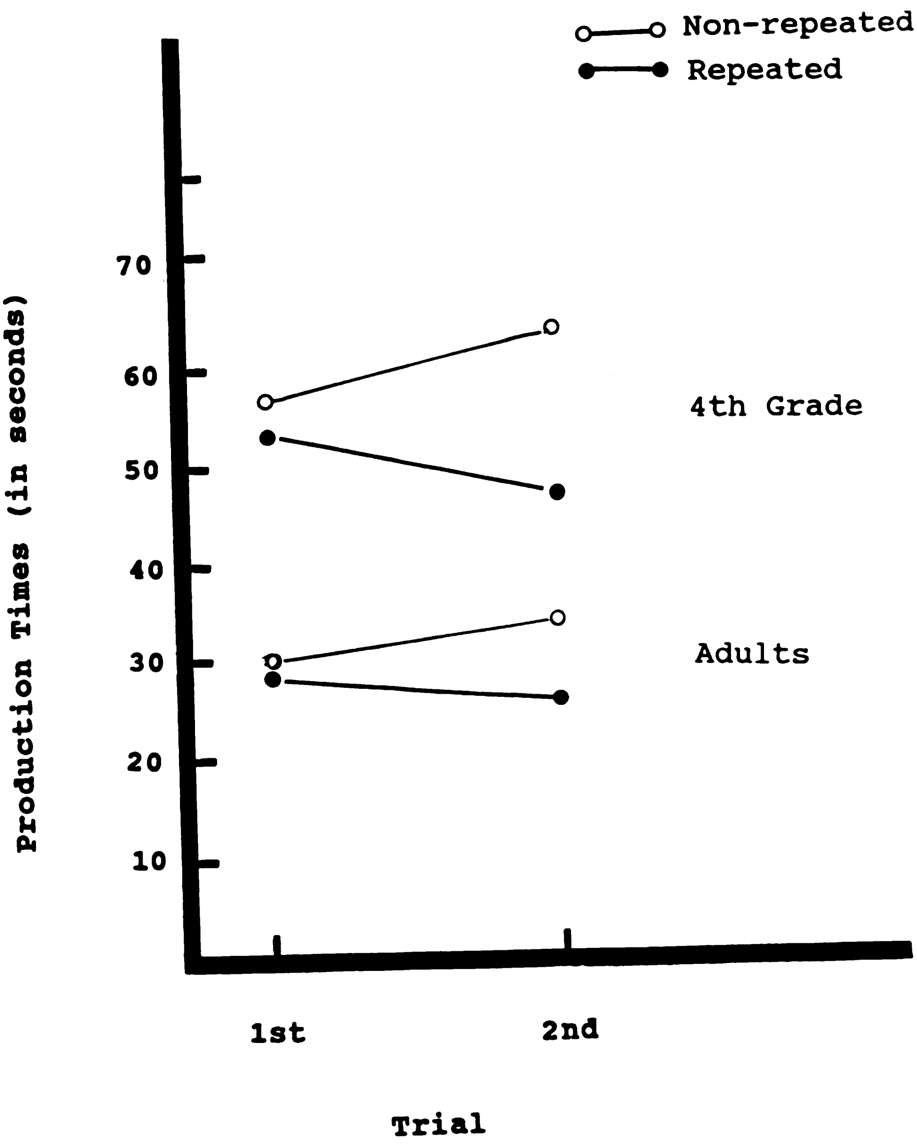


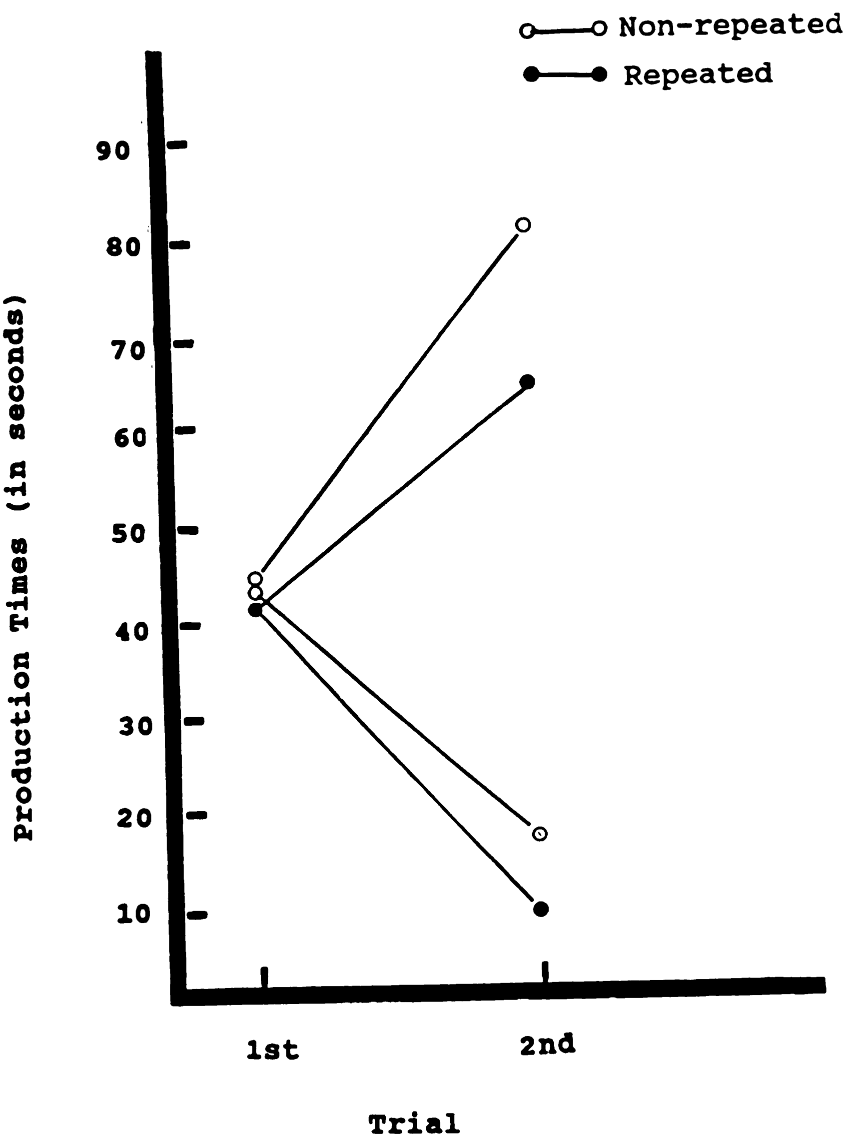
FIGURE 2: Mean Performance Times (in seconds) in Experiment 1 as a Function of Grade Level, Repetition, and Trial.



