LITERACY AS A LEARNER VARIABLE IN THE USE OF SALIENT LETTER CODES FOR DEDICATED SPEECH COMPUTERS

by

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ABSTRACT

Literacy level is an important user variable in the process of selecting an appropriate augmentative communication device for a nonspeaking individual. This study investigated how much literacy was sufficient for a child to learn and remember salient letter codes to access prestored communicative messages from the memory of dedicated speech computers. Recent investigations (Light et al., 1988) have demonstrated that salient letter codes are the type of code most easily and accurately remembered by nonspeaking, literate adults.

The present study examined the use of the salient letter encoding technique by children with varying degrees of literacy. The performance of three groups of normal children (19 literate, 21 emergent literate and 21 preliterate) was measured in terms of error rate and strategy use as a function of literacy ability after specific codes and the salient letter encoding strategy were explicitly taught for accessing ten communicative messages. Error analysis showed that the emergent literate and literate groups used the salient letter encoding strategy whereas the preliterate group used two ineffective visual strategies. Mean accuracy scores indicated mastery of the salient letter encoding technique by literate subjects (89% correct), sufficient performance by emergent literate subjects (66% correct) and very poor performance by preliterate subjects (27% correct). The accuracy scores and patterns of strategy use indicated that emergent literacy skills were sufficient for use of salient letter codes. It seems likely that future research using personalized codes with emergent literate children may demonstrate improved accuracy.

The generalizability of these results to disordered populations and application to iconic systems was discussed. Extrapolated to the nonspeaking population, the results indicate that literate or emergent literate nonspeaking children would be capable users of salient letter codes. The performance of the three experimental groups was compared from the heuristic of a procedural view of memory with regard to opposing views of the nature of psycholinguistic and literacy development.

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CHAPTER 1

INTRODUCTION

The state of technology today is such that a wide and growing range of dedicated speech computers, also known as Voice Output Communication Aids (VOCA's) or electronic Augmentative and Alternative Communication (AAC) devices, is available for use by nonspeaking individuals. The prescribing Speech-Language Pathologist is faced with a choice between computer systems employing alphanumeric encoding techniques (combinations of letters and/or numbers) and those employing icon-based encoding techniques (such as Bruce Baker's [1986] semantic compaction system) to store and retrieve messages from the computer's memory. Recent investigations (Light et al., 1988) indicate that salient letter codes are the preferred encoding technique for use by literate adults. The augmentative communication research literature to date is deficient with regard to studies investigating the learning of these systems by children; nor do studies exist which examine the effect of literacy. The question addressed in my experiment is how much literacy is necessary for a child to use salient letter codes to retrieve programmed messages from the memory of dedicated speech computers.

The following is a review of research literature relevant to the purposes of defining terminology used in this paper, describing the current state of knowledge relevant to the research question. Chapter 2 describes the methodology of the study. Chapter 3 summarizes the results. In chapter 4, these results are explained and related to developmental and methodological issues raised in this paper. Clinical applications will also be discussed in chapter 4.

TERMINOLOGY: Augmentative and Alternative Communication

Fried-Oken (1987) wrote that because the subspecialty of Augmentative and Alternative Communication (AAC) is relatively new and the terminology not yet standardized, authors should define their use of terminology. Table 1 lists definitions for a number of technical terms used by investigators in the field of AAC. These definitions were taken from Fried-Oken (1987), Beukelman, Yorkston & Dowden (1985) and the ASHA ad hoc committee position statement of nonspeech communication (1981). Terms defined in table I are used throughout this paper without further definition.

TERMINOLOGY: Literacy

In order to differentiate between the topics of research reports in the area of reading, one must understand that the term "emergent literate" individual is synonymous with "beginning reader" or "emergent reader" and clearly distinct from "early reader." Early readers are those who have attained some initial degree of literacy earlier than their average peers. The term "early readers" refers to children who are either in Kindergarten or of preschool age (depending on the author), who "have not received school instruction in reading, who are able to recognize a minimum of approximately twenty words on a word list and who read some books independently. In standardized test terms they would be reading at a Grade 1 level or higher" (Teale, 1978, p. 924).

STUDIES OF ENCODING IN AAC

A limited number of studies have investigated encoding techniques. These will be discussed in detail.

Table I: DEFINITIONS OF TECHNICAL TERMS

Augmentative and alternative communication (AAC): "Any approach designed to support, enhance or augment the communication of individuals who are not independent verbal communicators in all situations. Other terms used synonymously include assistive, alternative, nonvocal or nonoral communication." (Beukelman et al., 1985, p. 3)

AAC device: In the context of this paper, this term refers to any one of various computer-based electronic communication systems with synthesized speech output; the term is used synonymously with Voice Output Communication Aid (VOCA) and dedicated speech computer. In general usage, the term can have a broader meaning.

Augmentative communication system: "The total communication system of a [nonspeaking] individual which includes a communication technique, a symbol set or system and communicative/interactive behaviour." (ASHA, 1981)

Nonspeaking persons: "The group of individuals for whom speech is temporarily or permanently inadequate to meet all of his or her communication needs and whose inability to speak is not due primarily to a hearing impairment." (ASHA, 1981)

Verbal: Synonymous with "linguistic", i.e. "a system with convention-governed rules, productivity and semanticicity," e.g. oral speech. (Fried-Oken, 1987)

Nonvocal: Without the use of voice. (Fried-Oken, 1987)

Message encoding: Assignment of a "code" (a sequence of one or more symbols) to represent a communicative message (utterance), e.g. "It's all gone" may be encoded as "AG." The code is used to retrieve the message from the memory of a dedicated speech computer. Codes (also known as abbreviations) may be factory-assigned, clinician-assigned, personalized or some combination of these, depending on the particular AAC device.

Abbreviation expansion: The process of using a code to produce a communicative message, e.g. AG becomes "It's all gone."

Iconic encoding techniques: Encoding techniques in which the symbols are pictures (icons).

Alphanumeric encoding techniques: Encoding techniques in which the symbols are print (numbers and/or letters). Alphanumeric codes may be arbitrarily related to the communicative messages, may be categorical (e.g. a number may specify a category and a second letter or number may specify an item within that category) or they may be logical letter codes.

Logical letter codes (LOLEC): Codes consisting of letters which bear a logical orthographic relationship to the communicative messages (ACS RealVoice/Epson instruction manual, 1989). Logical letter codes may be letter category codes or salient letter codes (Light et al., 1988).

Letter category codes: Codes in which a letter specifies the category (e.g. F for food or R for requests) and the following letter(s) specify an item within the category.

Salient letter codes: Codes which consist of "the initial letters of salient words in the [communicative] message" (Light et al., 1988).

Relevant variables

Watkins (1988) studied the influence of several variables on children's ability to learn an iconic encoding technique for an electronic AAC device. Watkins identified the user variable as cognitive level, but defined it as chronological age. Fifteen normal 3-year-old children and fifteen normal 5-year-olds were the subjects in the experiment. The stimuli consisted of pictures which represented (encoded) single words from four different semantic categories. Stimulus variables were of two types: code related and message related. The cognitive ability (age) of subjects, iconicity (representativeness/transparency) of codes, and the usefulness and concreteness of messages (in this case, single words) significantly affected learning, as measured in terms of ability to learn the code and ability to formulate novel sentences.

Preferred Encoding techniques

The current state of knowledge indicates that not only are literate individuals successful users of alphanumeric encoding techniques, but that salient letter codes are the most accurately and easily retrieved of the various codes in use today.

Beukelman & Yorkston (1984) compared five alphanumeric coding systems using two normal adult subjects. Their results indicated that coding systems that grouped words by meaning were remembered most accurately. However, these investigators did not study iconic codes or salient letter codes.

Bruce Baker (1986) claimed that alphanumeric encoding techniques were too abstract and arbitrary and proposed that his system of "semantic compaction," a system of icons ("minsymbols") which could be combined through multiple visual or meaning associations, was a better alternative. This claim was based on argumentation from linguistic theory and had not been empirically tested.

Light et al. (1988, unpublished manuscript) were the first to test this claim. They investigated the preferred system from Beukelman & Yorkston (1984) in comparison with two other systems: salient letter codes and semantic compaction. Letter category codes grouped words by meaning and therefore were of the type found to be most accurately retrieved in the Beukelman & Yorkston (1984) study. Salient letter codes and letter category codes belong to the class of codes now known as logical letter codes (LOLEC). Semantic compaction is an iconic encoding technique. The subjects in the Light et al. study were six functionally literate (i.e. reading skills at Grade 3 level or higher), nonspeaking, physically disabled adult subjects. The results indicated that logical letter codes (i.e. LOLEC codes), and particularly salient letter codes, were retrieved most accurately and most easily. That is, in comparison to the other encoding techniques that exist in modern AAC devices, salient letter encoding is the preferred system. In the Light et al. study, thirty messages were encoded using two-element codes. The encoding technique was first explained and a few examples were given. Training consisted of presentation of each communicative message verbally and in print along with a verbal description of an appropriate communicative context, a demonstration of the corresponding code and an explanation of the relationship between code and message. The example given by Light et al. of an appropriate communicative context was "You want to listen to a record on your stereo, so you say. . ." for the message "Please put on my record." Subjects then studied the codes on their own for 15 minutes; the AAC device and a printed form of messages and codes were available and no mnemonic strategies were suggested to the subjects by the researchers. A 40 minute delay was interspersed between the end of the learning session and the beginning of memory testing. The testing consisted of providing the subjects with the verbal description of communicative context used in training and asking subjects to recall the two-element code to retrieve the appropriate message. The rationale for this testing procedure is that it simulates the communicative situations in which message encoding techniques would normally be used. A confound introduced by this procedure is that it also tests subjects' abilities to decide which message is appropriate for a particular context.

Why encode messages rather than single words?

The main problems with producing a multiword utterance using codes which represent single words are time demands, motoric demands and physical fatigue factors relating to the number of keystrokes required to produce an utterance. Each word will require a minimum of two keystrokes, with the number of keystrokes corresponding to number of letters in the code. The first problem is that timing is very important in many communicative interactions, such as those involving humour or in emergency situations (Light, 1988). The rate of normal verbal conversation using oral speech is 180 words per minute whereas AAC aid users achieve three to twenty words per minute (Vanderheiden, 1984). The rate of communication using an AAC device is slower than normal vocal communication even with one or two keystrokes per utterance. Slowing the AAC user further by increasing the number of keystrokes will require the listener to be even more patient and, in many cases, the moment will have passed for which the utterance was appropriate (e.g. another classmate will have already answered the teacher's question or a caregiver may have passed out of earshot before an attention-getting utterance has been accessed from the computer's memory).

The second problem is that the motoric demands on the user are increased, which may yield greater fatigue either for the particular utterance or as a cumulative effect over the course of the communicative day.

Third, memory demands are greater when single words are encoded. The user is required to remember several codes for each utterance, which significantly increases the number of codes the user must maintain in memory.

A fourth problem is that users must have sufficient grammar skills to construct their messages using combinations of single words. Young children can often express themselves with as few as one or two words, but much depends on the adult's use of contextual cues to disambiguate and interpret the utterance. For children and adults who are able to think abstractly but who have lost grammar production ability, contextual cues may be insufficient for this purpose. More importantly, a commonly encountered problem faced by AAC users is that listeners frequently fail to ask for or wait for verification of their interpretation of the AAC user's utterance.

A fifth reason for encoding sentences rather than single words is that for users with reading ability sufficient to recognize words which they desire to express, other systems are available which allow the user to access single words without having to remember codes. Several word-prediction programs are available for small laptop computers, such as E-Z Keys for the IBM or Zenith laptop, which allow users to access single words from a factory-stored lexicon with two keystrokes. The user does not need to remember codes for these words. The first keystroke is to type the first letter of a word; this yields a table which appears on the screen and contains a numbered list of words beginning with this letter. Depending on the specific program, the words are those which occur most frequently in the English language, those which are most frequently selected by the particular user of the device, or some combination of the two. The factory-stored words are usually the contents, or partial contents, of a standard dictionary and some programs give the user an option of adding words to the dictionary. A second keystroke is used to select the number of the desired word from the table.

USER VARIABLES

The independent variables in previous studies of encoding have primarily been aspects of the AAC system. A number of user variables must also be considered when selecting encoding techniques for children. Clinically, user variables are assessed to determine whether a client has the prerequisite skills to use various sorts of AAC devices. This forms part of a needs assessment. The ideal match between client and AAC device is a device which meets all of a particular client's needs and a client who has the prerequisite skills necessary to operate the device and to use it functionally.

Various user variables have been identified (Beukelman & Yorkston, 1985; Beukelman, 1989; Carol, 1989). These include visual skills (acuity, tracking and scanning), motor control, language and cognition. Specific skills within the areas of language and cognition include memory, problem solving, categorization skills, retrieval skills and comprehension of symbol systems. Symbol systems include the following, in order of decreasing iconicity (transparency) as determined by Mirenda & Locke (1989): objects, colour photographs of objects, colour pictures, black and white photographs, miniature objects, line drawings and line symbols, Blissymbolics and print (letters and numbers).

Literacy assessment is generally a measure of whether the potential user can spell a few of the words which the clinician anticipates would frequently be expressed in the user's environment (Beukelman et al., 1985) or yields an identification of the user as either a speller or a nonspeller (Barker, 1989). The clinician must judge whether a potential user's literacy skills are "sufficient" to be able to use a particular AAC device. However, results of formal reading assessment are of little use because we lack research results to assist the clinician in defining a criterion of "sufficient" literacy. My experiment will assist in filling this knowledge gap with respect to the use of salient letter codes.

