ANALYSIS OF DIFFERENT ENCODING MECHANISMS (PHONOLOGICAL, VISUAL, SEMANTIC) AS EMPLOYED BY HEARING IMPAIRED CHILDREN *

İŞİTME ÖZÜRLÜ ÇOCUKLARDA KODLAMA MEKANİZMALARININ (FONOLOJİK, GÖRSEL, SEMANTİK) İNCELENMESİ

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Bu çalışmada işitme özürlü çocukların kodlama mekanizmaları (fonolojik, görsel, semantik) araştırılmıştır. Sonuçlar dil, okuma ve zekâ düzeyleri açısından da incelenmiştir. Büyük çocuklarla dil, okuma ve zekâ düzeyleri yüksek olan çocukların daha çok fonolojik kodlama yaptıkları görülmüştür. Buna karşılık daha küçük olanlarla dil, okuma ve zekâ düzeyleri daha düşük olan çocukların ise görsel kodlama yaptıkları saptanmıştır. Sonuçlar gelişimsel yönden de tartışılmıştır.

In this study different encoding mechanisms (phonological, visual, semantic) of hearing impaired children were investigated. The results were also analysed with respect to their language, reading and intelligence levels. It was found that older children and those with higher language, reading and intelligence levels employed mostly phonological encoding in contrast to younger children and those with lower language, reading and intelligence levels who

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tended to encode mostly visually. The results were also discussed from a developmental point of view.

INTRODUCTION

In investigating the mediating processes of individuals, in attempting to explain directly how hearing impaired (HI) individuals acquire, store, structure and utilise information in short-term memory (STM), researchers in recent times have analysed the phenomena of STM within the framework of information processing models. The rationale of these studies was based upon the assumption that information should be processed, stored and retrieved showing similar features with respect to a particular coding system. Hence, researchers hypothesised that a certain mediating process (via visual forms of the printed word, signs or speech) should result in other cognitive processes (encoding, rehearsal, recall, recognition) revealing the same mediation as the individual's particular mediating system.

Among these studies, Conrad's (1964, 1970, 1972) work in particular has had great influence on subsequent investigations into memory mainly by emphasizing the notion of a memory code. As Gardiner (1976) states, coding processes serve to relate perceptual process, memorial process and the general backround of verbal linguistic knowledge which the individual has permanently available.

How a stimulus is perceived, and the way it is encoded determines what is stored, Encoding involves storing information for future use. Thus, encoding plays a crucial role in learning and retaining information, since its task is to represent the incoming information in the memory system. Encoding is both active and flexible. It's main function is to integrate, evaluate and store what is experienced (Morris 1978). Encoding operates as a constructive and sometimes as a problem solving system. Humans can encode information in a variety of ways ,affected by complex effects of their past experiences, the nature of the task involved, using a variety of strategies or mechanisms like rote repetition, formation of visual images or use of linguistic madiators.

Studies investigating the encoding mechanisms of the HI show that as a group HI children seem to memorise letters by employing coding processes which are different from those used by normally hearing (NH) children. Wallace and Corballis (1973) analysed STM processing in orally and manually trained HI subjects as well as NH subjects. Their results showed that both HI groups were inferior to NH subjects. The HI groups also made extensive use of visual coding with four letter sequences presented visually. The NH group's most predominant encoding, on the other hand, was phonological These results support findings of Conrad and Rush (1965) that HI subjects may make use of visual encoding in STM. It is suggested that, among the NH subjects, phonological encoding is preferred in remenbering verbal material because of its appropriateness for recall as a rehearsal mechanism. Also it is pointed out by Conrad (1972) that NH children, as they have more experience with reading, tend to encode visual stimuli in phonological form. Conrad's (1970) further investigation of STM processes in the HI showed that some of the subjects were primarily relying on phonological encoding and some were relying on a code which could depend on shape. So, Conrad concluded that not all HI children shared a common code in memorising. Bond's study (1971) suggested that HI children utilised both phonological and visual encoding. As age increased phonological encoding increased and conversely visual encoding decreased. It was also pointed out that reading success had a positive relationship with phonological encoding. Conrad (1979) also acknowledges this fact and adds that there are large gaps in our knowledge of hearing impairment and its relationship to reading. He states, for example, that intelligence is a significant factor in reading among the HI, where better reading abilities are associated with higher intelligence.