whether there is a sensitivity of these repetition benefits to task modality. The influence of modality on the repetition effect was tested by the interaction between target task modality (Writing or Talking), repetition, and trial (first or second). The observed three-factor interaction was significant, $F(1,239) = 7.348$, $p < 0.01$. As can be seen in Figure 3, second production times were faster when the same passage was repeated, but the size of the increase was larger for Writing than for Talking.

We now turn to the question of whether the effect of practice in one modality has any facilitation on another as yet unpracticed modality. First, the overall influence of practice modality on repetition was tested by the three factor interaction involving practice modality (same or different), repetition, and trial (first or second). This interaction was not significant, $F(1,239) < 1$. Second production times were reduced when the passage being produced was repeated and practice was in the same modality. However, this was also true for a passage that was practiced in a different modality. Similarly, second production times were increased when the passage was not repeated, and this also happened for both same-modality and different-modality practice. If one computes the difference between repeated and non-repeated second production times, this difference is 13.0 sec for same-modality practice and 11.4 sec for different-modality -- figures that are very close in

FIGURE 3: Mean Performance Times (in seconds) in Experiment 1 as a Function of Target Task Modality, Repetition, and Trial.



size.

The null result of practice modality just described collapses across target task. One can speculate whether any modality specificity might become apparent when the two target tasks are considered individually. This was tested by the four factor interaction between practice modality, target task modality, repetition, and trial. This interaction was not significant either, $F(1,239) = 1.415$, $p > 0.05$. Second production time in T - T condition is quite similar to second production time in the W - T condition, and second production time in the W - W condition is quite similar to second production time in the T - W condition.

With respect to the effects of practice modality, the same pattern of results was obtained from the fourth graders as from the adults as shown by the non-significance of the grade x practice modality x repetiton x trial interaction, and the grade x practice modality x task modality x repetiton x trial interaction.

We turn first to the four factor interaction, grade x practice x repetition x trial which tested the influence of practice modality (same or different) on repetition for both fourth graders and adults. This interaction was not significant, $F(1,239) < 1$. Second production times for both fourth graders and College students were reduced when the passage being produced was repeated and practice was in the same modality. However, this was also true for a passage that was practiced in different modality.

If one computes the difference between repeated and non-repeated second production times, this difference for the adults is 8.4 sec for same-modality practice and 6.7 sec for different-modality. Similarly, for fourth graders the difference between repeated and non repeated second production times is 17.7 sec for same-modality practice and 16.1 sec for different-modality. Obviously, these figures of difference for same and different modality practice are very close in size for both fourth graders and adults.

Given the null result of practice modality for both fourth graders and adults, one can speculate whether any developmental difference in modality specificity might become apparent when the two target tasks are considered individually. This, in fact, was tested by the five factor interaction between grade level, practice modality, target task modality, repetition, and trial. This interaction was not significant either, $F(1,239) = 1.081$, $p > 0.05$.

As we can see in Table 3, for the adults second production times in T - T is quite similar to second production times in the W - T condition; and second production times in the W - W condition is quite similar to second production times in the T - W condition. If one computes the difference between repeated and non- repeated second production times, this difference is 7.40 sec when

TABLE 3. Mean Performance Times (in seconds) for First and Second Productions as a Function of Practice Modality, Target Task Modality, Repetition, and Grade Combination.

		MODALITY							
		T - T		W - T		T - W		W - W	
	STIMULUS	1st	2nd	1st	2nd	1st	2nd	1st	2nd
ADULTS	Non-Rep	12.0	14.2	48.7	13.0	10.0	55.2	51.8	55.3
	Repeat	8.5	6.8	47.2	7.9	8.5	46.9	50.1	45.9
4th GRADE	Non-Rep	15.2	16.7	98.5	26.7	15.1	105.2	100.0	108.0
	Repeat	12.9	10.2	93.7	12.6	11.9	87.1	93.6	79.0

practice is Writing and target task modality is Talking (W - T) the difference is 5.1 sec. In the W - W condition this difference is 9.4 sec, whereas in the T - W condition the difference is 8.3 sec.

Computing the analogous difference between repeated and non-repeated second production times for fourth graders, we can see that this difference is 6.50 sec for T - T, and 14.04 sec for W - T. In the W - W condition the difference between repeated and non repeated second production times is 28.8 sec , whereas for T - W the difference is 18.1 sec.

Despite the non-significance of the interaction, these differences give the impression that fourth graders did show modality specificity even though college students did not. However, there were also baseline differences between groups of subjects on first production times that need to be taken into account. When this is done in a way that will be described next, the impression of modality specificity disappears.

The magnitude of the passage-specific repetition benefit, with first-production baseline taken into account, was measured by computing the mean difference between first and second production times in both repeated and the non-repeated conditions, then subtracting the difference in the non-repeated condition from the difference in the repeated condition. For the fourth graders this resulting repetition benefit is 4.26 sec when practice and target modality are both Talking (the T - T condition). When practice is Writing and target task is Talking (W - T) the benefit is 9.26 sec. In the W - W condition this benefit is 22.35 sec, whereas in the T - W condition the benefit is 14.9 sec.

Similarly, for the adults the repetition benefit is 3.85 sec for T - T, and 3.52 sec for W - T. In the W - W condition the repetition benefit is 8.49, whereas for T - W the benefit is 6.49 sec. The magnitude of repetition benefit as a function of age, practice modality and target task modality is shown in Table 4 and Figure 4.