VISUAL LETTER DISCRIMINATION

For the purpose of designing visual shape foils for my study, I needed letters which were visually similar to letters in the two-letter codes chosen for training. Therefore, I consulted research reports in the area of visual letter discrimination. Letter discrimination tasks in this literature require subjects to make a judgement as to whether the letters presented are the same or different and to indicate their decision nonverbally, e.g. by depressing a switch. Latency data is more reliable than data from error analysis involving adult subjects because adults make few letter discrimination errors (Garner, 1979). Two other factors which must be considered in reviewing reports of letter discrimination research are the type of orthography used and whether lower case or capital letters were used.

In a letter discrimination study by Clement & Carpenter (1970) using latency measures, the judgement of "same" for letter pairs which were in fact the same required a minimum reaction time of 428 msec. The authors used 428 msec. as a criterion to divide highly similar letter pairs (those with a reaction time longer than 428 msec.) from letter pairs with low similarity. Clement & Carpenter found no significant order difference; that is, the reaction time for "F-E" was not significantly different from the reaction time for "E-F". This meant that order could be ignored when using letter pair discrimination data to select visual shape foils for my experiment. Visual discrimination latency data were also reported in Garner (1979); Garner found a high correlation between these results and those of Gibson et al. (1968).

The findings of Clement & Carpenter (1970), Garner (1979) and Gibson et al. (1968) were based on the performance of adult subjects. Gibson & Levin (1975) studied the performance of children and concluded that children attend to four distinctive features to discriminate between abstract visual symbols: straight line segments (as in 'I' and 'T'), curved segments (as in 'C' and 'O'), symmetries (as in 'W' and 'X') and discontinuities (as in 'K' and 'A').

LITERACY DEVELOPMENT

Many authors, including Ferreiro (1984), Goodman (1986) and Pflaum (1986), have documented a series of steps leading up to early literacy. Preliteracy skills begin with strong contextually-based meaning associations to printed representations. For example, a preliterate child may recognize the Crest toothpaste logo only in a particular context, such as on a tube of Crest toothpaste, or in contexts which bear strong resemblances to this original context. The process of attaining true literacy involves progressive decontextualization of print-meaning associations. A fully literate child can recognize the words "Crest toothpaste" in contexts which bear no resemblance to the original context, such as printed in typewriter orthography in a book. Harste et al. (1984) contest the view that true reading is the ability to read decontextualized print. They propose that even adult reading involves interactions between various contexts, such as situational context, co-text and related readings. On this view, context should be made available to children when asking them to recognize print. In relating this information to the field of AAC, and specifically to the learning of alphanumeric codes, the following question is of interest: if the original context in which a child learns a salient letter code is designed to be similar to the context in which a child is later asked to recognize the representation, will the performance of a preliterate child be similar to that of a literate child?

Clay (1979) reports that literate and emergent literate children use the same processes to read print. These processes involve use of the following aspects: sense, syntax, order, size, special features (distinctive features), first and last letter cues and -- only as a last resort -- left to right sounding out of words

(p. 2). A corollary to this is that emergent literate children should use the same processes as literate children to recognize an encoding technique based on print. Clay (1979, p.2) and McDonell & Osburn (1978) report that the following types of background knowledge are important for literacy: 1) oral language competence (although Harste et al., 1984, claim that complete mastery of oral language is not a prerequisite), 2) knowledge of conventions about print (e.g. that print carries a message, that reading follows a left to right orientation, etc.), 3) knowledge of visual patterns (visual analysis skills, e.g. to separate a visual pattern into letters) and 4) phonological and graphophonemic knowledge. Metalinguistic awareness would also fall under the umbrella of oral language competence. Specific information within these types of knowledge forms the "content" aspect of literacy and would be necessary for reading and remembering alphanumeric codes as well, since these codes are based on print. Preliterate children, by definition, are severely lacking in the latter three types of knowledge whereas emergent literate children possess them to a much larger extent, although not as much as literate children (Adams et al., 1978).

The research discussed in the area of literacy would lead to a prediction that preliterate children would be unsuccessful at learning alphanumeric codes and that emergent literate children would be successful but less so than literate children. Since emergent literate children possess the same <u>type</u> of knowledge, but not the same <u>quantity</u> of knowledge that literate children possess, it would follow that errors in code recognition by the two groups of children would be qualitatively similar but that the emergent literate group would make a larger number of the same type of errors.

<u>PSYCHOLINGUISTIC DEVELOPMENT: Opposing Viewpoints</u>

Proponents of a maturational view of psycholinguistic development/learning include Piaget (cited in Yussen & Santrock, 1982), Montessori (1964) and Havighurst (1952). On this view, the developing child progresses through a series of stages which differ both qualitatively and quantitatively. With regard to literacy development, Teale (1978) and other authors (Clay, 1979; Holdaway, 1979; Teale & Sulzby, 1986) accept terms such as "emergent reader" and "reading readiness" as stages in the development of the ability to deal with written language.

The opponents of this view, including Keil (1981, 1986), Rozin (1976), Chi (1981) and Harste et al. (1984), concur that quantitative changes occur with development but claim that development is continuous rather than stagelike. On this view, conceptual frameworks do not undergo fundamental reorganization, but rather, development "consists of an increasing ability to use the same [cognitive/linguistic] structures in a wider variety of tasks" (Keil, 1981, p. 200). Since literacy is a psycholinguistic skill (Kavale & Schreiner, 1978), these theories of infant and child competence may also apply to literacy. With regard to literacy development, Harste et al. (1984) state that terms such as "emergent reading" and "reading awareness" correspond to a maturational view of literacy development; these authors propose that at a process level (although not at a content level), there is no fundamental difference between children labelled as "literate," "emergent readers" and "preliterate" in terms of activities involving their general psycholinguistic or sociolinguistic abilities[1]. This view would predict that no qualitative differences would be observed among the three groups at a process level on the psycholinguistic task presented in my study. However, because relevant strategies for task completion require some degree of literacy knowledge, content knowledge may be an important factor determining

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[1]Sociolinguistic abilities are those which involve sociocultural factors affecting linguistic behaviour, e.g. comparison of consonant cluster reduction in differenct social dialects and regions, linguistic styles (styles of using vocabulary, syntax or phonology), slang and sex differences in linguistic behaviour.

capability to learn the strategies, i.e. content differences may determine differences at a process level.

TRANSFER APPROPRIATE PROCESSING

Transfer Appropriate Processing (TAP) is a general framework for research and theory in remembering proposed by Morris, Bransford & Franks (1977). TAP forms the heuristic for my study. TAP employs a procedural metaphor for memory (Roediger & Kolers, 1984), viewing memory as a pattern of interaction distributed throughout the cognitive system, with diffuse memory storage rather than a focal point where a memory or memories reside. Central to the TAP view is the idea that memory exists only at the time of stimulation (either external of internal stimulation) and is an end-product of process(es) rather than being a structure. This contrasts with the previously held view of a spatial, multistore model of memory wherein a memory is an entity/structure which is stored somewhere in the brain; examples of spatial models and multistore models are Penfield's view; Atkinson & Shiffrin's (1968) box model, Tulving's (1972) episodic and semantic memory stores (Craik & Lockhart, 1972; Roediger, 1980). Most importantly, TAP looks at remembering and characteristics of remembering (the processes involved in remembering) rather than at characteristics of a memory. The TAP view assumes that what is important is the extent to which learning tasks "transfer" to the test situation (i.e. overlap with the test situation in terms of what is required). On the TAP view, similarity of the encoding (learning) situation to the testing situation is one of the determinants of how well something is remembered; other processes in encoding may also provide Transfer Appropriate Processing if they are relevant ("appropriate") to retrieval. Remembering is explained as re-creation of what is to be remembered by going through the same process/pattern as was gone through during encoding. Memory is mediation between encoding and decoding. Although TAP is by no means a form of behaviourism, it does re-emphasize features that can be observed in the encoding and decoding situations. The TAP framework is capable of explaining evidence accounted for by previous models, such as Levels of Processing (Craik & Lockhart, 1972) and multistore models. TAP also accounts for newer evidence which contradicts previous models, including memory studies by Morris et al. (1977), by Kolers et al. (Kolers, 1975; Kolers & Smythe, 1979) and mood-memory association studies (e.g. Gilligan & Bower, 1984).

MEMORY DEVELOPMENT

Several studies of recognition memory have shown similarities across ages when background knowledge has been eliminated as a confounding factor (Kail, 1979). However, differences were noted when mnemonic strategies became important for achieving accurate recognition (Kail, 1979; Tighe et al., 1975).

Daehler & Bukatko (1977) found that the recognition memory of preschoolers aged 1;6 to 3;6 was highly accurate for a stimulus set of over 100 pictures. Similar results were obtained by 4-year-old children studied by Brown & Campione (1972) and Brown & Scott (1971). However, these investigators used simple pictures depicting familiar, concrete items.

Nelson (1971) investigated the ability of children in Grade 1 (the same grade level as the emergent literate group in my study), Grade 4 (same grade level as the literate group) and Grade 7 to recognize complicated or abstract stimuli. The groups did not differ from each other in their ability to recognize objects; for all groups, recognition of simple, familiar stimuli was better than recognition of complex, abstract, unfamiliar stimuli. Nelson & Kosslyn (1976) found similar results in their comparison of adults and 5-year-old children. It must be noted that for each of the aforementioned recognition memory experiments, the stimulus was a single object. Also, the investigations described thus far studied memory as content or as a structure rather than as a process.

Newcombe, Rogoff & Kagan (1977, cited in Kail 1979) studied recognition memory for objects and scenes with subjects of three age levels: 6-year-old children (roughly the same age as my emergent literate group), 9-year-old children (roughly the same age as my literate group) and adults. Mandler & Robinson (1978, cited in Kail 1979) compared recognition for meaningfully arranged stimuli to recognition for disorganized stimuli in a study with children in grades 1, 3 and 5. Developmental differences in accuracy of memory were noted only for complex stimuli and meaningfully arranged scenes. Kail (1979) attributed these differences to differences between groups at a process level: older children and adults scanned scenes and complex stimuli more effectively and used meaningful relationships between the components of each stimulus whereas younger children (6-year-olds) did not. That is, younger children did not use the mnemonic strategies used by older subjects in situations where subjects were expected to devise their own strategies.

Tighe, Tighe & Schechter (1975) approached the study of recognition memory from a process perspective, more in keeping with the heuristic of Transfer Appropriate Processing. Their task tapped subjects' <u>use</u> of background knowledge and new information rather than measuring content of knowledge about the experimental task as had the aforementioned experiments. Tighe et al. studied how subjects used their background knowledge to develop strategies for a remembering task. They found that even in situations where children 7 years of age and adults each possessed the same relevant background knowledge (knowledge of word categories and classification) and were provided with the same new information (specific words) necessary for completion of the task , the young children did not use the same strategies as the adults to complete the task. Although both groups remembered the content equally well, procedural differences in remembering resulted in differences in performance on the memory task because the young children used different aspects of this knowledge than did older subjects. The young children used specific features of the actual stimulus (a printed word presented visually) whereas the adults focussed more broadly on task dimensions by categorizing words. An important criticism in reviewing these results is that age effects in the Tighe et al. studies may in fact be literacy effects because the task involved visual recognition of words. In any case, whether age-related or literacy-related, these results contradict Harste et al.'s (1984) claim that no differences exist between developmental groups at a process level. Another question which arises from the Tighe et al. study and from the studies discussed in the preceding paragraph stems from the fact that the investigators intentionally did not tell subjects which aspects of the stimuli to remember and did not specify any strategies for remembering. Would strategy-use have shown developmental differences if a preferred strategy had been explicitly identified and taught to each group of subjects?

The experimental task in the present study will tap both accuracy of remembering and, through error analysis, strategies for remembering as evidenced by the type of knowledge used to remember letter codes. This study differs from the aforementioned memory studies in that a preferred memory strategy (salient letter encoding of semantic aspects of messages using orthographic aspects of specific words) is identified explicitly and explained in detail.

EXPERIMENTAL QUESTION AND HYPOTHESIS:

I have defined various terms including Augmentative and Alternative Communication (AAC), encoding, logical letter codes (LOLEC), salient letter codes, emergent reader and preliterate. I have argued that alphanumeric encoding techniques, particularly salient letter coding, are preferred over iconic systems for prestoring messages for access by capable users. A need has been identified for studies of encoding with a focus on user variables, specifically a study of the relationship between literacy and AAC. Various developmental issues have been raised.

This leads to the question to be addressed in this study: how much literacy is necessary for a child to use logical letter codes to retrieve programmed messages from the memory of dedicated speech computers? Specifically stated, do preliterate and emergent literate children have sufficient literacy skills to enable them to learn and remember salient letter codes as compared with literate children?