Frumkin and Anisfeld (1977) found that HI children used visual properties of words in their coding process and retained the semantic content of the words as well. Frumkin and Anisfeld emphasize the importance of semantic encoding in the memory of the HI. They state that this is in contrast to findings with young NH children who display only a weak semantic effect in memory coding. They conclude that the unavailability of speech leads to a greater reliance on semantic codes.

Memory is only one of our cognitive abilities. Our cognitive system selects, modifies and rephrases what we experience which is then encoded accordingly. Hence, the vital role of memory in our central cognitive activity is integrated within the overall cognitive abilities of the individual. Therefore, any discruption within our integrated cognitive system is bound to affect the interacting mechanisms. Disruption of the auditory system would thus lead to an impairment of language, the consequence of which is a disparity between the NH and the HI in areas of cognition involving language. A deficiency in auditory channels, as well as affecting auditory memory and areas involving verbal cognition, also has an effect on sequential memory. Vision can process input spatially as well as sequentially, whereas hearing processes input in a temporal sequential manner. On the whole, HI individuals seem to perform worse than NH individuals in tasks requiring sequential memory (Das, 1983).

It is implied by comparative studies of memory between the NH and HI that an impairment of language caused by hearing impairment affirms some other deficit not present in the NH. Research in this area has not concentrated on how one HI child might be different from another HI child with respect to the same quality. Rather research has been concerned with whether a HI child is different from a NH child. It seems to be more constructive not to treat the HI population as a homogeneous group and investigate aspects and effects of hearing impairment by taking the whole cognitive system into account. As Menyuk (1976) states, among the HI children, as among the NH population, wide differences exist in their capacity to process both linguistic and nonlinguistic input. There are also wide differences amog the HI in their hearing acuity. Such a wider outlook can reveal more useful information concerning encoding mechanisms in relation to the general cognitive structures. Hence, investigating the inter-relationships within the cognitive system among the HI, examining the extent to which encoding mechanisms and/or successive and simultaneous memory are dependent on or related to linguistic abilities, intelligence and reading success can lead to an improved understanding of developmental cognition processes. By not treating the HI as a homogeneous group, the similarities and differences observed within the

HI group in their performances on certain memory tasks may assist improvements in ways of encouraging communication development of the HI.

Evidence from previous studies have shown that visual (Conrad and Rush, 1965; Wallace and Corballis, 1973), phonological (Conrad, 1970; Bond, 1971), and semantic (Frumkin and Anisfeld, 1977) encoding are employed by HI children. The positive relationship between phonological encoding and better reading abilities (Bond, 1971; Conrad, 1972), higher intelligence and better reading abilities (Conrad, 1979) and more frequent use of phonological encoding with increasing age (Bond, 1971) have been documented. However, little has been said about the conditions under wich the memory codes come to be employed, in what way these codes are related to other cognitive aspects. More significantly there is little information concerning the diversity of the HI population wich may cause differences in the way(s) HI children encode visual material in STM.

In investigating the three encoding mechanisms (phonological, visual, semantic) as used by the HI, the main aim of this study is not to disconnect memory from other major cognitive processes such as language, reading and non-verbal intelligence. Hence, the main aim is to investigate how children's encoding processes and their performance on successive and simultaneous visual memory tests interact with their language, reading and intelligence levels.

From existing evidence concerning the use of phonological and visual encoding (Conrad, 1972, 1979), especially on the basis of Bond's results, it is hypothesised that phonological encoding will increase with age and with better reading abilities. Visual encoding is expected to be more popular among younger children and among those children with relatively lower reading levels. Also children with higher levels of intelligence are expected to perform better on the reading test. Higher language levels, by more easily providing the child with a speech-based encoding strategy, are expected to influence phonological encoding. In this study, it will be also attempted to discover how a semantic presentation of the stimulus words will affect semantic encoding. A semantic presentation is expected to increase the use of semantic encoding. The following hypotheses will be investigated :

1. that children with higher levels of language will use more phonological encoding.
2. that children with relatively lower language levels will use more visual encoding.
3. that children with better reading abilities will use more phonological encoding.
4. that children with poorer reading abilities will use more visual encoding.
5. that semantic presentation will increase the use of semantic encoding.
6. that children with higher scores on the intelligence test will also obtain higher scores on the reading test.
7. that older children will use more phonological encoding.
8. that older children will use less visual encoding.