Summary

In summary, first it has been shown that repetition improves Writing and Talking speed. This repetition effect is sensitive to developmental changes. That is, the size of the effect is larger in the performance of fourth graders.

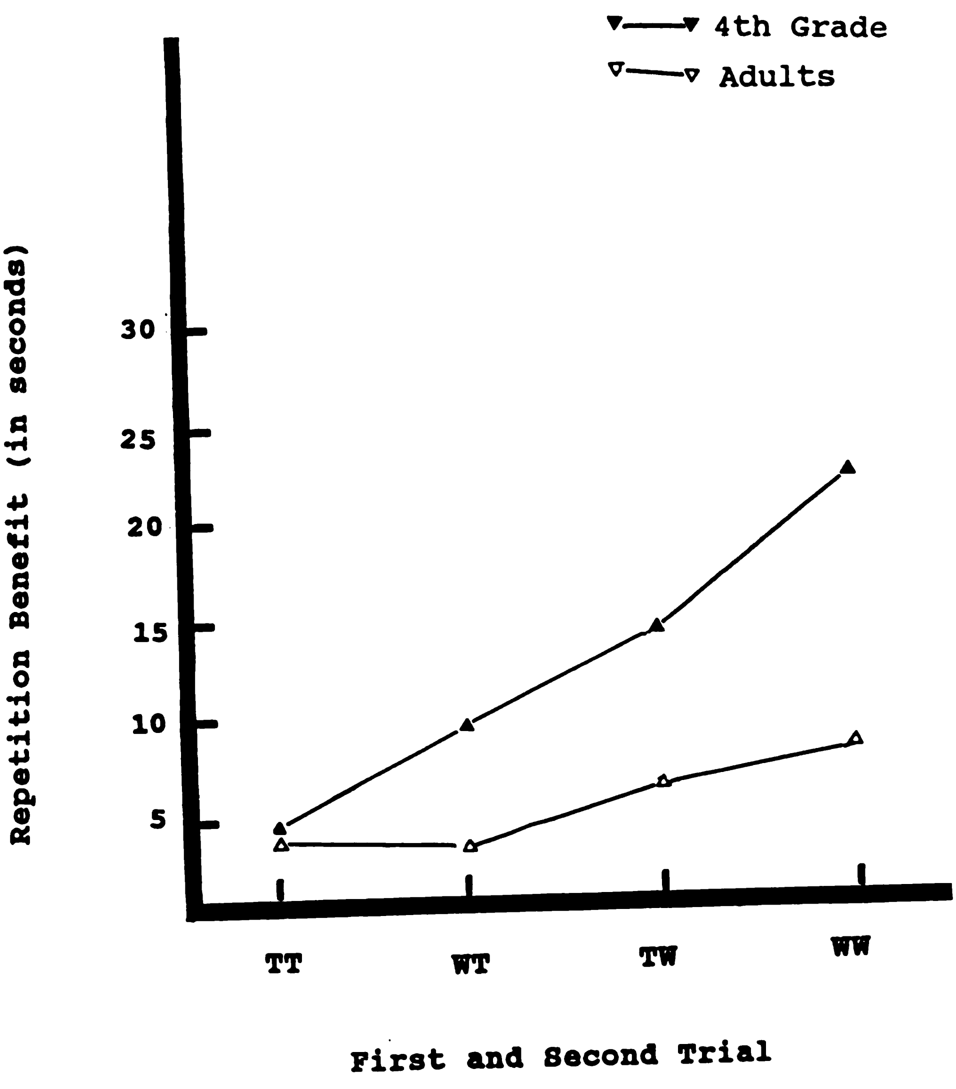
Second, repetition effects are sensitive to target task modality, and the modality difference is sensitive to developmental changes. Both fourth graders and adults benefited more when task modality was Writing than when it was Talking; but even more, the effect of target task modality was larger for fourth graders.

Third, repetition effects are not influenced by practice modality in either fourth graders or adults. Thus, a complete cross modality repetition effect is observed in the performance of both fourth graders and adults.

TABLE 4. Magnitude of Repetition Benefit as a Function of Practice Modality, Target Task Modality and Age.

	PRACTICE MODALITY			
	ADULTS		FOURTH GRADERS	
TARGET TASK MODALITY	T -	W	T -	W
Talking	3.85	3.52	4.26	9.26
Writing	6.49	8.49	14.83	22.3

FIGURE 4: Magnitude of Repetition Benefit as a Function of Practice Modality, Target Task Modality and Age.



EXPERIMENT 2

Data Analysis

The performance time data were analysed to examine the issues of interest in Experiment 2. The issues and the approach to the analysis are analogous to those of Experiment 1. These issues are:

1. Does skill in Copying or Reading increase as a function of repetition?
2. If there is repetition benefit, what is the magnitude of this benefit in Copying compared to that of Reading?
3. Does the effect of practice in the Copying modality have any facilitation on the modality of Reading and vice versa?
4. Does this repetition effect change developmentally, and if so, how?

The analysis consisted of 2x2x2x2x2 Analysis of Variance (ANOVA). The analysis compared first and second copying and reading production times to establish the occurrence of repetition, target task modality, practice modality, and grade effects. The between-subjects factors in this analysis were grade level (College students or fourth graders), repetition (repeated or non-repeated stimulus passage), target task modality (Copying or

Reading), and practice modality (same or different). The within-subjects factor was trial (first performance, second performance).

Results

The effects of most interest in Experiment 2 are again those that involve the influence of a variable on the magnitude of the repetition effect. The presentation of results will begin with the main effects of all variables to establish which ones were effective in an overall way.