I predict that explicit training and identification of a preferred remembering strategy and of relevant stimulus aspects will eliminate differences in recognition memory between groups that are based on differing abilites to devise effective mnemonic strategies. Matching the context of training to the context of testing will eliminate performance differences based on differences in dependance on contextual cues. The groups, by definition, differ in their level of literacy (background knowledge). The view that emergent literates do not differ from literate subjects at a process level is assumed for the purposes of the study. Also, the emergent literate subjects' literacy level is considered to be <u>sufficient</u> though not complete, which leads to the prediction that emergent literate subjects will achieve lower accuracy than literate subjects, but will produce the same predominant error type. Both literate groups of children (literate and emergent literate) will be successful at learning salient letter codes and will produce primarily errors related to the encoding process (encoding salient content of the communicative messages into letter codes), i.e. they will produce salient word errors. An assumption of this experiment is that salient word errors (selection of salient word foils[2]) indicate that a child is using the salient word encoding

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[2] Salient word foils are two letters which corresponded to two salient words in the communicative message, but of which one word and corresponding letter was different from the target, e.g. MF representing "<u>M</u>y <u>F</u>oot hurts" for semantic confusion with the target FH representing "My <u>F</u>oot <u>H</u>urts."

technique. In view of the preliterate group's minimal print awareness and lack of graphophonemic knowledge, the quantitative deficit that exists by definition at a content level (literacy skills) should yield differences at a process level. That is, I predict that preliterate subjects will be unsuccessful at learning the codes: i.e., poor accuracy, with errors related to visual strategies for remembering characteristics of specific codes rather than to the salient word encoding process. Stated as a null hypothesis, there will be no significant difference in error rate (accuracy) or error type based on literacy level for the task of learning and remembering salient letter codes for accessing communicative messages in the memory of a dedicated speech computer.

CHAPTER 2

METHODOLOGY

DESIGN

Normal children were grouped according to three levels of literacy:
1) a literate group (capable readers)
2) an emergent literate group (beginning readers)
3) a preliterate group (nonreaders with minimal print awareness).
The children were taught ten logical letter codes corresponding to ten communicative messages stored in the memory of the ACS Real Voice/Epson(a dedicated speech computer with speech output). The subjects were asked to remember these codes after a 40 minute delay. The accuracy of remembering and the relative frequency of error types in the response set were compared as a function of literacy level.

SUBJECTS

The subjects included in the sample were those who met the following criteria:

General criteria:

Students had English as their first language. Towards the purpose of including only subjects with average cognitive ability, subjects were no more than one grade behind or ahead of their chronological age matched peers. These students had no severe language delays or known sensory impairments (e.g. visual, hearing) significantly affecting their participation or performance in the activities.

The subject criteria were designed to ensure, as much as possible, that the subjects' responses were a function of their literacy level rather than an effect of potential confounds such as cognitive/linguistic exceptionalities, severe sensory impairments and English as a second language.

The grade 1 and grade 4 students were exposed to IBM computers at school on a regular basis as part of their school curriculum and were therefore somewhat familiar with computers/keyboards.

Group-specific criteria:

1) Literate group: Students were in Grade 4, aged 9 years, 0 months (9;0) to 10;5, with reading scores between the 25th to 75th percentile of the distribution of the normative population on the Gates-MacGinitie Reading Tests (Canadian Edition, Level D) as compared to normative data for Grade 4 peers in midyear (February) of the school year. Literacy testing of Grade 4 subjects was completed in February and results were compared with normative data for February. Of the 36 Grade 4 students who participated in the experimental task, 19 met the criterion for literacy level.

2) Emergent literate group: Students were in Grade 1, aged 6;0 to 7;5, with average reading scores on one or both of the Letter Sounds subtest and/or the Comprehension subtest of the Gates-MacGinitie Reading Tests(Canadian Edition, Basic R Level) as compared to normative data for Grade 1 peers in Spring (May) of the school year. Grade 1 subjects participated in the experiment in May of the school year, thus increasing the validity for comparison with normative results for May. Fifty-four Grade 1 students originally participated in the study. The data from a group of 21 Grade 1 subjects was excluded due to inconsistency in instructions given during training, which could not be controlled by the

investigator for this group of 21. Twelve of the remaining 33 Grade 1 subjects were excluded because they did not meet the criterion for literacy level. Thus, the data from a total of 21 Grade 1 subjects was included in the analysis (54-21-12=21).

3) Preliterate Group: Preschool children aged 3 years, with scores below 21% correct or below the 4th Stanine for normative data on the Concepts About Print test. Twenty-one Preschool subjects were included in the study. Due to the nature of the Concepts About Print test, it was necessary to administer this test to subjects individually. Therefore, due to time constraints, a random sample of six preschool students was selected from among the 21 to receive literacy testing; each of these students met the criterion for preliteracy. One child in the preschool classroom was known to be literate and was therefore not included in the study.

PROCEDURES

Experimental Setting:

The study was conducted in the subjects' regular classrooms for the literate and emergent literate groups and students, with subjects grouped according to their regular homeroom class, because most of each class participated. The preliterate subjects, with their young age and high level of distractibility, were trained in small subgroups of three to five students and tested individually; their sessions were conducted at a desk in a small room on the same floor of the building as their regular classroom, but away from the noise and bustle of the class.

Training sessions were held in the same room as testing sessions for two reasons: 1) to facilitate Transfer Appropriate Processing, and 2) to eliminate the confound of differences related to a need for generalization of skills to a new environment.

Selection of Messages and Codes:

Ten communicative messages were created, containing three to four critical elements (main ideas). At least one critical element for each message was selected from Beukelman & Yorkston's (1982) list of the 500 most commonly expressed words by adult users of an augmentative communication system. The content of messages was selected and in some cases modified to be appropriate for children.

A different two-letter code was selected for each message. These codes and messages are listed below in the sequence of training:

YN = What's your name.

PC = Let's play computer games.

DB = Don't bug me.

DJ = I want to drink some juice please.

HP = I need help please.

MT = Look at my toy.

AG = It's all gone.

FH = My foot hurts.

WM = I want more please.

RS = Please read me a story.

The codes used were two-element "salient letter codes," as defined in the study by Light et al. (1988), i.e. the letters in the codes were the first letter of two of the salient words in the message. The first letter of each code was different from the second letter of the same code (i.e. no codes were double letters); the purpose of this was to be able to test for sequencing errors (i.e. reversals, in the case of two-letter codes). Sixteen different letters were used for codes, with no letter occurring more than twice in the entire pool of letters used in codes. The purpose of using a wide variety of letters was to minimize errors due to confusion between messages. In addition to constraints relating to frequency of occurrence, the selection of letters for codes was also constrained by the salient words in the communicative messages, including words from Beukelman & Yorkston's word list, in that the initial letters of these words formed the source for code letters. A total of 23 different letters were used in the recognition task in target codes or in foils; the only letters which were not used were "Q," "V" and "Z," which occur with very low frequency in the English language. However, "Z" was used in two of the examples on the test form, bringing the total number of different letters used to 24.

Training Procedure:

Training commenced with a brief, general introduction to the investigator and the task, including having children listen to the Epson/RealVoice (AAC device) saying "Hello boys and girls." In order to maintain a high level of interest, attention and motivation, subjects were explicitly instructed that they would be given a chance to use these codes on the "talking computer" if they attended to instructions and thought about the codes. Subjects were also explicitly told that they would be asked to remember the codes later on in the session; this explicit instruction was for the purpose of ensuring that the subjects would take advantage of any remembering strategies they knew. Eleven items were trained, including one example item (to be used also as an example item during testing) and ten target items (the ten communicative messages listed on page 22).

Training of items was provided multimodally so as not to place children who learn better through one mode than another at a disadvantage. Visual stimuli consisted of (i) ten coloured pictures (one per communicative message) to hold the subjects' attention during training and to give visual support to the message, (ii) the corresponding two-letter code, represented as a picture of two RealVoice/Epson keyboard keys with one letter on each key (under the corresponding picture), (iii) the RealVoice/Epson keyboard (which provided a stimulus through the personal experience/tactile mode as well as visual mode). Each subject was exposed to visual stimuli (i) and (ii) for each stimulus for a period of two minutes per training item. Each picture in (i) bore some relevance to the corresponding communicative message and communicative context. Each subject was exposed only once to a close-up view of and chance to press the appropriate keys on the AAC device keyboard. Visual stimuli (i) and (ii) were presented to the literate and emergent literate groups on overhead transparencies, using an overhead projector and a large white screen. To bring these stimuli closer to the preliterate group to maintain attention, the same pictures/letters on the same overhead transparencies were placed in transparent sheet protectors, backed with white paper (to provide the same background as for other groups) on top of black paper (to prevent the next picture or the previous picture from showing through) and were housed in an attractive, bright red binder (also for the purpose of piquing the subjects' interest).

Auditory stimuli consisted of (i) a verbal description (two presentations per item) of the communicative context (e.g. "If someone was taking your toys away, you could make the computer say . . ."), (ii) two verbal presentations of the message for each item, (iii) two verbal presentations of the two-letter code for each item (e.g. "The letters you need to pick are "D" and then "B", in that order), (iv) & (v) an explanation of the relationship between the code and the message and rationale for the letter sequence (e.g. "D is the first letter of the word <u>don't</u>. D comes first in the secret code, so it is on the left side [investigator points to "D" on the overhead]. B is the first letter of the word <u>bug</u>. B comes next in the secret code, so it is on the right side [investigator points to "B" on the overhead]).

Appendix A is a copy of the training protocol.

Time Delay

A 40-minute delay was inserted between the end of training and the beginning of the recognition task. During this delay, the Gates-MacGinitie Reading Tests were administered to the emergent literate group. The literate group spent 40 minutes in an academic classroom activity. The preliterate group spent 40 minutes playing with various toys in their preschool classroom.

The Gates-MacGinitie Reading Tests were administered by this investigator to the literate group in February, 1989 as part of a study by Susan Blockberger (work in progress); the reading tests were administered only to determine if the subjects were capable of comprehending a written questionnaire about their attitudes toward nonspeaking children. Therefore, these recent results were used to determine literacy level, rather than repeating the same test.

Letter Code Recognition Task: Selection of Test Stimuli

A recognition task was designed by the investigator. The task consisted of thirteen items: three practise items and ten test items. The test items were the ten communicative messages which had been trained earlier in the day. The ten communicative messages were tested in random order according to a random numbers table. The task format was multiple choice rather than written responses or selection of keys on a keyboard. The choices were two-letter codes depicted as pairs of computer keys. Subjects responded by colouring in an oval under their choice of response (the same method of response as for the Gates-MacGinitie Reading Tests). Towards the purpose of minimizing distractions and removing potentially interfering "clues", no words, numbers or extraneous letters (e.g. test name, page numbers, item numbers) appeared on the test forms received by subjects; the only exception to this was an identification code pencilled into the upper left hand corner of the page of practise items (the first page of the test form). The identification code consisted of four letters and three numbers (representing school, literacy group and subject number). Appendix B is a copy of the test form.

The first three items in the recognition task were practise items designed to ensure that the subjects understood task requirements. Practise items were on a separate page from test items and followed the same format as test items; however, they were less difficult than test items, so that difficulty of practise items did not interfere with learning of task requirements; e.g. practise items included double-letter responses (e.g. SS for "Ernie lives on Sesame Street) or two-word target sentences (e.g. "Hi Suzanne"). The first practise item was intended to teach subjects to scan all four choices in a given row and to teach subjects the method of indicating their selection: the oval under the fourth choice was already filled in on the test form. The second practise item was designed to teach subjects to be aware that visual foils and salient word foils were included among the choices for each item: the investigator pointed out a visual foil and a salient word foil as choices for this item and explained how they were related to the target and why they were wrong. The second item also provided the subjects with an opportunity to practise the response method (colouring in the appropriate oval with a dark pencil mark) after the investigator told them which choice was the correct one. The purpose of the third practise item was to teach subjects to beware of reversed order foils included among the choices and to give the subjects a chance to practise selecting a choice on their own. It also gave the investigator an opportunity to explain how to self-correct errors (erase error clearly and fill in the appropriate oval) and subjects were asked to practise self-correction by correcting any errors on this item.

The format for each test item was as follows. Each item took up a separate row on a page, with no more than four rows on any one page. At the left side of each row was a picture corresponding to the item (a black and white copy of the visual stimulus used in training). This provided (i) a visual context, (ii) provided some similarity between testing context and training context to facilitate Transfer Appropriate Processing (TAP)(Morris, Bransford & Franks, 1977), (iii) provided a means of identifying to subjects the specific item they were to focus on at any given time (e.g. "Now put your finger on the picture of a foot") and (iv) allowed the examiner to quickly and easily check that individual subjects were in the right place on the test form and looking at the correct set of stimuli. This means of focussing group attention on a particular item was the same as that used for the Gates-MacGinitie Reading Tests. To the right of the picture in any given row were four choices, consisting of one correct response (target response) and three foils, sequenced randomly from left to right in a row according to a random numbers table.

For each test item, the incorrect choices included one salient word foil (two letters which corresponded to two salient words in the communicative message, but of which one word and corresponding letter was different from the target, e.g. MF representing "My Foot hurts" for semantic confusion with the target FH representing "My Foot Hurts") , one reversal (e.g. HF for FH) and one visually confusing foil (with one letter different from but visually similar to a target letter, e.g. EH for FH). These three foil types were chosen because of their correspondence to three of the four types of errors that are possible in the use of logical letter coding based on salient letter codes. The possibility of a fourth error type (confusion between codes for different communicative messages) was minimized by limiting overlap of code letters between different messages (as described above under section entitled "Selection of Messages and Codes").