METHOD

Subjects : Twenty-eight HI subjects (14 males, 14 females) between the ages 7 years and 8 month and 13 years and 11 months from one school for the deaf took part in this study. The school's educational philosophy is oral. Subjects hearing loss was averaged across the five frequencies, 250Hz, 500Hz, 1000Hz, 2000Hz, and 4000Hz, as suggested by the National Executive Committee of the British Association of Teachers of the Deaf (1981). The average hearing loss for each subject was not less than 75dB in the better ear.

Measurement Techniques : Ten stimulus words were chosen to test the encoding mechanisms of the chldren. Each stimulus word had four accompanying nonsense choice words. Six of the stimulus words were chosen from Bond's (1971) stimulus words. The remaining four words were chosen by the author according to the ease of devising the accompanying nonsense choice words. The choice words were designed by the author with the help of a phonetician. For each stimulus word (for example : father) one of the choice words was phonologically similar and visually dissimilar (varda), another choice word was visually similar and phonologically dissimilar (totkun), the third choice word was phonologically and visually similar to a real word which was semantically related to the stimulus word (mada). There was also one distractor choice word which showed no apparent similarity to the stimulus word (plong). Hence, the choice words for each stimulus word consisted of four nonsense words : a phonologically similar (PS), a visually similar (VS), a semantically similar (SS) and a distractor (D) choice word. Choice words were the same for each subject for a particular stimulus word, although the order of the choice words was altered for each subject. The order of arrangement was random.

Procedure : First group of 14 subjects (Group 1) viewed the ten stimulus words one at a time for 5 seconds. The same ten stimulus words were shown to the second group of 14 subjects (Group 2), again one at a time for 5 seconds. This time each stimulus word was presented with a semantically related word. (For example : father-family). Hence, a semantic element was introduced to the second group by pairing a semantically related word with the target stimulus word, both of which were presented on the same card. All of the stimulus words were written on cards (3.5 X 5.5 in.) with lower case letters. For the second group the target word was underlined, i.e. *father*-family. For each presentation, the order of the stimulus words was varied randomly. Both of the groups received the same choice words. Subjects' preference on the four choice words were evaluated for each stimulus word to gain a measure of their memory encoding processes.

To investigate the encoding mechanisms in a broader context of general cognitive abilities, an assessment of the subjects' language levels was incorporated. Subjects' language levels were assessed by the Full Range English Picture Vocabulary Test (EPVT), (Brimer and Dunn, 1973). Children in both groups were balanced according to their language levels. Each of the groups had two subgroups, subgroup A and subgroup B. Subgroup A in each group consisted of the 7 subjects with the highest language ages and subgroup B in each group consisted of the 7 subjects with the lowest language ages.

Instructions were given orally and in written from. After viewing the stimulus word subjects were asked to look for a word that looked the same, sounded the same and for Group 2 children a word that went with the word they had just seen. They were told to choose only one word.

Each child also completed the SPAR Reading Test, Form A (Young, 1976). Subjects in both Group 1 and 2 could also be formed into two further subgroups, subgroup C and subgroup D depending on their reading age. This enabled results on the choice words to be analysed with respect to the children's reading levels. Half of the subjects in both Group 1 and 2 formed the subgroup C which consisted of the 7 subjects with the highest reading ages and subgroup D consisted of the 7 subjects with the lowest reading ages.

The Standard Progressive Matrices (Raven, 1960) was employed as a measure of non-verbal intelligence.

As an additional investigation into successive and simultaneous memory, the Visual Attention Span subtest of the Hiskey-Nebraska Test of Learning Aptitude (Hiskey, 1966) was used. Only 17 of the 28 subjects took part in this part of the study. The picture meterials of the Visual Attention Span were presented successively as well as simultaneously to the subjects.