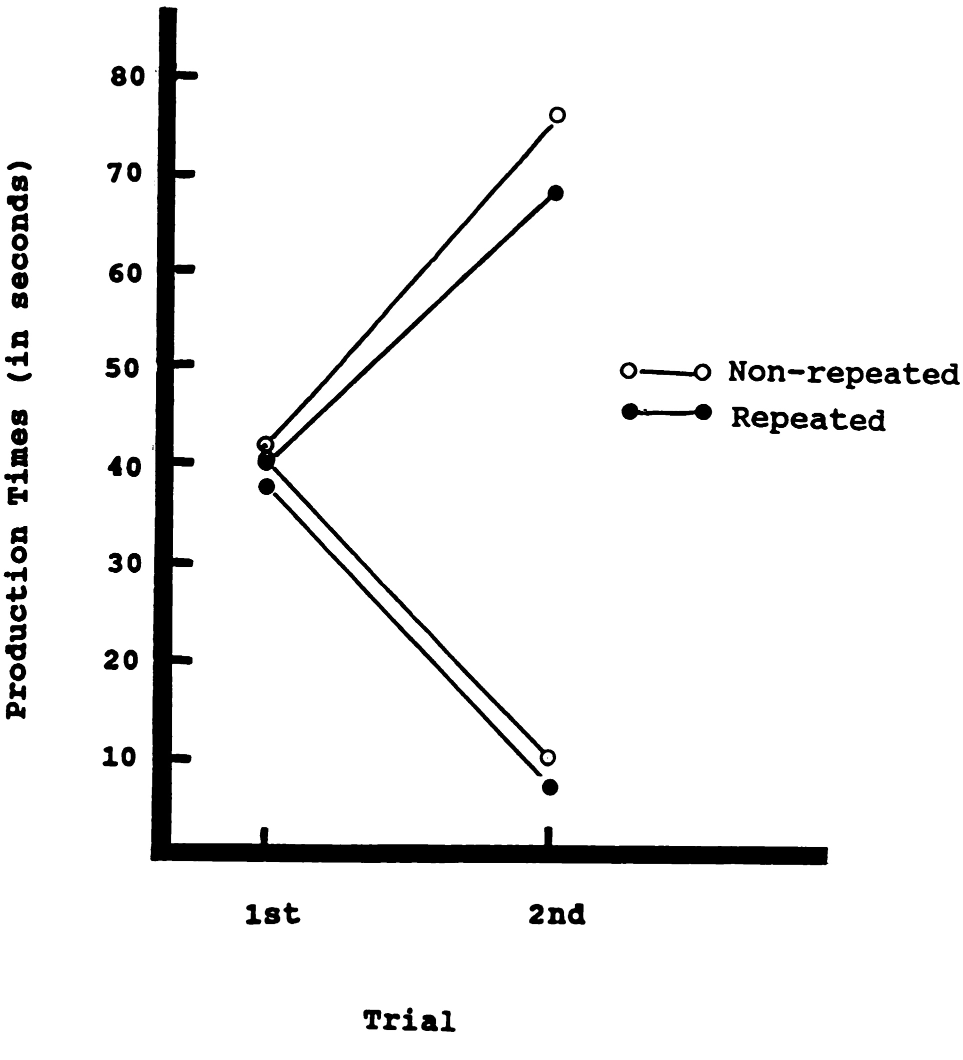
As in Experiment 1, first there was a significant main effect of repetition, $F(1,240) = 12.672$, $p < 0.01$. That is, repeated stimulus passages ($M = 38.0$ sec) were produced faster than non-repeated (new) passages ($M = 42.0$ sec). Second, there was a significant main effect for target task modality (Copying or Reading), $F(1,240) = 775.162$, $p < 0.01$. Thus, performance was slower in Copying ($M = 57.0$ sec) than in Reading ($M = 24.0$ sec). A significant main effect for grade level was also observed with fourth graders ($M = 55.0$ sec) spending more time on each performance than college students ($M = 25.6$ sec), $F(1,240) = 639.628$, $p < 0.01$. The main effect for practice modality (whether same or different) was not significant, $F(1,240) < 1$, nor was the main effect of trial, $F(1,240) = 1.067$, $MSe = 47.873$, $p > 2$.

Though the main effect of repetition is significant, the interaction between repetition and trial is the real index of the passage-specific repetition effects that are the focus of the study.

A non-significant interaction was observed between stimulus repetition and trial, $F(1,240) < 1$. Second trial times were very little reduced when a given passage was repeated, whereas they were almost the same when the passage was new (non-repeated). Thus, repeating a passage made very little difference in the performance. This non significant repetition effect was not influenced by grade level as shown in the three factor interaction between grade level, repetition, and trial, $F(1,240) < 1$. Again, second production times for both College students and fourth graders were very little reduced in repeated passages, whereas time was slightly increased in the non-repeated passages.

Thus, at an overall level, collapsed across target task modality, it would appear that there were almost no repetition benefits in Experiment 2. However, the three-factor interaction between target task modality (Copying or Reading), repetition (repeated stimulus passage or new), and trial (first or second) was significant, $F(1,240) = 9.062$, $p < 0.01$. As shown in Figure 5, this interaction indicates that repetition benefits did occur, but they were restricted to one of the target task modalities, Copying. Computing

FIGURE 5: Mean Performance Times (in seconds) in Experiment 2 as a Function of Target Task Modality, Repetition and Trial.