For five of the salient word foils and five of the visual foils, the first letter in the two-letter code was correct (i.e. was the same as in the target letter code) and the second letter was a foil (5 TS's and 5 TV's). The remaining five salient word foils and five visual foils consisted of a foil letter followed by a correct letter (5 ST's and 5 VT's). This aspect of the design was for the purpose of equalizing code-position of target (i.e. frequency of first letter in code being correct equals frequency of second letter in code being correct) and noting code-positional error patterns (e.g. fewer errors if target letter is correct in first position rather than correct in second position in the code). One reversal was included for each test item, for a total of ten sequencing foils. Row-positional errors were also noted (i.e. errors based on a child's preference for response choices in a particular position in rows, e.g. high frequency of selection of responses in fourth position)

The multiple choice response mode was chosen in order to avoid crossing modalities (from visual comprehension to graphic expression). This rendered the task a recognition task rather than recall task.

Letter Code Recognition Task: Testing Procedure

The subjects were seated such that they could not see each others' papers. They were asked to clear their desks of all materials except the test form, a pencil and an eraser. The task was then introduced by telling subjects that the investigator was now going to find out how many of the "secret codes" (salient letter codes) the subjects remembered. They were asked to be silent during testing and to avoid looking at each others' papers. Subjects did not receive feedback about the accuracy of their responses during testing, except for practise items.

To ensure Transfer Appropriate Processing (Morris, Bransford and Franks, 1977), the testing task was designed to be similar to the training task (e.g. similar visual cues, same physical environment, same verbal description of communicative context, choices in shape of keys).

The protocol used in the administration of practise items is detailed in Appendix C.

The following procedure was used for each test item:

1. Use an attention-getting remark (e.g. "Listen carefully") to ensure that all subjects are attending.
2. Identify the picture corresponding to the item as a placefinder and as a visual contextual cue (e.g. "Put your finger on the picture of a foot").
3. Verbally describe the communicative context, using the same verbal description as for training (e.g. "Pretend you dropped something on your foot and you want to tell your teacher how it feels").
4. Remind subjects to scan all of the choices to the right of the picture.
5. Say the desired communicative message with equal emphasis on each of the words and remind the subjects to find the letter code (e.g. "Find the group of letters that makes the computer say 'My foot hurts'")
6. Repeat the desired communicative message with equal emphasis on each of the words and remind subjects to fill in the oval under their choice of letter code (e.g. "Colour in the oval under the group of letters that makes the computer say 'My foot hurts'").

RATIONALE

The rationale for the methodology of this study is based on operational definitions, statistical and practical constraints, clinical experience and the results of previous studies in the areas of AAC, literacy, memory and perception (visual letter discrimination). This rationale is explained below.

Operational Definition of Literacy

In the present study, the user variable of literacy has been divided into three levels: literate, emergent literate and preliterate. The subjects were normal children whose literacy skills were average for their chronological age, for reasons to be discussed later. By definition (Teale, 1978), early readers are above average in their literacy skills. Therefore, this group was excluded from this study. Emergent literate subjects were those who had received school instruction in reading, were in Grade 1 and were reading at a Grade 1 level. The preliterate group consisted of preschool children who had not received school instruction in reading and who had minimal print awareness. Grade 4 reading ability was the criterion for the literate group. In traditional schools, literacy skills are specifically taught in the primary grades (up to the end of grade 3). From Grade 4, students are expected to have mastered basic literacy skills to the degree of being able to use reading as a mode for learning academic information such as geography, history, etc. (Westby, 1985; Ekwall, 1986).

Findings of Previous Studies

As described in chapter 1, Watkins (1988) determined that iconicity of codes and the usefulness and concreteness of messages significantly affected children's ability to learn iconic codes. In my experiment, all of the codes were equally noniconic in that they were all capital letters of the Roman alphabet. Messages were equally useful in that the main focus of each was selected from Beukelman & Yorkston's (1982) list of the 500 words most frequently used by Canon Communicator users. Age/cognitive effects were not isolated from literacy effects because teasing these variables apart introduces other confounding variables; however, the relationship between age, cognitive level and literacy level was selected to be that of normal children. In different disordered populations, the developmental relationships between cognitive ability, language ability and literacy skills can be different; the results of my study might be generalizable to disordered children with fairly uniform profiles of ability and perhaps less generalizable to children with profiles characterized by peaks and valleys.

The rationale for selecting salient letter codes was based on the results of the Light et al.(1988) study, which showed this type of code to be the most accurately and easily retrieved by literate subjects. My study investigated whether the user group for this system could be expanded to include literate, emergent literate and preliterate children. In order to use salient letter codes as effectively as possible, much of my training procedure is similar to that used by Light et al. Some of the ways in which my procedure was different will be described. A confound introduced by Light et al.'s procedure was that it also tested subjects' abilities to decide which message was appropriate for a particular context. In my study, the message was provided to subjects and subjects were asked only to remember the two-element code. Light et al. recorded accuracy and error type. They investigated strategy use by asking subjects to explain their rationale for incorrect selections of letter codes; this procedure requires that the subjects have a great deal of metalinguistic awareness and would therefore be of questionable use with young subjects. Also, two of Light et al.'s error types (inappropriate message and incorrect message) were related to memory for code, memory for message and ability to decide which message is appropriate for a particular context; therefore these error types did not purely reflect remembering strategies for codes. The error analysis of the present study was designed to reflect only remembering strategies for codes. Light et al.'s third error class, "incorrect code" was too nonspecific for the purposes of my study. In order to study strategy use, incorrect codes were classified as either salient word errors, visual shape errors or reversals. A potential confound in both studies was intercoder variation (see "Subexperiment" section in this chapter). Light et al. found considerable variation between codes selected by different people for the same messages. They found, however, that codes remained stable for an individual coder over time. Clinically, intercoder variation is not a problem because codes are personalized for the individual user. Also, the _most_ salient words are frequently not the most appropriate selection, e.g. when the initial letters have already been used to encode a different message or when the combination of initial letters forms an English word.

Why use normal subjects?

Because of the difficulty in finding a homogeneous sample of nonspeaking individuals, studies with handicapped subjects generally have a small sample size with a very small number of matched subjects and/or a within-subjects design. This significantly increases the amount of time commitment required from each subject in order to obtain a large number of observations. A within-subject design was not possible for my study because it examines a user variable (literacy) which cannot have more than one level for each subject. My study used a large number of subjects in order to improve the reliability of results. Also, a larger number of subjects requires less time commitment from subjects (requiring less time away from classroom programs scheduled for the school year) and is more efficient in that many subjects can be tested at once in groups. The use of handicapped subjects introduces other confounding variables such as differences in years of experience with/exposure to printed material, differing cognitive abilities, differences in physical abilities and, therefore, in response time (which relates to the amount of time codes must be maintained in memory), etc. For these reasons, I chose to use normal subjects with literacy skills which were appropriate for the subjects' chronological age.

This decision is supported by the fact that other researchers in the field have also chosen to use normal subjects. Watkins (1988) and Beukelman & Yorkston (1984) chose to use normal subjects in their studies of encoding. Ratcliff (1988) used normal child subjects in her study of two task variables (scanning versus direct selection, and difficulty of direction-following task) and two user variables (cognitive style and grade level) in the use of AAC systems without encoding. Children from Grade 1 to Grade 5 participated in the study, with 20 children per grade level. The sample sizes of the three groups in my study were 19, 21 and 21.

Selection of Visual Shape Foils

The letter pairs "F-E", "R-B" and "C-O" were highly similar pairs from the Clement & Carpenter study which were selected for visual shape foils in my study. I used Letraset Roman letters as stimuli, which is the orthography used by Clement & Carpenter. The letter pairs used in the Clement & Carpenter study were various combinations of only 17 letters and approximately half of the letter pairs were easily discriminable (i.e. were low in similarity). My study required a larger variety of letters from which to select foils, in order to reduce interference from letters in previous items (by reducing overlapping of letters between test items) and to ensure that letters selected for visual foils were not in fact semantic foils (i.e. the first letter of any words in the communicative message corresponding to the letter code). The remaining visual shape foils in my experiment contained letters with minimum reaction times no shorter than 428 msec. and were taken from visual discrimination latency data reported in Garner (1979), which Garner found to be highly correlated with Gibson et al. (1968).

The aforementioned visual discrimination studies used adult subjects. A potential problem in applying these results to research with children is that children may perceive letters as abstract visual symbols and may find them less meaningful than do adults. Therefore, the selection of letters for visual shape foils was verified against results obtained by Gibson & Levin (1975) with children.

Need for Contextual Cues in the Testing Situation

Harste et al. (1984) claimed that children should be allowed to use context to understand print. The TAP view (Morris et al., 1977) assume that how well something is remembered depends to a great extent on contextual similarity and similarity of task requirements between learning and testing situations. Contextual similarity between learning and testing conditions forms part of the design of the present study. In order to maximize remembering, the experimental design of this study ensures a great deal of overlap between training and testing in terms of what is required and ensures similarity of the learning situation to the testing situation, according to the principles of the TAP framework. If preliterate children perform as well as literate children in conditions of contextual similarity, the clinical implication is that preliterate children have the ability to use AAC devices with alphanumeric encoding techniques within at least restricted contexts; it may be expected that children will use these devices in a progressively wider range of contexts as literacy and language skills develop.

Design of Letter Code Recognition Task

The task for investigating how well the subjects had learned and remembered codes was designed to be a recognition task (selecting codes from a number of choices) rather than one of recall (writing out the code). This design was selected for the following reasons:

1. Crossing modalities was avoided.

2. Effects of manual writing ability were eliminated as confounds, e.g. differences in dexterity, legibility and time to write out responses. In general, it is critical to minimize differences in response time between subjects in a memory task, because response time directly affects the amount of time stimuli must be maintained in memory. This may or may not be important to the experimental task in the present study, in view of the 40-minute time delay.

3. Writing is not the means by which AAC devices are accessed. Access is by selecting letters on a keyboard.

4. Children of the age range in the present study are known to be capable of performing pointing recognition tasks, e.g. Peabody Picture Vocabulary Test (Form M), Test of Auditory Comprehension of Language.

The letter code recognition task was designed to replace responses using the keyboard for the following reasons:

1. It would have been too time-consuming to test each subject individually with a keyboard.

2. The potential bias of differences in familiarity with keyboard was eliminated (differences in scanning time, etc).

3. Motor skills such as speed and pressure of activation were eliminated as confounding factors.

4. Foils in the designed task simulated typical types of confusions occurring during selection from keyboard array.

5. Letters in target codes and foils were drawn as simulations of computer keys.

MEASURES AND DATA ANALYSES

Responses were categorized according to experimental group (literate subjects, emergent literate subjects, preliterate subjects). Each subject's responses were recorded and scored in terms of percentage correct. An error analysis was done for each subject to identify the type of error (salient word error, visual error, reversal error) and to calculate the frequency of occurrence of each error type. Code-position of error (i.e. whether target letter was in first or second position) was recorded for all subjects and row-position (first to fourth positions from left to right in a row on a page) was also recorded for preliterate subjects to determine whether position was a major factor in their selection of response choices. This raw data appears in Appendices D, E and F.

The following calculations were made for each experimental group:

1. Mean accuracy
2. Frequency of occurrence of each error type (means for experimental groups).
3. Relative frequency of each error type for each experimental group.
4. Relative frequency of each answer type for the preliterate group.

Statistical analyses were completed to compare the three literacy groups in terms of mean accuracy and relative frequency of error types. A one way ANOVA test was done, with the individual child as the unit of analysis, to compare mean accuracy of the three experimental groups to determine if any mean was different from any other mean. Accuracy similar to the literate group would indicate that the subjects are able to use salient letter coding to access the memory of a dedicated speech computer. A G-test (or a chi-squared contingency table test and t-tests) was used to compare the relative frequency of error types between the three groups and to determine which groups differed significantly from each other. Within-group analyses were also completed by means of a one-tailed t-test to determine whether or not salient word errors were the most frequently occurring error type for any of the groups. The reason for this is that a predominance of salient word errors indicates that the subjects are using the salient letter coding strategy in most cases when they do not remember the correct code; this error type indicates that the subjects would probably be able to use salient letter coding to access the memory of a dedicated speech computer if the specific codes are personalized (further testing would need to be done to determine stability of code selection over time).

PILOT STUDY

The investigator completed a pilot study to test the practicality of this methodology. The subjects for the pilot study consisted of one emergent literate child in Grade 1, one literate child in Grade 4 and one literate adult. The subjects in the pilot study were from a different school district than the subjects in the actual study. The methodology of the pilot study was the same as the actual study with the following exception: the subjects were presented with 20 training/test items.

The adult attained a score of 40% correct (eight correct out of twenty) with salient word errors. The literate child attained a score of 10% correct (two correct out of twenty) with primarily salient word errors. The emergent literate child produced no correct responses and did not finish the task. The emergent literate child was visibly upset with the difficulty level of the task.

The investigator concluded that twenty items presented an unreasonably heavy cognitive load for the amount of training time provided and for the amount of time delay between training and testing. Also, such a large number of new items would not typically be taught in a clinical setting with the expectation of mastery within a single session.

Literate clients are known to be successful learners of alphanumeric systems (e.g. Light et al., 1988). For the experimental task to be a valid measure of ability to learn salient letter codes, literate subjects must achieve success (arbitralily set at 90% correct, as this is generally taken to be the criterion for mastery of skills in clinical settings, e.g. Templin, 1957). Therefore, the number of training/test items was reduced to ten for the purposes of the actual study.

SUBEXPERIMENT

A post-hoc subexperiment was conducted and is described below.

Purpose:

The purpose of the subexperiment was to determine which words in the communicative messages were the most salient according to a sample of literate adults.

Subjects:

Ten literate adults, ranging in age from fifteen to forty, participated as subjects in the subexperiment.