RESULTS

Effects of language levels and semantic presentation on STM encoding :

A three way (4x4x2) analysis of variance with repeated measures (Winer, 1962) was used to analyse variance of choice words by subjects belonging to different language levels (subgroup A and B) and nonsemantic or semantic groups (Group 1 and 2). Variance among the choice words was significant at 0.01 level

(F : 17,55). Due to the nature of the testing design the 'Between Subjects' section of the analysis of variance was not applicable for statistically analysing the results. For results nullified in this manner, the Chi-square (X^2) statistics was used. X^2 results for choice word variance among the two language subgroups showed that children belonging to the subgroups A and B differed from each other in thir choices of the four nonsense words (X^2 11,34 : 13,86, $p<0{,}01$).

Subjects' language scores were correlated with their PS choice words to test Hypothesis 1 («Children with higher language levels will use more phonological encoding»). A statistically significant positive correlation was obtained (r 0,478 : 0,486, $p<0{,}01$). All the subjects' language scores were also correlated with their VS choice words to test Hypothesis 2 («Children with relatively lower language levels will use more visual encoding»). This time a statistically significant ngative relationship was observed (r 0,478 : -0,5, $p<0{,}01$). Children whose language scores were lower tended to choose more VS words in contrast to children whose language scores were relatively higher who chose mostly PS words. Hence, both hypotheses were supported.

The second main effect, semantic versus nonsemantic presentation proved to be statistically not significant when X^2 was used. However, when Group 1 and 2 results were taken separately to analyse variance of the four choice words, both of the groups differed from each other as revealed by post-hoc comparisons (Newman-Keuls test). Among Group 1 subjects SS versus D choice word comparison was not significant. Group 2 subjects, on the other hand, chose significantly more SS words in comparison to D choice words (Group 2, D versus SS, q :3,29, $p<0{,}05$). On the whole, Hypothesis 5 stating that «Semantic presentation will increase semantic encoding» seems to be partially supported. X^2 statistic did not support the hypothesis. Only separate analysis of variance followed by post-hoc comparison demonstrated that the introduction of a semantic factor during the presentation of the stimulus words had an effect on the choice words mainly by bringing the SS choice word into the perceptive awareness of the children in

Group 2. The SS choice word seems to have acted as a second D for Group 1 subjects, as it was expected.

Effects of different levels of reading ability on STM encoding :

A three way (4x4x2) analysis of variance with repeated measures was also used to analyse variance of choice words by subjects belonging to different reading ability subgroups (subgroup C and D) and nonsemantic or semantic groups (Group 1 and 2). The main effect choice words was once more significant (F : 21,33, $p < 0{,}01$). X^2 testing used to investigate the variance of choice words of subgroup C and D subjects also yielded a statistically significant result (X^2 11,34 : 30, $p < 0{,}01$). This supported the assumption that different reading abilities have an effect on the preferences for choice words. To test Hypothesis 3 («Children with better reading abilities will employ more phonological encoding») subjects' reading scores were correlated with their PS choice words. The relationship was positive and statistically significant (r 0,478 : 0,636, $p < 0{,}01$). Hypothesis 4 («Children whose reading abilities are worse will employ more visual encoding») was tested by correlating subjects' reading scores with their VS choice words. This time the relationship was negative and statistically significant (r 0,478 : -0,627, $p < 0{,}01$) suggesting that subjects with higher reading scores tended to choose fewer VS words. Hence, correlation results supported the two hypotheses, implying that better readers used more phonological encoding in contrast to subjects with worse reading abilities who tended to use more visual encoding. Subjects' reading scores correlated positively with their language scores (r 0,478 : 0,573, $p < 0{,}01$). Subjects with higher language levels seemed to perform better on the reading test.

Successive and simultaneous memory performances of the subjects :

Seventeen subjects took part in tests of successive and simultaneous memory. Single factor analysis of variance implied that subjects did not perform equally on successive and simultaneous presentations (F: 11,60, $p < 0{,}01$). The post-hoc comparison (Newman-Keuls test) showed that subjects performed significantly better on the simultaneous presentation than on the successive (q:4,8, $p < 0{,}01$).

It was also found that subjects' intelligence scores correlated positively and significanlty with their simultaneous scores (r 0,482 : 0,488. $p<0{,}05$). and with their successive scores (r 0,482 : 0,539), $p<0{,}05$).