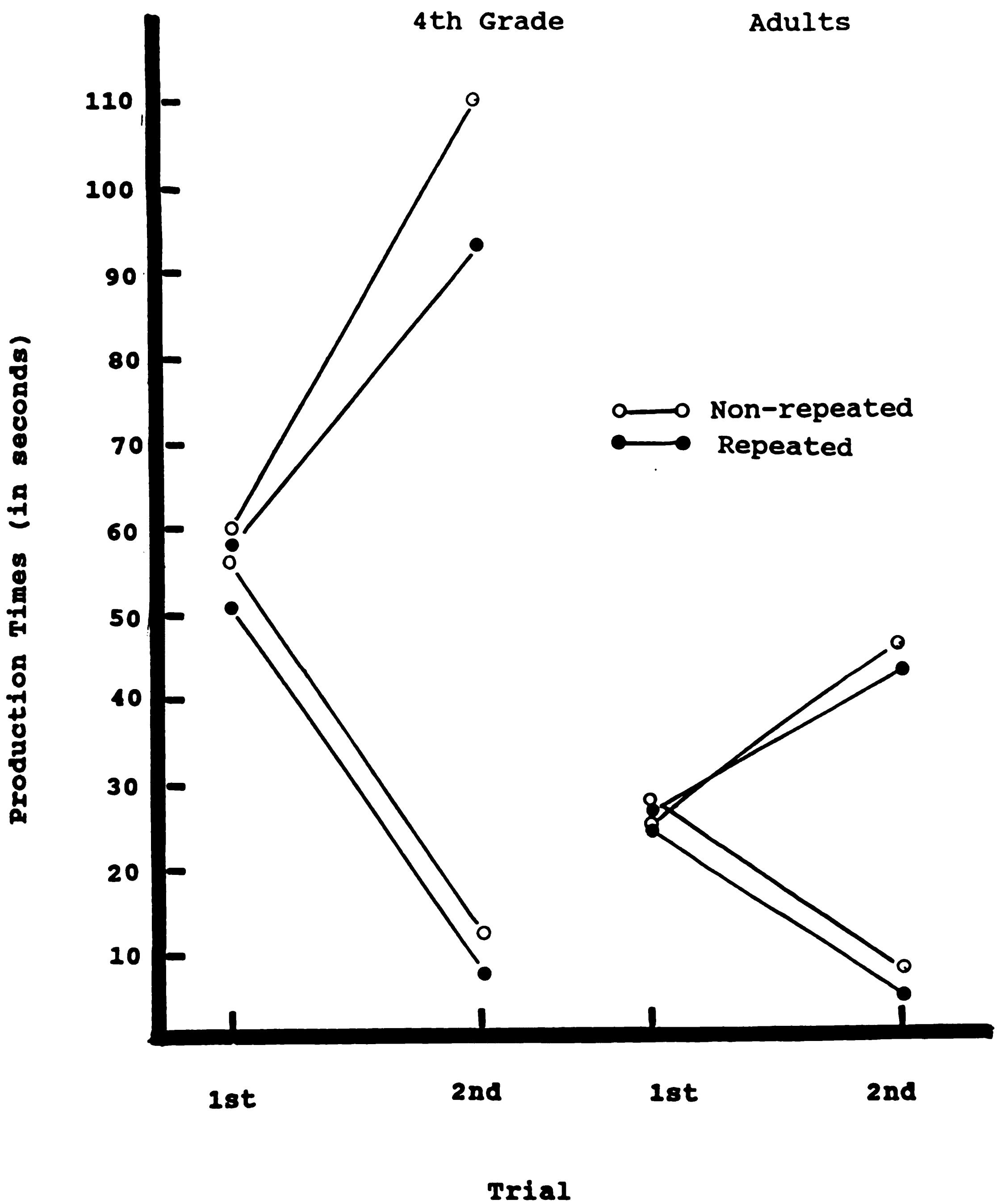
difference between repeated and non-repeated second production times, this difference is 8.37 sec for Copying but only 2.14 sec for Reading.

If one takes a step further with first production baseline taken into account, following the same procedures as in Experiment 1, the resulting repetition benefit is 5.8 sec when target task modality is Copying, whereas this benefit is -1.52 sec when target task modality is Reading. Thus, facilitation due to repetition is restricted entirely to Copying.

The magnitude of the repetition benefit in Copying changed develomentally as shown by the significant four-factor interaction of grade level, target task modality, repetition status, and trial, $F(1,240) = 6.599$, $p < 0.05$. This interaction is shown in Figure 6 where the size of repetition benefit was larger in the performance of the fourth graders, especially when target modality was Copying.

Computing the difference between repeated and non-repeated second production times, this difference for the adults is 2.0 sec when target modality is Copying and 1.5 sec when it is Reading. For fourth graders the difference between repeated and non-repeated second trial times is 14.7 sec when target modality is Copying and 3.1 sec when it is Reading. With first production baseline taken into account, the resulting repetition benefit for the adults is 0.96 sec

FIGURE 6: Mean Performance Times (in seconds) in Experiment 2 as a Function of Grade Level, Target Task Modality, Repetition, and Trial.



when target task modality is Copying and <u>-0.12</u> sec when target task modality is reading. For fourth graders the repetition benefit is <u>10.7</u> sec when target modality is Copying, whereas this benefit is <u>-2.88</u> sec when target task modality is Reading. Thus, the facilitation effects already found to be isolated in Copying are enjoyed primarily by fourth graders rather than by adults.

We now turn to the question of whether effect of practice in one modality has any facilitation on another as yet unpracticed modality. The overall influence of practice modality on repetition was tested by the three-factor interaction involving practice modality (same or different), repetition, and trial. This interaction was not significant, $F(1,240) < 1$.

The null result of practice modality just reported collapses across target task. One can speculate whether any modality specificity might be observed when the two target tasks are considered individually. This was tested by the four factor interaction between practice modality, target task modality, repetition, and trial. This interaction was not significant either, $F(1,240) = 1.454$, $p > 0.05$. Second production time in Reading - Reading (R - R) condition is quite similar to second production time in the Copying - Reading (C - R) condition, and second production time in the Copying - Copying (C - C) condition is quite similar to second production time in the Reading - Copying (R - C) condition.

With respect to the effects of practice modality, the same pattern of results was obtained from the fourth graders as from the adults as shown by the non-significance of the grade x practice modality x repetition x trial interaction, and the grade x practice modality x task modality x repetition x trial interaction.

We start first with the grade x practice x repetition x trial interaction which tested the influence of practice modality (same or different) on repetition for both fourth graders and adults. This interaction was not significant, $F(1,240) = 1.569$, $p > 0.05$. Second production times for both fourth graders and College students were reduced when the passage being produced was repeated and practice was in the same modality. However, this was also true for a passage that was practiced in different modality.

If one computes the difference between repeated and non-repeated second production times, this difference for the adults is 2.8 sec for same-modality practice and 1.2 sec for different-modality. Similarly, for fourth graders the difference between repeated and non repeated second production times is 11.4 sec for same-modality practice and 6.4 sec for different-modality.

Given the null result of practice modality for both age groups, the question arises whether any developmental difference in modality specificity might be observed when the two target tasks are considered individually. This was tested by the five factor interaction between grade level, practice modality, target task modality (Copying or Reading), repetition, and trial. This interaction was not significant either, $F(1,240) = .475$, $p > 0.05$. As it can be seen in in Table 5, for the adults second production time in R - R is quite similar to second production time in the C - R condition; and second production time in the C - C condition is quite similar to second production time in the R - C condition.