Method:

Subjects received a sheet of paper on which the ten communicative messages had been printed. Each message was on a separate line on the page and no letters were capitalized except for the word "I." For each message, subjects were asked to underline the two words which they felt conveyed the meaning of the message, stood out the most and were the most important to the message (i.e. the two most salient words in the message).

Results & Discussion:

The raw performance data are summarized in Appendix G. There was a great deal of intercoder variability in the selection of codes. The most frequently selected pair of words matched the target code for six of the ten communicative messages. Discrepancies from targets were in most cases the same as salient word foils. At least some of the adults chose the same code as the target for every message, confirming that the targets were salient to some degree. Subjects selecting the most salient words in each communicative message were most likely to select the target code or the salient word foil. For each communicative message, the order of the two words written by each subject was the same as the order relationship of the two words in the communicative message, i.e. there were no reversals.

The relevance of these results to the main study is as follows. These results would indicate that subjects in the main study using a salient word encoding strategy to use salient letter codes would be most likely to select a target code or salient word foil and unlikely to select a reversed order foil. By design, visual shape foils in the main study contained none of the word-initial letters in the corresponding messages; therefore, subjects using a salient word encoding strategy would be unlikely to select visual shape foils. One may validly assume that subjects selecting primarily target codes and salient word foils are using a salient word encoding strategy. The effect of intercoder variability on accuracy of remembering salient letter codes in the main study will be discussed in chapter 3.

CHAPTER 3

Results

Mean accuracy and the mean number of each type of error was calculated for each experimental group. These calculations and the size of each experimental group are summarized in Table II. Statistical analyses were completed to determine literacy effects on performance (accuracy and strategies) and for the purposes of task analysis. A criterion of 0.05 was set as the level of significance for each of the analyses in view of the fact that this is an initial study in the area of literacy and encoding.

INTERGROUP COMPARISONS

Accuracy

In order to determine whether literacy affected accuracy, mean accuracy scores for each experimental group were compared using a one way analysis of variance (ANOVA) test with completely randomized design. The mean accuracy scores (mean number correct out of ten) are listed in Table II.

TABLE II

MEAN ACCURACY (NUMBER CORRECT OUT OF TEN) AND MEAN NUMBER OF EACH ERROR TYPE FOR LITERATE (L), EMERGENT LITERATE (E) AND PRELITERATE (P) GROUPS AND SAMPLE SIZE (n) FOR EACH GROUP

	LITERACY LEVEL		
	L	E	P
Sample size:			
n	19	21	21
Accuracy:			
correct	8.89	6.57	2.67
Error types:			
salient word	0.95	2.81	2.71
visual shape	0	0.14	3.52
reversals	0.16	0.48	1.1

groups in the mean accuracy for remembering the salient letter codes. Table III presents a summary of the ANOVA calculations. The result of the ANOVA was significant. Therefore, I rejected the null hypothesis and concluded that at least two means differed significantly. The ANOVA test does not specify the particular means which differ; therefore, Tukey's Honestly Significant Difference (HSD) procedure was followed to determine which means were significantly heterogeneous. The results appear in Table IV. This test was selected because the error introduced by analysis is smaller than for tests such as the t-test.

The observed range between each pair of means was greater than the least significant range, indicating that the difference between means was significant. This confirms that the three means were drawn from three different populations. The literate group attained the highest accuracy in selecting the salient letter codes trained, the emergent literate group was less accurate and the preliterate group was least accurate.

TABLE III

ANOVA SUMMARY TABLE FOR COMPARISON OF MEAN ACCURACY OF LITERATE (L), EMERGENT LITERATE (E) AND PRELITERATE (P) GROUPS

	STATISTICS											
	# correct	n	sum of x	SS	CM	SS Total	SST	SSE	df	MST	MSE	F
GROUP:												
L	169	19										
E	138	21										
P	56	21										
STATISTIC:			363	2729	2160.2	568.9	399.3	169.6	2	199.6	2.9	68.3

TABLE IV

TUKEY'S HONESTLY SIGNIFICANT DIFFERENCE PROCEDURE FOR COMPARING MEAN ACCURACY OF THE LITERATE GROUP TO THE EMERGENT LITERATE GROUP (L&E), EMERGENT LITERATE TO PRELITERATE (E&P) AND LITERATE TO PRELITERATE (L&P)

	PAIRS OF GROUPS		
CALCULATED STATISTIC	L & E	E & P	L & P
Least Significant Range	1.335	1.223	1.083
Observed Range	2.323	3.904	6.228

Proportion of error types

Error types were analyzed to determine the basis for performance by looking at strategies used. This was done by looking at the error types. It seemed possible that the literate groups (literate and emergent literate) would differ from the preliterate group in terms of the strategy used, i.e. that the literate groups would use a salient word encoding strategy yielding a higher proportion of salient word errors in cases of uncertainty, whereas the preliterate group would use a different strategy that was unrelated to the salient words in the messages. Table II lists the mean number of errors of each type for each experimental group. To determine whether a relationship existed between literacy level and proportion of errors, the three experimental groups were compared with each other in terms of proportions of error types, using the G-test with four degrees of freedom. The null hypothesis stated that the proportions of error types were independent of literacy level.

The number of errors of each type (visual shape, reversal, salient word) have been tabulated for each experimental group in Table V along with row totals, column totals and the grand total of errors. The calculated G statistic was 73.55, which was significant. This indicated that the proportion of error types was not independent of literacy, i.e. was not due to chance.

TABLE V
NUMBER OF ERRORS OF EACH TYPE PRODUCED BY LITERATE (L), EMERGENT LITERATE (E) AND PRELITERATE (P) GROUPS, TOTAL NUMBER OF ERRORS OF EACH TYPE (ROW TOTALS), TOTAL NUMBER OF ERRORS PRODUCED BY EACH EXPERIMENTAL GROUP (COLUMN TOTALS) AND GRAND TOTAL OF ERRORS

	LITERACY LEVEL			
ERROR TYPE	L	E	P	ROW TOTALS
# of Salient word errors	18	59	57	134
# of Visual shape errors	0	3	74	36
# of Reversal errors	3	10	23	77
COLUMN TOTALS:	21	72	154	
GRAND TOTAL OF ERRORS:				247

As can be seen in Table V, the literate and emergent literate groups were relatively unlikely to make visual shape or reversal errors and were more likely to make salient word-based errors. The preliterate group showed a different pattern with a predominance of visual errors. It was interesting that the preliterate subjects were unlikely to make reversal errors. This fact and other aspects of group error patterns were explored in another set of analyses, described in the next section.

INTRAGROUP COMPARISONS

The initial set of analyses supported the view that preliterate subjects were visually oriented and that literate and emergent literate subjects were oriented to salient word encoding. I then looked within groups for further evidence of selective use of strategies. Characteristics of each of the experimental groups were determined by analyzing each group separately. These analyses are described below.

Predominance of Error Type

Within-group analyses of error type were completed to determine whether one error type predominated in each group and, if so, to determine what that error type was. The prediction was that the predominant error type for the literate and emergent literate groups would be salient word error and that the predominant error type for the preliterate group would be visual error. The results confirmed these impressions.

In order to determine predominance patterns rather than simply heterogeneity of classes of errors, the analyses proceeded as follows. The number of productions of each error type was ranked for individual subjects in each sample, using the ranking procedure commonly used for nonparametric tests. A rank assignment of three corresponded to the error type with the highest number of productions, a rank of one corresponded to the least frequently produced error type and a rank of two corresponded to the error type in the middle. For example, the tenth emergent literate subject listed in Appendix D (line 12) produced one visual shape error, four reversals and three salient word errors. These three error types were subsequently ranked at one, three and two respectively for that particular subject. Average ranks were assigned in the case of ties; for example, the first emergent literate subject produced no visual shape errors, no reversals and one semantic error with corresponding ranks of 1.5, 1.5 and 2. The mean rank was then calculated for each error type. These values are tabulated in Table VI for each error type and each experimental group. By definition, a mean rank above 2.0 indicated that the error type was the most frequently occurring type of error.

TABLE VI

MEAN RANKS FOR FREQUENCY OF PRODUCTION OF DIFFERENT ERROR TYPES BY LITERATE (L), EMERGENT LITERATE (E) AND PRELITERATE GROUPS (P)

	LITERACY LEVEL		
ERROR TYPE	L	E	P
salient word	2.55	2.88	2.00
visual shape	1.61	1.45	2.60
reversal	1.84	.67	1.40

A one-tailed single sample t-test was applied to the error types with mean rank above 2.0. The null hypothesis for each experimental group was that the mean rank of the error was not significantly greater than 2.0.

The only error type with a mean rank above 2.0 for the literate group was the category of salient word errors, with a mean rank of 2.55 and a standard deviation of 0.52. Application of a t-test demonstrated that this mean rank was significantly greater than 2.0. The null hypothesis was rejected. Salient word errors were therefore the most predominant error type produced in the literate sample.

Salient word errors were the only error type with a mean rank above 2.0 in the emergent literate sample. This error type had a mean rank of 2.88, with a standard deviation of 0.31. The mean was significantly greater than 2.0 according to the t-test. Thus, the predominant error type in the emergent literate sample was salient word errors, which is the same as the predominant error type in the literate sample.

Visual shape errors were the only error type with a mean rank above 2.0 in the preliterate sample. The standard deviation of ranked visual shape errors was 0.604. The mean rank of 2.60 was significantly greater than 2.0 according to the t-test, indicating that visual shape errors were the predominant type of error made by the preliterate subjects.

<u>Row position</u>

During individual testing with the Letter Code Recognition Task, I observed what appeared to be row position preferences among the preliterate subjects. For example, it appeared that some of the subjects selected the first choice in each row regardless of the specific letters. The following analyses were completed to determine whether preliterate responses could be explained on the basis of preferences for row position.

The number of items was calculated for each answer type in the multiple choice task (correct, visual shape foil, reversed order foil, salient word foil) in each row position (first,second, third or fourth position) on the blank test form. For example, the second choice in the row was a correct answer for four items, was a visual shape foil for two items, was a reversal for two items and was a salient letter foil for two items. These numbers were multiplied by 21 to form the expected number of responses based on preference of row position. Although one choice from each of the four answer types was provided for each item on the test form and answer types were randomly assigned to row positions for each item, answer types differed in their frequency of occurrence in a given row position. The chi-squared contingency tables containing the expected number of responses and the observed number of responses of each answer type are given in Tables 7-1 through 7-4 for positions one through four respectively. A chi-squared test was applied to each table. For position one, the salient word cells and reversal cells were pooled as part of the statistical procedure (Sokal & Rohlf, 1969, p. 568-569) to ensure that the value of each cell in the analysis was at least five; the rationale for the choice of cells to be pooled was that these were the two least frequently occurring error types in the preliterate sample. The calculated statistic appears for each position in Tables 7-1 through 7-4. The results of the chi-squared test was not significant in each case.

This indicated that the distribution of the preliterate subjects' responses did not match any of the distributions obtained by preference for row position. The responses in the preliterate sample cannot be accounted for by a preference for a particular row position.

TABLE VII

CHI-SQUARE CONTINGENCY TABLES CONTAINING THE EXPECTED NUMBER OF RESPONSES AND THE OBSERVED NUMBER OF RESPONSES OF EACH ANSWER TYPE, THE CALCULATED STATISTIC AND DEGREES OF FREEDOM (df) FOR ROW POSITIONS ONE THROUGH FOUR

TABLE VII-1: POSITION ONE

Answer Type	Expected #	Observed #	Calculated Statistic	df
Correct	63	56		
Visual shape	84	74		
Reversals + Salient word	63	70		
			6.56	2

TABLE VII-2: POSITION TWO

Answer Type	Expected #	Observed #	Calculated Statistic	df
Correct	84	56		
Visual shape	42	74		
Reversals	42	23		
Salient word	42	57		
			47.67	3

TABLE VII-3: POSITION THREE

Answer Type	Expected #	Observed #	Calculated Statistic	df
Correct	21	56		
Visual shape	42	74		
Reversals	105	23		
Salient word	42	57		
			152.11	3

TABLE VII-4: POSITION FOUR

Answer Type	Expected #	Observed #	Calculated Statistic	df
Correct	42	56		
Visual shape	42	74		
Reversals	63	23		
Salient word	63	57		
			55.02	3

Code-Position

As described in the methodology section, half of the visual shape foils (VT) and half of the salient word foils (ST) were confusions for the first letter in thecode, whereas the other half (TV and TS) were confusions for the second letter in the code. Higher accuracy (fewer errors) for a particular code position (first element or second element) would indicate a visual attentional strategy for remembering, i.e. that the child's response was related to the position of the letter (left or right) in the code rather than to the relationship between code and content of the communicative message. Chi-squared contingency tables were used to determine the effect of code-position. The null hypothesis stated that the number of errors subjects made involving the second letter of the code was no greater than the number of errors made involving the first letter of the code. Table VIII shows the contingency tables and the calculated statistic for each of the experimental groups.