Effects of intelligence levels on subjects' cognitive abilities :

The significant positive correlation between subjects' intelligence scores and their reading test scores (r 0,478 : 0,7, $p<0{,}01$) supported Hypothesis 6 («Children with higher scores on the intelligence test will also obtain higher scoress on the reading test»). Also subjects with higher language levels scored higher on the intelligence test (r 0,478 : 0,5, $p<0{,}01$). Subjects with higher intelligence scores seemed to choose more PS words (r 0,374 : 0,45, $p<0{,}05$) and fewer VS words (r 0,374 : -0,44, $p<0{,}05$). Correlations also revealed that subjects with higher intelligence scores seemed to perform better both on successive and simultaneous memory tasks as we have seen before.

Effects of age on STM encoding, language levels, reading abilities, intelligence, and successive and simultaneous memory :

The X^2 statistic results showed that subjects of different age groups differed in their choices of the four nonsense words (X^2 16,92 : 17,787, $p<0{,}05$). The positive significant correlation between subjects' age and the number of PS words they chose (r 0,374 : 0,375, $p<0{,}05$) supported Hypothesis 7 («Older children will use more phonological encoding»). The Hypothesis 8 that «Older children will use less visual encoding» was supported at the 0,05 level by the correlation between subjects' age and VS choice words (r 0,374 : —0,4534). There was also a positive significant relationship between age and successive memory (r 0,482 : 0,5158, $p<0{,}05$). Older children also tended to score better on the language test (r 0,374 : 0,3974 $p<0{,}05$) and on the reading test (r 0,478 : 0,6039, $p<0{,}01$). Finally, there was a positive correlation between subjects' intelligence scores and chronological age (r 0,478 : 0,6366, $p<0{,}01$).

No sex differences was found among the subjects in their nonsense word choices as demonstrated by X^2 statistic.

DISCUSSION OF THE RESULTS

In this study, HI children were not found simply to be either phonological or visual encoders. The use of phonological or visual encoding among the subjects seems to depend on their age (as also argued by Bond, 1971), their scores on intelligence, language and reading tests (also found by Conrad, 1979).

Older children scored more highly on the language and reading tests and used more phonological encoding. Hence, higher levels of language seems to be associated with a speech based, phonological encoding mechanism. At this point it is worth remembering that the language test used in this study was a test for vocabulary. Therefore, it is more appropriate to argue that increases in the knowledge about words is highly associated with phonological encoding.

Underwood (1979) argues that phonological encoding is an effective device in deriving meaning from text. The results showing that children with relatively lower reading levels employed more visual encoding lends further support to the importance of phonological encoding in reading, by showing that visual encoding is not as efficient as phonological encoding. Phonological encoding seems to play a crucial role in linking an individual's linguistic knowledge to the written form. It can be argued on the basis of the results of this study that with increasing age, as children gain more experience in reading and language, they are more inclined to make more use of their existing linguistic knowledge during reading by using a speech based encoding strategy which facilitates their reading success. This is also in line with the developmental argument by Hagen and Stanovich (1977) who suggested that among NH children, phonological encoding comes to be employed more as they gain more experience with reading.

Taking into account the crucial role of phonological encoding on reading success and the findings of this study, I would endorse Bond's (1971) suggestions for the educator. As Bond states, in learning new visually presented verbal material, greater use of the Listening Reading Speaking method should be made to reinforce the relationship between the visual stimulus and phonological encoding.

We have also seen from the results that an introduction of a semantic element during presentation did increase the choice of SS nonsense words (i.e. semantic encoding) to some extent. However, a further study investigating purposeful reading rather than word encoding might reveal the relationships between reading achievement and semantic encoding more fully. The differences in the usage of semantic encoding among the HI and its relationship to reading success could thus be highlighted. These differences might then assist in improvements involving reading success.

Results concerning the successive and simultaneous memory of the HI, on the whole, showed that children performed better on the simultaneous than on the successive test. The two significant results obtained from successive and simultaneous memory tests involve chronological age and intelligence. Higher levels of intelligence correlated positively with both tests' scores, and older children performed better on the successive test. It can be argued that changes that take place over time, as a result of more experience with language and reading, may provide the older HI children with more useful devices (for example, phonological encoding) to aid their successive memory. These changes, more specifically the quality of these changes occurring over time, need to be investigated further in order to provide adequate information as to how the HI child encodes and processes visually presented material.