Computing the difference between repeated and non-repeated second production times, this difference is 1.3 sec when practice and target modality are Reading (R - R). When practice is Copying and target task is Reading (C - R) the difference is 1.0 sec. In the C - C condition this difference is 2.6 sec, whereas in the R - C condition the difference is 1.4 sec.

Computing the analogous difference between repeated and non-repeated second production times for fourth graders, we can see that this difference is 3.6 sec for R - R and 2.6 sec for C - R. In the C - C condition the difference between repeated and non repeated second production times is 19.2 sec, whereas for R - C the difference is 10.3 sec.

Despite the non significance of the interaction, these figures of difference give the impression that fourth graders did show modality specificity, especially when

TABLE 5. Mean Performance Times (in seconds) in Experiment 2 for First and Second Productions as a Function of Practice Modality, Target Task Modality, Repetition, and Grade Combination.

		MODALITY							
		R - R		C - R		R - C		C - C	
	STIMULUS	1st	2nd	1st	2nd	1st	2nd	1st	2nd
ADULTS	Non-Rep	7.1	7.1	48.8	6.7	6.5	45.6	43.5	44.4
	Repeat	6.7	5.8	46.6	5.7	6.3	44.2	41.8	41.8
4th GRADE	Non-Rep	10.4	11.3	101.0	11.1	11.2	103.5	109.4	111.9
	Repeat	9.6	7.7	90.1	8.5	10.4	93.2	102.0	92.7

target task modality was Copying, even though College students did not. However, taken into account the baseline differences between groups of subjects on _first_ production times this modality specificity is not present.

The magnitude of the passage-specific repetition benefit, with first production baseline taken into account, was computed as in Experiment 1. For the fourth graders this resulting repetition benefit is _2.88_ sec when practice and target modality are both Reading (the R - R condition). When practice is Copying and target task modality is Reading (C - R) the benefit is _-8.75_ sec. In the C - C condition the repetition benefit is _11.8_ sec, whereas for the R - C condition the repetition benefit is _9.48_ sec. Similarly, for the adults the repetition benefit is _0.94_ sec for R - R, and _-1.2_ sec for C-R. In the C - C condition the repetition benefit is _0.9_ sec, whereas for R-C the benefit is _1.18_ sec. The magnitude of repetition benefit as a function of age, practice modality, and target task modality is shown in Table 6 and in Figure 7.

Summary

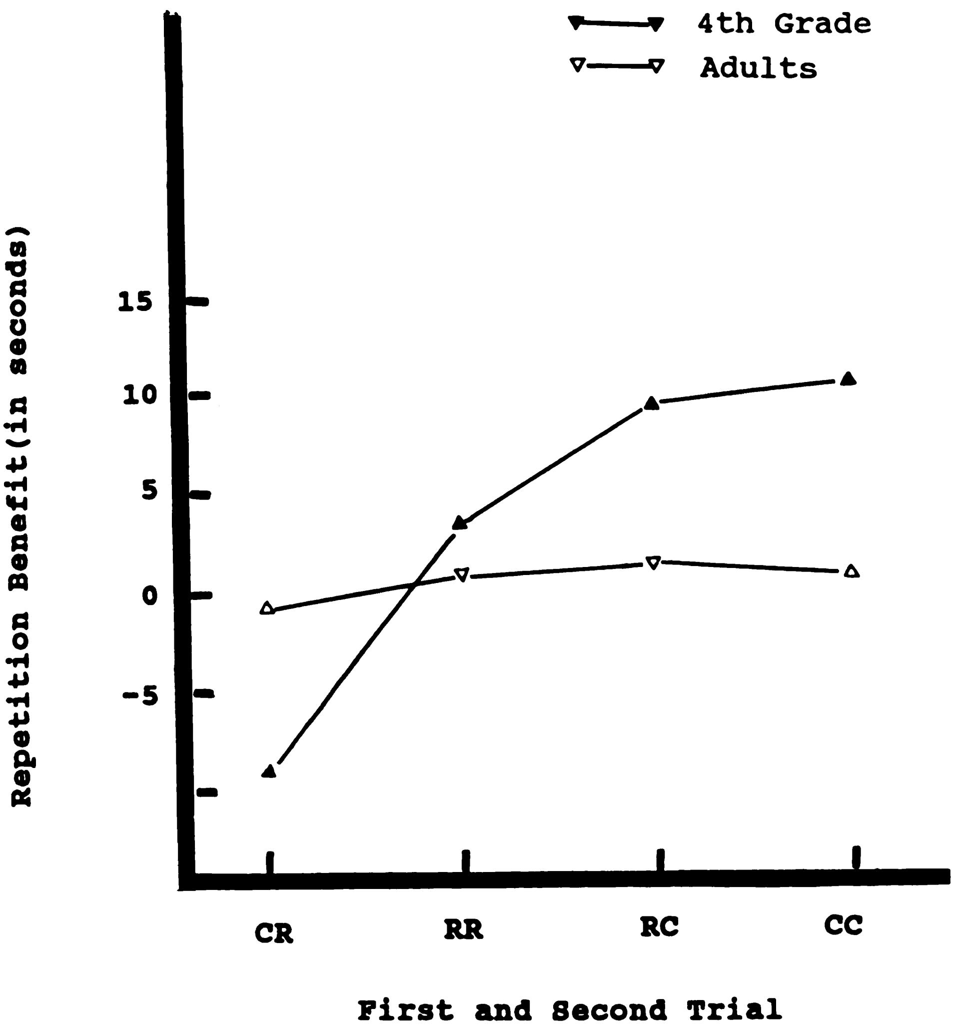
In summary, the results of Experiment 2 show first that repetition improves Copying, at least among fourth graders, but has little effect on Reading at either grade level. That is, although repetition benefits did occured, they were restricted to one modality, to that of Copying; and this effect of repetition on Copying was largely restricted to the performance of fourth graders.