TABLE VIII

CHI-SQUARE CONTINGENCY TABLES CONTAINING THE OBSERVED # AND EXPECTED # OF OCCURRENCES OF LEFT CODE POSITION CONFUSIONS (XT) AND RIGHT CODE POSITION COFUSIONS (TX) FOR SALIENT WORD FOILS (ST & TS) AND VISUAL SHAPE FOILS (VT & TV) FOR THE PRELITERATE, EMERGENT LITERATE AND LITERATE GROUPS

	Observed #	Expected #	Calculated Statistic
PRELITERATE TABLE			
XT = VT + ST	54	65.5	
TX = TV + TS	77	65.5	
			4.04
EMERGENT LITERATE TABLE			
XT = VT + ST	29	31	
TX = TV + TS	33	31	
			0.26
LITERATE TABLE			
XT = VT + ST	6	9	
TX = TV + TS	12	9	
			2.00

The results for code-position were not significant for the literate group or for the emergent literate group. However, the result for the preliterate group was significant. The null hypothesis was rejected in the case of the preliterate group and supported for the literate and emergent literate groups. The results indicated that preliterate children made more errors on the second letter of the code than on the first; that is, preliterate children remembered the first letter of the code better than the second. This may also account for the relatively small number of reversal errors produced by preliterate subjects: the first letter of the reversed order foil did not match the letter remembered and the code was therefore judged to be incorrect. Remembering the first letter (the letter on the left) and ignoring whether the second letter is correct or not is a visual strategy. Emergent literate and literate children, on the other hand, demonstrated no preferences for code-position.

TASK ANALYSIS

Salient word foils

In the course of my experiment, I also became concerned as to whether words I selected as salient for the targets were in fact equally salient. Comparison of my selections with the selections of ten literate adults indicated that some targets contained the most salient words in the corresponding messages and others did not. There was high intercoder agreement (above 80%) for three of the targets, middling intercoder agreement (50-60%) for three of the targets and low agreement for four. To determine how this affected performance, I compared the accuracy for the three different item types (high, mid and low salience) for the three experimental groups. One of the low agreement items was dropped by means of random selection (using a random numbers table) so that each salience group would contain three items. The mean accuracy scores for each experimental group for the three item types are summarized in Table IXa.

TABLE IXa

MEAN ACCURACY SCORES OBTAINED BY THE LITERATE (L), EMERGENT LITERATE (E) AND PRELITERATE GROUPS (P) FOR THE THREE DIFFERENT ITEM TYPES (HIGH, MID AND LOW SALIENCE)

	LITERACY LEVEL			
ITEM TYPE	L	E	P	Row Totals
high agreement	2.80	2.10	1.05	5.95
mid agreement	2.21	1.67	0.71	4.59
low agreement	2.89	1.86	0.76	5.51
Column Totals:	7.90	5.63	2.52	16.05

TABLE IXb

SUMMARY OF TWO-WAY ANOVA WITH REPEATED MEASURES FOR EFFECTS OF SALIENCE AGAINST LITERACY LEVEL ON MEAN ACCURACY SCORES OF THE LITERATE (L), EMERGENT LITERATE (E) AND PRELITERATE (P) GROUPS

Source of variation	SS	df	MS	F	p
Salience	0.32	2	0.16	5.82	n.s.
Literacy	4.86	2	2.43	88.36	<0.05
Error	0.11	4	0.03		
Total	5.30	8			

A two-way ANOVA with repeated measures was completed to determine whether salience of targets influenced mean performance. Table IXb provides a summary of the ANOVA. Literacy effects (experimental group effects) were significant. The salience effect was not significant. A graph of the results appears in Figure 1. There was no effect of literacy X salience interaction.

Visual shape foils

Visual shape foils consisted of letters which were highly similar visually to targets; however, the visual shape foils were not exactly equal to each other in visual discriminability as measured by reaction time because different letter pairs have different reaction times (Garner, 1979; Clement & Carpenter, 1970). To determine whether this difference significantly affected the results of my

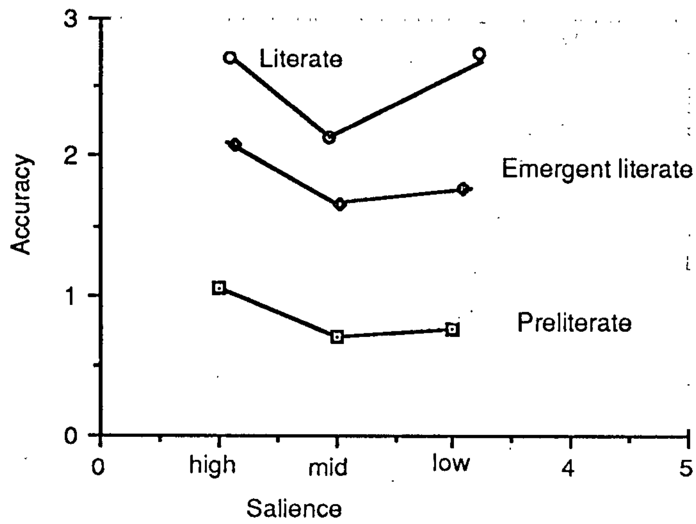

Fig. 2.-- Mean accuracy for literate, emergent literate and preliterate groups as a function of salience of target codes and literacy level.

experiment, I divided the items into two sets of five on the basis of reaction time (one higher set and one lower set). Since the preliterate group was the only group for whom visual shape errors were a predominant pattern, I applied a chi-square contingency table test to the preliterate results (Table X) to compare the two sets of items with regard to the number of visual shape errors. The calculated statistic was 0.486, which was not significant at a 0.05 level of significance. Therefore, these differences in reaction time were minor and did not bias the results of my experiment.

TABLE X

CHI-SQUARE CONTINGENCY TABLE CONTAINING THE EXPECTED NUMBER, OBSERVED NUMBER AND TOTAL NUMBER OF VISUAL SHAPE ERRORS PRODUCED BY PRELITERATE SUBJECTS AND THE CALCULATED STATISTIC FOR FOILS WITH LOWER REACTION TIME AND HIGHER REACTION TIME FOR DISCRIMINATION FROM TARGET LETTERS

Reaction Time	Expected #	Observed #	Calculated Statistic
Lower set	37	34	
Higher set	37	40	
			0.486
Total errors:	74	74	

SUMMARY OF RESULTS

1. The differences between the three groups in terms of mean accuracy were highly significant. The literate-preliterate, literate-emergent literate and emergent literate-preliterate differences were also significant.

2. The proportions of error types were not independent of literacy level.

3. Preliterate children produced significantly more visual shape errors than salient word errors or reversals. Literate and emergent literate children produced primarily salient word errors. Each of these results was significant. Nonstatistical inspection of the preliterate data seemed to indicate that preliterate subjects avoided selecting reversed order foils.

4. The responses in the preliterate sample cannot be accounted for by a preference for a particular row position.

5. Preliterate children remembered the first letter of the code better than the second. This visual strategy may explain the low proportion of reversal errors because the first letter in reversed order foils never matches the first letter of the target code. Emergent literate and literate children demonstrated no preferences for code-position.

6. Analysis of salience differences between items indicated that salience differences had no significant effect on the performance of the three experimental groups.

7. Task analysis revealed that minor differences in the minimum reaction time for letter discrimination were insignificant.

CHAPTER 4

Discussion

The results of the experiment will be explained and will be related to developmental issues raised in this paper. The discussion will also cover methodological issues, clinical applications and directions for future research.

The purpose of the study was to provide some direction to clinicians selecting AAC devices for nonspeaking children of various literacy levels. Although the subjects in the present experiment were normal children, the results were generalized to the clinical population. The reasons for using normal subjects rather than disordered subjects were detailed in Chapter 2 and included increased homogeneity of samples, increased number of subjects, elimination of confounding effects related to differences in physical and mental handicaps and previous AAC studies using normal subjects (Watkins, 1988; Beukelman & Yorkston, 1984).

LITERACY EFFECTS

The results of the experiment indicated that emergent literate children made significantly more errors than literate children in learning and remembering salient letter codes, but made significantly fewer errors than preliterate children. Preliterate children made significantly more errors than either literate group (literate and emergent literate).

Emergent literate and literate subjects produce primarily salient word errors whereas preliterate children produce predominantly visual errors (visual shape and left letter preference). A predominance of salient word errors indicates that the child is using the concept of salient letter encoding in remembering letter codes. The use of this strategy is one indication that the child is a good candidate for VOCA's using LOLEC, specifically salient letter codes. In order to be clinically useful, the codes selected by means of this strategy must be maintained in memory with a reasonable degree of accuracy. The literate group remembered salient letter codes with a mean accuracy score of 89% correct, which approximates the 90% criterion used clinically for mastery. The emergent literate group attained a mean accuracy of 66% correct, which indicates that performance is sufficient most of the time but that the codes have not been completely mastered. Salient letter codes have been found to be the least cognitively demanding as compared to other alphanumeric codes and semantic compaction (an iconic encoding technique) for literate nonspeaking adults (Light et al., 1988). The results of the present experiment indicate that the user group for this preferred system includes literate and emergent literate children.

Visual errors indicate that the child is using visual rather than semantic information to remember the letter codes. This strategy involves the use of visual features of the symbols in the codes; because the symbols are letters, the visual features are unrelated to the content of communicative messages. Salient letter encoding which is, by definition, the encoding of salient words by means of letters, is based on salient content of messages, not salient letters of codes. Because visual shape and left element preference are not central to the encoding process, the child who uses a visual strategy is not using the salient letter encoding technique. Predominant usage of these visual strategies by the preliterate group yielded very poor accuracy scores on the experimental task, with a mean of 27%. These results suggest that preliterate children receiving this degree of training would be unsuccessful users of an AAC device in which communicative messages are encoded using salient letter codes. Because previous investigations demonstrated that salient letter codes were the most easily and accurately remembered of the various types of alphanumeric codes, and because all alphanumeric codes, regardless of the system, use symbols which bear no physically visible resemblance to the semantic content of communicative messages, these results may be generalized to the use of all types of alphanumeric encoding techniques by preliterate children.

With the degree of training provided in this study, the emergent literate and literate subjects became successful users of salient letter codes, whereas preliterate subjects did not. Young children are generally less efficient learners than older children. Could preliterate subjects become successful users of salient letter codes if provided with additional training and practise? If so, this would have implications for children who will eventually become literate: the expense of time and effort to learn a task which is initially difficult (salient letter encoding) may be more beneficial than an initially easier task in the long term, with regard to flexiblity and continuity when the child becomes literate. A learning to criterion experiment is needed to determine whether preliterate subjects can successfully learn salient letter encoding when provided with additional training and practise and, if so, to determine the amount and type of training and practise necessary to achieve success.

Accuracy alone is not an indicator of success. The subjects must achieve not only an acceptable accuracy score, but must also use a salient letter encoding strategy, e.g. as indicated by a predominance of salient word errors. Otherwise, the subjects are only memorizing specific examples of codes (rote memory) rather than learning and using the salient letter encoding technique. Rote memory will be ineffective when the number of codes is significantly increased to meet communication needs; this assumption may be tested by training a large number of codes (corresponding to the number of messages used by competent AAC users in the clinical population) in the learning to criterion experiment. Salient letter encoding requires knowledge of various concepts: the concept of what a "word" is, what a "letter" is, what the first letter of a word is, graphophonemic concepts and word salience. Therefore, extensive teaching of salient letter encoding to children who are not using a salient letter encoding strategy (the preliterate subjects in the present study) would require explicit teaching of these concepts in order to avoid rote learning of other features of the target code. However, because these concepts are literacy concepts, training these concepts would change the "preliterate" status of the subjects to emergent literate and success on the task might be attributable to the change in literacy ability.

Let us now look at the effects of explicit strategy training. As detailed in the first chapter, Tighe et al. (1975) found that the strategies used by 7-year-olds (who were normal and therefore emergent literates) were different from those used by older subjects (who were normal and therefore literate) to remember and later recognize words presented in printed form; in this experiment, no mnemonic or learning strategies were specified to the subjects. In contrast, the emergent literate group in the present study used the same strategies as older subjects when mnemonic/ learning strategies were explicitly taught. Thus, the differences in Tighe et al.'s study may be accounted for by differences in the ability of children of different ages/literacy levels to devise effective strategies for learning and remembering orthographic stimuli rather than in the ability to use these strategies.

Maturational versus nonmaturational viewpoints

The performance of the experimental groups will now be compared in relation to two opposing developmental theories. The difference in strategy-use by preliterate children as compared to the two literate groups of children (literate and emergent literate) indicates qualitative as well as quantitative change with literacy level in the ability to learn and remember salient letter codes to access communicative messages from the memory of dedicated speech computers. This evidence challenges the nonmaturational theory supported by authors such as Chi (1981), Keil (1981) and Harste et al. (1984) that changes with development are quantitative but not qualitative in the domains of cognition and language, i.e. that no differences exist at a process level across development. In the present experiment, differences in content knowledge (literacy abilities) between the groups were related to qualitative aspects (strategy use, determined from error patterns) and quantitative aspects (accuracy) of performance on a particular cognitive-linguistic task; the results demonstrate that success on this task requires this background knowledge to at least some degree (emergent literacy level). Since attainment of this background knowledge constitutes development in this area, I could then reason that both quantitative and qualitative changes occur with development. Stated more directly, quantitative differences (differences at a content level) exist between the preliterate group and the literate groups, as measured by their performance on literacy tests and as reflected in performance on the letter code recognition task. Quantitative differences are not a point of contention between the maturational and nonmaturational theorists. The preliterate group used visual strategies to complete the task, whereas the literate group used the salient letter encoding strategy. This process level difference supports a maturational point of view, in keeping with theories such as those proposed by Piaget (see Yussen & Santrock [1982] for a comprehensive overview).