Das et al (1979) mention that successive and simultaneous processing are related to performance on task which require either «analysis of the sequential linear structure of the input» or «the grasping of quasi - spatial conceptual relationships» (p. 177). The intelligence test, Raven's Matrices, requires abstract or spatial reasoning, and in order to solve the relationships between the images viewed in the test, the child needs to attend to both the parts and the whole at the same time. As Das et al (1979) argue performance in intelligence tasks requires certain subskills and skills to be learned which are necessary to solve a problem. Hence, since both successive and simultaneous processing are needed to solve a problem, it can be argued that those children who obtained higher scores on the intelligence test, were also likely to be more successful on the successive and simultaneous memory tests.

From the results we can see that there was an intrinsic relationship between intelligence, reading and language levels. Since in reading the child has to internalise words and linguistic structures that he has had experience with, it is not surprising to observe this relationship between higher levels of language and higher levels of reading.

If we conceptualise intelligence and intellectual growth in terms of acquiring techniques to represent our experiences of the world, which according to Bruner et al (1966) constitute modes of representational thinking, we can argue that language is one of the most important symbolic activities having a central role in the development of intelligence. Verbal intelligence and linguiskic skill may be independent abilities, but they are often intercorrelated (Vernon, 1971). One can argue that higher levels of language among the subjects may have contributed to their performances on the intelligence test by providing them with a mediating process which may have aided their representational thinking.

The effects of intelligence levels on reading success among the HI was reported by Conrad (1979). In this study, children with higher intelligence scores were also found to perform better on the reading test. Vernon (1971) suggests that intelligence and linguistic skill are both involved at some stages in learning to read. Hence, a child with higher intelligence scores who possesses the necessary skills to solve the problems in an intelligence test would be expected to perform better on the reading test which not only requires the perception and memory of visual shapes and sounds, «but also more complex cognitive processes» (Vernon, 1971, p. 77).

Cognitive processes exhibit great changes from infancy to adulthood The concept of development inherently assumes change within time. Das et al (1979) state that a theory of intelligence should focus on what is changing during the course of cognitive development. Since memory provides a central role in our cognitive abilities, to build a picture of cognitive development memory processes must also be investigated. Howe and Ceci (1978) account for the differences observed in memory as children get older, in terms of the development of more effective strategies for coding, organising, rehearsing etc.. They argue that age-related improvements in strategies and increases in the degree of knowledge about the particular materials are the main causes for memory development. Improved memory strategies are a by-product of increased knowledge about the items retained in memory. Older children tend to use effective strategies for rehearsal and organisation spontaneously. The fact that older children in this study were more successuful in remembering successively presented pictures than younger children, can also be explained by drawing attention to the use of more effective strategies. It can be suggested that older HI children, who also obtained higher scores on the intelligence, reading and language tests and are phonological encoders, having had more experience with oral language and reading have developed and are aware of more effective strategies, such as sub-vocal rehearsal which was observed by some subjects during the successive and simultaneous tests. At this point it is important to remember that the school the children in this study were attending was using oral methods of instruction.

The kinds of strategies children use to remember affect their performance on a memory task. Also, what children know about memory determines which strategy they use. Therefore, differences in remembering and/or encoding might be attributed to differences in knowledge about memory. Under this theoretical framework, it would be useful to investigate HI child's metamemory. Findings about how a HI child comes to discover weaknesses in his memory as he grows older would help in improving the young HI child's memory. It could be suggested here that a useful teaching strategy might be firstly to discover what strategies children tend to use in dealing with certain material, and then to act upon their existing strategies to provide them with more effective strategies in coping with different kinds of materials to be learned. Hence, children could then actually be taught how best to remember different kinds of materials, for example by making more use of phonological encoding and/or successive and/or simultaneous memory.

Improvements in memory, use of more effective encoding mechanisms and strategies are not only important for the sake of improving memory per se. They are also of value hecause of the crucial role memory plays in our cognitive system, especially in learning and consequently in education.

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