Second, the results show, as in Experiment 1, that repetition effects that did occur are not influenced by practice modality in either fourth graders or adults.

TABLE 6. Magnitude of Repetition Benefit as a Function of Practice Modality, Target Task Modality and Age.

	PRACTICE MODALITY			
	ADULTS		FOURTH GRADERS	
TARGET TASK MODALITY	R -	C	R -	C
Reading	0.94	-1.2	2.88	-8.75
Copying	1.18	0.9	9.48	11.8

FIGURE 7: Magnitude of Repetition Benefit as a Function of Practice Modality, Target Task Modality and Age.



CHAPTER V

DISCUSSION

The effect of practice on perceptual processing has been the focus of substantial research recently. But despite the extensive investigation on the perceptual domain, analogous research on the production domain is scarce in the literature of repetition effects. Furthermore, developmental data on the issue are completely lacking.

The purpose of this study was to focus on the nature of the representation underlying repetition effects in text generation tasks. Text generation in Writing and Talking was examined in individuals at two age levels: undergraduates and fourth graders. Experiment 1 examined the effects of same and different output modality on the magnitude of repetition benefits, both when written text was being generated from memory and when spoken text was being generated from memory. Experiment 2 examined the effects of same and different modality conditions on the magnitude of repetition benefits when text was copied by writing and when text was read aloud.

Both of these experiments support an abstractionist position of the processes of production tasks involved in

Writing and Talking. In Experiment 1, for both production tasks, whether Written or Spoken from memory, second production times were uninfluenced by whether the first production was Written or Spoken. That is, benefits of repetition were undiminished by modality manipulation during the practice and test phase. A complete cross-modality repetition effect was observed, and this was exactly what an abstractionist account would have predicted. The output in this study shows that mature writers and speakers can abstract across the differences in modality between Written and Spoken text of the words' referents, so that the learning supporting repetition benefit occurs at an abstract, conceptual level of processing at which the two output modalities are equivalent for the purposes of the generation task.

This phenomenon of complete transfer of repetition effect between written text and spoken text also occurred for fourth graders. In fact, the benefit of repetition was larger for fourth graders and even larger when the target task modality was Writing. This probably can be explained by the fact that fourth graders have less experience in Writing and, hence, have more room for improvement.

In Experiment 2, the results are weaker as compared to those of Experiment 1 because repetition effects were much less in evidence. However, the repetition effects that did occur were again uninfluenced by practice modality in either fourth graders or adults.

One could ask, of course, "how in principle could an abstractionist position --as represented, for example, by a logogen model -- account for Writing and Talking?" We know already from the introduction of this paper that Morton's original logogen model (Morton, 1969) would have predicted cross-modality facilitation on recognition tasks. And this is because abstract, conceptual word representations (logogens) from past experiences were not tied to a particular modality; therefore, any form of a word (whether written or spoken) would be equivalently involved in eliciting a vocalized or a written form of the word.

In 1979, and in 1980 Morton added a distinction between "input logogens" for perceptual recognition (auditory logogens for recognizing spoken words, and visual logogens for recognizing written words) and "output logogens" for production. In speech production, output logogens are activated by semantic information from the cognitive system and produce their phonological code. Later (1980), Morton extended his model to include "grapheme output logogens" (for writing) which by analogy are also activated by semantic information from the cognitive system.

A similar explanation of how speech production operates on activation principles is offered by Ellis (1984; Miller and Ellis 1987). These authors noted that the speech output lexicon includes a "node" for each word in a speaker's vocabulary. These "nodes" are much like Morton's logogens. A node or entry of a particular word "is activated in speaking by the prior activation of the semantic representation of the word's meaning. On being activated, the lexical entry releases or activates the spoken form of the word." If, for example, we want to talk about a specific concept, the appropriate word will be articulated since the corresponding node in the speech output lexicon is being activated by the semantic representation of that concept.

Similarly, in Writing, inputs from the semantic system and possibly inputs from the corresponding units of the speech output logogens (Ellis, 1982; Morton, 1980) activate lexical units of the orthographic output lexicon. As a lexical unit is activated, it activates the appropriate graphemes in a word, and this results in writing the correct word.

By looking at the observed facilitation of repetition in this study, we can draw some conclusions about the degree of overlap in the way Written and Spoken text are processed and also describe the flow of information processing in these output modalities.

First, we can examine the locus or level of representation at which these facilitation effects took place in Writing and Talking production tasks. It is very clear that the locus of learning that supports repetition benefit is not motoric (or peripheral). Learning does not take place at the neuromuscular execution level (i.e., articulatory movements, or hand/finger movements). If the locus of learning was at the periphery, then one would expect a modality-specific pattern of the results similar to those that have been observed in some perceptual identification tasks. That is, significant within-modality transfer but no between-modality transfer. Writing from memory would facilitate Writing, Talking would facilitate Talking, but neither of them would facilitate each other.

A second possibility regarding the locus of the learning mechanism supporting repetition benefit is that it takes place at the semantic and motor level as a result of associative connections between these two components. Under this possibility one could expect to see repetition benefit within-modality (modality-specific) and also some transfer or cross-modality facilitation; but still the within-modality would be significantly larger than that of the between-modality facilitation. Again, this is a pattern of results that has been observed in such perception tasks.

What, then, do the results of this study show? The results are very straightforward: Complete cross-modality facilitation. Therefore, the learning that supports repetition benefit in written and spoken text production from memory is at the conceptual level of processing information. The two modalities are represented in a semantic or lexical-concept system that is amodal, so within-modality and cross-modality combinations produced equal facilitation. Speaking in logogens terms, semantic representations, speech output logogen, and writing or orthographic output logogens are interconnected to produce cross-modality transfer. A suggested information-flow diagram of this mechanism is presented in Figure 8. This figure contains an attempt to show the nature of the basic architecture of information processed during Writing and Talking production tasks as represented in the form of a diagram. The components of the diagram are created as a best-guess about what it should look like based on the results of this study. The "ovals" represent stored information, and each arrow corresponds to a pathway along which information can flow from one component to another.