Let us examine error patterns in more detail. Literate children made absolutely no visual shape errors and did not have a code position preference, whereas preliterate children made primarily visual shape and configuration errors; this may be viewed as a qualitative change in the type of cognitive-linguistic strategy used to complete the task, i.e. no use of visual strategy versus use of visual strategies. This may also be viewed as a quantitative change, however, because early literate children made some visual errors but visual errors were less prevalent than for preliterate children. The children at the next stage of development, literate children, made even fewer visual errors, i.e. none.

Therefore, fine analysis would suggest that proponents of the maturational viewpoint of qualitative change in the area of cognitive-linguistic development may simply be missing a middle stage of development with features in common but not identical to an earlier stage of development and which forms a "bridge" or progression between early and later stages. However, if importance is placed on gross analysis of patterns rather than on fine analysis of details, then the maturational view is correct.

This issue cannot be resolved in a discussion section. My intention is only to introduce and discuss the issue insofar as it relates to the findings of the present study. It may be argued that development consists of qualitative changes at a process level that are based on a continuum of quantitative changes at a content level. At certain points along the continuum, such as between preliteracy and emergent literacy, the degree of quantitative change at a content level is sufficient to yield a qualitative change at the process level. Interaction in development across domains may also be a factor in terms of the effect of one domain on another.

SIGNIFICANCE OF PRELITERATE STRATEGIES

There are at least three visual characteristics of the array of codes in the recognition task: visual shape and two forms of visual configuration (code position and row position). These characteristics were examined along with their relationship to the children's performance.

I have argued that code position preference is indicative of visual strategies. An alternative interpretation might be that code position preference has to do with a semantic strategy of word order, i.e. that the preceeding words in the communicative message are more salient than the following words. If this is the case, salient word codes of the form ST should be selected more frequently than VT visual shape codes. The second letter in the ST code was correct, i.e. was the same as in the target letter code, and the first letter was a salient word preceeding this target in the communicative message. The foil in the VT code bore no relationship to words in the message. The results indicated that ST codes were in fact selected less frequently than VT codes in a ratio of 23 ST to 31 VT. Furthermore, code positions were taught as a visual strategy during the training procedure: "The letter P is the first letter in the code, so it goes on the left side (investigator then points to letter on the left in code). The letter C is the second letter in the code, so it goes on the right side (investigator then points to letter on the right in code)." The training procedure discussed code position as a visible feature of the letter and the code and did not suggest any semantic relationship between code position and message. These arguments support the view that code position preference is a visual strategy.

To understand the training instructions for code position, subjects did not necessarily have to comprehend and linguistically differentiate the words "left" versus "right" and "first" versus "second," nor the correspondence between these labels in the code. Subjects were required only to note the letter pointed to and its visible position in the printed code; it was not necessary that the subjects understood the linguistic labels for this visible position. However, because young children tend to confuse left with right and first with second, the use of these labels in the instructions may have been confusing for the preliterate subjects. Additional testing is necessary to eliminate the effects of this potential confound by using the pointing gesture and printed representation of the computer keys for the code and saying, "Look where the letter P" is and "Look where the letter C is," without using the labels "first/second" or "left/right."

Preliterate subjects preferred the left code position rather than the right code position even for salient word foils, i.e. if the first letter matched the target, they selected it. However, they chose more visual shape foils than salient word foils because they were using two strategies: left letter (visual configuration) and visual shape. Using both strategies at once would be to select the left letter with the same visual shape as the target; the choices for this approach would be VT, TV, TS or correct. Therefore, if these strategies are visual, the preliterate subjects should make very few ST selections and very few reversals. The data confirm this: Only 23 ST and 23 reversals were produced. In contrast, there were 56 correct responses, 43 TV responses, 34 TS and 31 VT responses. Thus preliterate children used a visual strategy even for semantic foils.

It has been established that the performance of preliterate subjects was based on the use of visual strategies. What is the significance of these particular strategies? They indicate that even children who are nonreaders have some initial awareness of print conventions, namely left-to-right orientation. They notice the left first; they did not carry this far enough in that they then ignored the element on the right in many cases. These strategies also indicate that preliterate children possess some visual analysis skills. They were able to segment the visual pattern of the two-element code into its elements and to note the first element. They were also able to note visual shape features. Results of the Print Awareness Test, which was administered to a random selection of six preliterate subjects, confirmed these impressions. Four out of six children demonstrated initial visual analysis skills by pointing out individual letters (the first and the last letter, as requested) or noting that the print was inverted. Three out of six children demonstrated orientation from the left by either moving their finger from left to right on a line to indicate the direction of reading or by pointing to the top left corner of the page to indicate where to begin reading. The fact that PAT results confirm observations of strategy use supports the finding that subjects use their literacy knowledge to learn salient letter codes, i.e. that literacy affects performance.

METHODOLOGICAL ISSUES

Subjects with outlying reading scores were not included in the study, in order to eliminate overlap in literacy ability between the three groups. Also, eliminating subjects with exceptionally poor or exceptionally good cognitive or reading abilities as compared to chronological age peers decreased random variance resulting from a skewed rather than normal distribution of literacy abilities in each literacy group; otherwise, results could have been biased by certain children in a particular group being exceptionally high or low in intelligence, which would limit the generalizability of the results. The three groups were similar in size which also maintained the power of the statistical tests and reliability of results.

Biases may have been introduced because of possible associations among the children who were not included in the study due to lack of parental consent; however these biases, if present, were not important to the nature of the task.

The potential for bias from salience differences between target codes and from differences in visual discrimination latency data between visual foils was investigated through task analysis and was found to be insignificant.

For the various reasons discussed in chapter 2, the task for investigating how well the subjects had learned and remembered codes was designed to be a recognition task (selecting codes from a number of choices) rather than one of recall (writing out the code) and the response mode was with paper and pencil rather than using the keyboard. Both keyboard use and the experimental task are recognition tasks, with the difference being that there are more choices available on the keyboard. If recognition is a problem clinically, when all 26 letters of the alphabet are available, the number of choices can be reduced by taping a list of the salient letter codes to the child's computer. The literate groups in the present study were able to select the appropriate code from a number of choices with letters in common. This indicates that an emergent literate or more fully literate child would be able to recognize the code from among others in the list.

On the recognition task, code position of letters (first/last) corresponded to left/right because of the printed representation of codes. Preliterate subjects attended more to the letter on the left. On a keyboard, the first/last characteristics of code elements correspond to the action of depressing the key first or last. The printed task requires the child to remember left and right positions (although not the verbal labels, 'right' and 'left') rather than time sequence. This difference from the keyboard would affect only the production of reversal errors. Children who find it more easy or more difficult to remember time sequence than left/right position may produce less or more reversal errors respectively using a keyboard than were observed on the experimental task. However, training of first/last characteristics of code elements during the experiment taught the correspondence to time sequence as well as to left/right position. It may be possible that preliterate children would attend more to the letter in the code which is further to the left on the keyboard; this is not always the first letter in the code. Alternatively, they may attend more to the letter on the key which is depressed first. Both of these are visual rather than semantic strategies in that they bear no relevance to the semantic content of the communicative message. The former strategy involves attention to static visual features of the keyboard whereas the latter involves attention to dynamic visual aspects of the learning situation (the visible action of depressing keys).

An aspect of the testing procedure was that subjects were provided with the same verbal description of communicative context used in the training session and were also provided with the communicative message. The only task which subjects were asked to perform was to remember and select the appropriate letter code. In situations where VOCA's are normally used by nonspeaking persons, users must decide and remember which message is appropriate for the communicative context as well as thinking of code. However, this skill is one of linguistic competence rather than being literacy-related. To use the results of the study clinically, a clinician must also determine whether the emergent literate user or literate user also had the linguistic and pragmatic competence necessary for message-selection. Selection of an appropriate message is a necessary pragmatic language skill common to all encoding techniques, whether iconic or alphanumeric.

CONCLUSION

Summary of Clinical Applications

Preliterate children used strategies unrelated to the salient word encoding process and the strategies they used were ineffective, attaining a mean accuracy score of 27%. Preliterate children would therefore be poor candidates for an augmentative and alternative communication device employing a salient word encoding technique. Clinically, an iconic encoding technique might allow preliterate children to make use of their visual approach to the task of learning codes; that is, a picture may be worth a thousand words, or at least enough words to form a communicative message. The literate group successfully mastered the use of nonpersonalized salient letter codes with a mean accuracy score of 89% correct, which approximates the 90% criterion used clinically for mastery. The emergent literate group's performance was qualitatively the same but quantitatively different from that of the literate group: they used the salient word encoding strategy (assuming that salient word errors indicate that the child is using the salient word encoding technique) but made more errors, attaining the clinical criterion of sufficient performance but not mastery. The results indicate that emergent literacy skills are sufficient for successful use of salient letter codes to access prestored messages from the memory of dedicated speech computers -- at least in a constrained task with relatively short sentences and simple words -- given that linguistic and pragmatic skills are also sufficient for functional communication.

As discussed in chapter 2, these results may be generalized to a disordered population of clients with fairly uniform profiles of abilities. The results suggest that literate or emergent literate nonspeaking children would be capable users of salient letter codes, which are the least cognitively demanding type of code commercially available to access prestored communicative messages from the memory of dedicated speech computers. The results may be less generalizable to clients who have significant differences between their levels of language, cognition and literacy ability.

Salient letter encoding is the technique used by nonspeaking individuals for accessing prestored messages from the RealVoice/Epson. Other VOCA's with storage capabilities are primarily iconic; however, those that use key sequences for accessing stored messages may be adapted by replacing icons on the keyboard with letters. Some iconic devices, such as the Prentke Romich Company's Light Talker and Touch Talker, display letters on the keyboard for use in "spell mode" (letter by letter spelling of messages to be spoken by a speech synthesizer in the device). This keyboard can be easily adapted for salient letter codes by using the letters to form codes in "communication mode" (the mode for accessing prestored messages) and ignoring or removing the pictures.

Directions for future research

At least three research questions arise from the present study and are described below:

1. The incorrect responses produced by emergent literate subjects were primarily salient word errors, which may be viewed as preference for an alternate salient letter code. It seems highly likely that use of personalized codes for emergent literate children would yield higher accuracy and perhaps the same accuracy as literates; this prediction needs empirical verification. The investigator would also need to check that code selections are stable (maintained

in memory) over time. The target codes in the present experiment were stable over the time period of the experiment (training time plus testing time plus forty minute time delay). It would be worthwhile to investigate whether the alternate salient letter codes chosen by emergent literate subjects are stable over time.

2. Emergent literate children remembered codes which were the initial phonetically spelled letters of salient words in communicative messages. Clinically, even nonphonetically spelled words may be assigned phonetic codes, but is this really necessary? Future research may investigate accuracy of remembering by emergent literate subjects when initial letters of salient words selected for codes are not spelled phonetically, using words which the subjects know how to spell correctly. This is a minor point which may be incorporated into a larger study.

3. The preliterate subjects' attention to and use of visual features indicated that preliterate nonspeaking children may benefit from an encoding technique in which visual features of a code are relevant to the content of the corresponding communicative message and in which icons are less visually similar than letters. The visual features of iconic codes are, by definition, relevant to the content of the corresponding messages. The icons may be objects, photographs of objects, black and white photographs, coloured drawings, black and white pictures, line drawings, line symbols or minsymbols. A hierarchy of iconicity (transparency) has been established by Mirenda & Locke (1989). A direction for future research would be to study the effect of visual features (configuration, transparency of relationship of visual features to content of communicative message, and similarity among icons in terms of shape) on the accuracy with which preliterate subjects remember these various types of iconic codes.

<u>Benefits of AAC Research Using Normal Subjects</u>

An additional effect of this study was that it increased "mainstream" students' awareness of what it is like to have a disability. Experiencing the demands of the task may have helped them to better understand, respect and accept the non-speaking people in their school and in their community who must use dedicated speech computers to communicate. Informal comments from some of the children who participated in the study indicated that such an awareness had developed.

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APPENDIX A
TRAINING PROTOCOL

GENERAL INTRODUCTION

The examiner introduces herself and briefly explains what the RealVoice/Epson is, giving a demonstration with the code "HBG" for "Hello boys and girls."

PRACTISE

Put up overhead transparency and say the following:
"If I come up to you and smile at you, you could make the computer say, 'Hi Suzanne!' To make it say that, the special letters are the letters 'H' and 'S'. " First I push the letter 'H'. (Do so). Then I push the letter 'S'. (Do so; then push the 'talk' button and pause to listen to the voice output of the device). The computer said 'Hi Suzanne'."

TRAINING INTRODUCTION

"Now I'm going to show you ten more messages that the computer can say and you can each have a turn. Each message needs a secret code -- that's the two letters you need to remember for the message. Different messages have different secret codes. You need to remember the letters in the secret code and the order of the letters.

"For example, the secret code to make the computer say 'Hi Suzanne' is the letters 'H' and 'S'. You always have to do the 'H' first; that's why it's on the left side (point on overhead transparency). You always have to do the 'S' second; that's why it's on the right side (point on overhead transparency).

"Listen very carefully and try to remember the secret codes. You're each going to get a turn with the computer now. Then later this morning, I'm going to ask you to rember all of the secret codes that make the computer talk. Try hard to remember them. Put up your hand if you don't understand. Do you have any questions?"

TRAINING ITEM ONE

Put up the overhead transparency of a woman and say the following:
"Here's another thing the computer can say. If you wanted to know this lady's name (communicative context), you could make the computer say, 'What's <u>your</u> <u>name</u>?' The letters you need to pick are 'Y' and 'N', in that order.