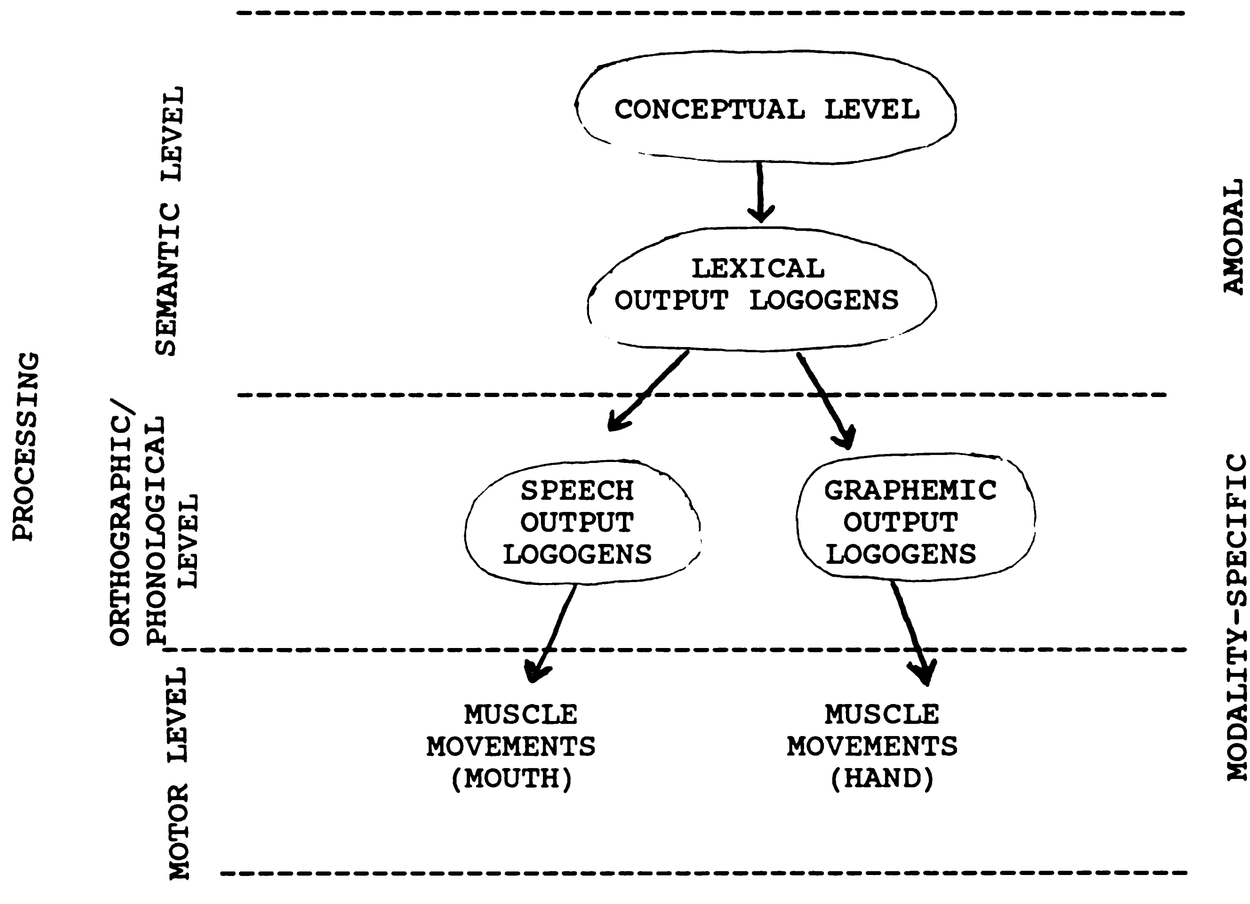
Interestingly, the absence of developmental change in practice modality effects show that this suggested organization in Writing and Talking is developed prior to grade four, or about that grade. Thus, it seems that at an early stage in the acquisition of writing skill, practice or repetition is producing learning at levels that can abstract across the written structure of language and relate its meaning to the meaning and structure of spoken language. This phenomenon may be very important in learning to write because it can allow one's understanding of written text to guide processing by taking advantage of similar conceptual experiences, even if the modality in which those experiences occur is different (e.g., Talking).

The above implication cannot of course be generalized to lower grades of normally learning students at the moment, as it is not known whether first, second, or third graders would benefit from abstract trasnsfer across modality. This is a question which hopefully can be answered in the near future by continuation of this study. It is also hoped that the issues addressed in this study will be explored in other populations, such as learning disabled individuals and neurological or other communication disordered individuals. Findings from such studies might have implications for classroom instruction and therapeutic intervention.

While the results of this study lead to the conclusion that repetition-based learning in the production tasks occurs in the "amodal" components of the semantic level, a further study could be developed to determine the level of linguistic representation at which the facilitatitve effect occurs. Such a study might determine whether semantic facilitation occurs at the contextual level, at the word level or at the phonological level. This could be done by manipulating the linguistic organization of the stimulus sentences by srcrambling procedures. One, for example, might find that repetition benefits occur at the lexical level if transfer is observed independently of whether the repeated stimulus is coherent text or scrambled text.

Through such observations, future research can ultimately decide whether the architecture depicted in Figure 8 is the correct one. For the moment, it is a plausible architecture that account for the results of the present experiments.

FIGURE 8: Basic Architecture of the Mechanism for the Production of Writing and Talking.



Repetition-based learning in production tasks occurs in the AMODAL components of the SEMANTIC LEVEL.

APPENDIX

STIMULUS MATERIAL

Whale sharks are the biggest fish in the world. They have broad, flat heads with yellow spots and a very wide mouth. On average these monsters are thirty feet long.

The sea urchin is the porcupine of the sea because it is covered with spines. Its mouthe is on the bottom of its body. It eats dead animals and weeds.

STIMULUS MATERIAL (continued)

The grizzly bear is a very strong wild animal. This creature may weigh up to eight hundred pounds. He can kill a large deer with a sweep of his paw.

The moose is the largest deer in noth America. He is taller than a horse and is a big eater. In one day he can eat fifty pounds of leaves.

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