"Y is the first letter of the word 'your'. Y comes first in the secret code, so it's on the left side. N is the first letter of the word 'name'. N comes second in the secret code, so it's on the right side."

Choose two subjects and say:
"Pretend you want to know that woman's name (repeating context). Make the computer say, 'What's your name?'. (To one of the children:) You push the letter Y for your (point out the letter Y on the keyboard). (To the other child:) Now you push the letter N for name (point out the letter N on the keyboard)."

After the child pushes the N key, the examiner pushes the 'talk' button and pauses to listen to the voice output of the device. The examiner then says:
"You made the computer say, 'What's your name?'"

TRAINING ITEMS TWO TO TEN

The procedure is the same for each item. Two new subjects are selected for each item so that each subject is exposed to the keyboard once. The corresponding overhead transparency is shown during the training of each item. The communicative contexts, codes and communicative messages for each item are listed below:

Item 2: You want someone to play games on the computer. Make the computer say , 'Let's play computer games' = PC.

Item 3: Someone is teasing you and taking your toys away. Make the computer say, 'Don't bug me.' = DB.

Item 4: You are thirsty and want someone to give you a drink of juice. Make the computer say, 'I want to drink some juice please.' = DJ.

Item 5: You want something that's up high on a shelf and you want someone to help you get it down. Make the computer say, 'I need help please.' = HP.

Item 6: Your mom or dad bought you a really neat toy and you want to show it to your friends at school. Make the computer say, 'Look at my toy.' = MT.

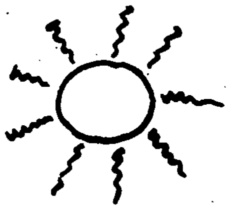
Item 7: You ate up an apple and your teacher said, 'Where's the apple?' Make the computer say, 'It's all gone.' = AG.

Item 8: You dropped something on your foot and you want to tell your teacher how it feels. Make the computer say, 'My foot hurts.' = FH.

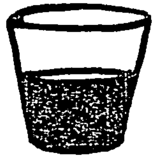
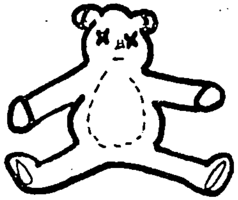
Item 9: You came home from school and your mom and dad gave you only one cookie. You're still hungry. Make the computer say, 'I want more please.' = WM.

Item 10: It's time for bed and you want someone to read you a story. Make the computer say, 'Please read me a story.' = RS.

APPENDIX B:
LETTER RECOGNITION TASK - TEST FORM

	A L	T E	Z U	N D
	Q E	E S	S S	Z Z
	T S	H S	S H	A C

	F H	E H	H F	M F
	H F	P H	H M	H P
	X N	Y N	N Y	W N

	D U	D J	J D	W J
	N B	D B	D R	B D
	M I	L T	T M	M T

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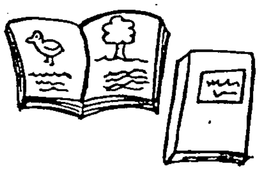
	A G	K G	I G	G A
	R P	S R	R S	B S
	P C	L P	C P	P O
	M P	W M	N M	M W

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APPENDIX C
TESTING PROTOCOL FOR PRACTISE ITEMS

Ensure that each student has a pencil, eraser and test booklet.

Say, "Listen carefully. Put your pencil down on your desk until I have finished talking. We learned some secret codes and messages earlier today and I asked you to try to remember them. Now I'm going to see how well you remembered them. Listen carefully and I'll explain what to do."

PRACTISE ITEM ONE

"Look at the front page of your booklet (point to the front page of a booklet held up by the examiner). Put your finger on the picture of a sun. If it's sunny out, I want the computer to say, 'What a nice day!' I need the letters 'ND' to make the computer say that. Look at the picture of a sun (point). Next to the sun, there is a row of letters (point). Under each group of letters is a little flat circle, called an oval (point), just like in the other booklet (the Gates-MacGinitie Test of Reading test booklet, which had been administered immediately prior to the Salient Letter Code Recognition Task). Look at each group of letters in the row (point). Look at the oval under the letters 'ND' (point). It has been coloured in with a strong, dark mark. The mark fills up the oval but does not go outside the oval. You are going to fill in some other ovals so they look like the oval under the letters 'ND'."

These instructions are a modified version of the instructions for the Gates-MacGinitie Test of Reading, because the response mode is the same: scanning the choices and colouring in the corresponding oval.

PRACTISE ITEM TWO

"Now move your finger down to the picture of Ernie (point). Next to Ernie is a row of letters (point). Someone asks me where Ernie lives. I want the computer to say, 'Ernie lives on Sesame Street,' so I need to pick the letters 'SS'.

"Look at the groups of letters next to Ernie (point). One of these groups has the letters 'SS.' Look at each group and find the one that says 'SS.' Put your finger on the group that says 'SS'. (Pause to allow the subjects to respond). Did you pick this one? (point and walk around the room to check that subjects have understood what to look for). Now colour in the oval under the group that says 'SS' (point). Make a strong, dark mark. Colour in the oval, but don't let your mark go outside the oval. (Pause to allow time for response). When you have finished, put your pencil down. Do not make any other marks."

Walk around the room to check that subjects understand the response mode (colouring the desired oval). Discuss each of the foils, explaining in simple language why they are incorrect (ES is a semantic foil and and ZZ is a visual foil).

PRACTISE ITEM THREE

"Keep your pencil down on your desk. Now move your finger down to the picture of a happy face (point). Next to the happy face is a row of letters (point). If I walked up to you, you cold make the omputer say, 'Hi Suzanne.' (a message and code practised in training).

"To make the computer say, 'Hi Suzanne,' you need to pick some letters. Look at the groups of letters next to the happy face. Look at each group and find the letters that say 'Hi Suzanne.'

"When you find the right group, colour in the oval under that group. Make a strong, dark mark. Colour in the oval, but don't let your mark go outside the oval. When you have finished, put your pencil down. Do not make any other marks. " (Walk around the room to check).

"To make the computer say, 'Hi Suzanne,' you need to pick the letters 'HS'. So, you should have coloured in this oval (point).

"If you coloured in the wrong one, erase it really well so that you can't see the mark any more. Then make a strong, dark mark in the right oval." (Check that subjects understand how to correct errors.)

Discuss each choice and explain, in simple language, why the foils are wrong (TS is a visual foil, SH is a reversal).

INTRODUCTION TO TEST ITEMS

"Now we are ready to go on. Don't worry if you don't know which oval to mark. Just try your best. Always listen carefully and then colour in the oval you think is right. Make sure you colour in only one oval for each picture. That means, choose only one answer for each picture. If you make a mistake, erase it really well and then make a strong, dark mark in the right oval.

"If you lose your place, or if your pencil breaks, put up your hand (demonstrate raising a hand).

"Now turn to the next page." Demonstrate turning to the second page of the booklet, which is the first page of test items. Hold up the desired page so that the subjects can see it.

Appendix D - Literate Group

	A	B	C	D	E	F	G	H
1		READING: TS/GE	% CORRECT	VISUAL (VT)	VISUAL (TV)	REVERSALS	SEMANTIC (ST)	SEMANTIC (TS)
2								
3		47/4.0	100	0	0	0	0	0
4		43/3.3	100	0	0	0	0	0
5		53/5.2	90	0	0	0	0	1
6		55/5.7	80	0	0	0	1	1
7		53/5.2	80	0	0	1	0	1
8		53/5.2	100	0	0	0	0	0
9		56/5.9	80	0	0	0	1	1
10		47/4.0	80	0	0	1	0	1
11		47/4.0	80	0	0	0	0	2
12		53/5.2	90	0	0	0	0	1
13		56/ 5.9	80	0	0	0	1	1
14		53/ 5.2	90	0	0	0	0	1
15		46/ 3.7	90	0	0	0	1	0
16		50/ 4.4	90	0	0	1	0	0
17		55/ 5.7	100	0	0	0	0	0
18		55/ 5.7	100	0	0	0	0	0
19		55/ 5.7	100	0	0	0	0	0
20		46/ 3.7	70	0	0	0	2	1
21		53/ 5.2	90	0	0	0	0	1
22								
23	TOTALS		1690	0	0	3	6	12
24	% of all responses			0	0	1.57894737	3.15789474	6.315789474
25	MEAN		88.9473684	0	0	0.15789474	0.31578947	0.631578947
26	% of all errors			0	0	14.2857143	28.5714286	57.14285714

Appendix E - Emergent Literate

	A	B	C	D	E	F	G	H	I
1		G-M: LS	G-M: Comp	%CORRECT	VISUAL (TV)	VISUAL (VT)	REVERSALS	SEMANTIC (TS)	SEMANTIC (ST)
2									
3		h	a	90	0	0	0	0	1
4		a	h	90	0	0	0	0	1
5		h	a	60	0	0	0	2	2
6		h	a	100	0	0	0	0	0
7		a	h	80	0	0	0	0	2
8		a	l	20	0	1	4	2	1
9		a	h	80	0	0	0	1	1
10		a	h	70	0	0	0	1	2
11		a	l	30	0	1	1	3	2
12		a	h	70	0	0	0	1	2
13		a	l	10	1	0	1	4	3
14		a	a	60	0	0	0	2	2
15		a	a	60	0	0	2	2	0
16		h	a	90	0	0	0	1	0
17		a	a	60	0	0	0	3	1
18		h	a	70	0	0	0	2	1
19		a	a	30	0	0	2	3	2
20		a	a	60	0	0	0	2	2
21		a	h	90	0	0	0	0	1
22		h	a	90	0	0	0	1	0
23		h	a	70	0	0	0	2	1
24									
25	TOTALS			1380	1	2	10	32	27
26	% of all responses				0.4761905	0.952381	4.76190476	15.2380952	12.85714286
27	MEAN			65.7142857	0.047619	0.0952381	0.47619048	1.52380952	1.285714286
28	% of all errors				1.3888889	2.7777778	13.8888889	44.4444444	37.5

	A	B	C	D	E	F	G	H
1		%CORRECT	POSITION	VISUAL (TV)	VISUAL (VT)	REVERSALS	SEMANTIC (TS)	SEMANTIC (ST)
2								
3		30	1:7X, 2:3X	2	1	1	2	1
4		20	1:8X, 2:2X	2	2	1	2	1
5		30	1:10X	3	1	0	2	1
6		30	1:3X,2:4X,4:3	1	1	1	2	2
7		30	1:9X, 2:1X	3	1	1	1	1
8		40	1:3X,2:6X,4:1	1	2	0	1	2
9		30	1:10X	3	1	0	2	1
10		60	1:4X,2:1X,3:1,4:4	0	0	2	1	1
11		30	1:7X, 2:3X	2	1	1	2	1
12		20	1:8X, 2:2X	3	1	1	2	1
13		30	1:8X, 4:2X	2	2	0	1	2
14		20	1:3X,2:2X,3:3,4:2	3	3	0	0	2
15		20	1:3X, 2:6X, 3:1X	2	1	3	1	1
16		30	1:7X, 2:2X, 3:1X	2	2	1	2	0
17		20	1:5X,2:1X,3:2,4:2	3	2	1	2	0
18		0	1:3X, 3:4X, 4:3X	2	1	4	2	1
19		30	1:6X,2:1X,3:1,4:2	2	1	2	2	0
20		40	1:9X, 2:1X	3	1	0	2	0
21		10	1:5X, 2:3X, 3:2X	3	4	0	1	1
22		20	1:4X, 2:2X, 4:4X	0	0	0	4	4
23		20	1:2X,2:6X,3:1,4:1	1	3	4	0	0
24								
25								
26								
27								
28	TOTALS	560		43	31	23	34	23
29	% of all responses			20.47619	14.761905	10.952381	16.1904762	10.95238095
30	MEAN	26.6666667		2.047619	1.4761905	1.0952381	1.61904762	1.095238095
31	% of all errors			27.922078	20.12987	14.9350649	22.0779221	14.93506494

APPENDIX G

SUBEXPERIMENT: RESPONSES OF SUBJECTS 1 TO 10 (S1-S10) FOR EACH COMMUNICATIVE MESSAGE (1-10), PERCENTAGE OVERLAP BETWEEN RESPONSES AND TARGET BY MESSAGE (% BY ITEM) AND PERCENTAGE OVERLAP BETWEEN RESPONSES AND TARGETS BY SUBJECT (% BY SUBJECT)

Target	Letter codes corresponding to subjects' selections										% by item
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
1. FH*	FH	FH	FH	FH	FH	FH	FH	FH	FH	FH	100
2. HP	n h	n h	HP	n h	n h	HP	HP	n h	n h	n h	30
3. YN*	w n	YN	YN	YN	YN	w n	w n	w n	YN	w n	50
4. DJ	w j	w d	j p	DJ	w j	DJ	d p	w j	w j	DJ	30
5. DB*	DB	DB	DB	DB	DB	DB	DB	DB	DB	DB	100
6. MT	l t	l t	l t	l t	l t	l t	MT	l t	l t	l t	10
7. AG*	i g	i g	AG	AG	AG	i g	AG	AG	i g	i g	50
8. RS*	RS	RS	RS	RS	RS	RS	p s	p s	RS	RS	80
9. PC*	l p	p g	PC	PC	c g	c g	l c	l p	p g	PC	30
10. WM	m p	i w	m p	m p	m p	WM	m p	WM	WM	WM	40
% by subject:	30	40	70	70	50	60	50	40	50	60	

* = most frequently occurring response for a particular message