CROSS-MODAL PERCEPTION OF AUDITORY AND ORTHOGRAPHIC MODE

Sabitha (C.N)
Register No. M 9315

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MAY 1995

With £ove

To,

Achan & Amma

and

. . . ., the eternal power

who gave me strenght

and made me what I am.

CERTIFICATE

This is to certify that this dissertation entitled ***"CROSS-MODAL PERCEPTION OF AUDITORY AND ORTHOGRAPHIC MODE"*** *is the bonafide work in part fulfillment for the degree of* ***"MASTER OF SCIENCE (SPEECH AND HEARING)",*** *of the student with Register No. M 9315.*

MYSORE

MAY, ***1995***

Dr. S. NIKAM
DIRECTOR
ALL INDIA INSTITUE OF
SPEECH AND HEARING
MYSORE - 570 006

CERTIFICATE

*This is to certify that this dissertation entitled "CROSS-MODAL PERCEPTION OF AUDITORY **AND** ORTHOGRAPHIC MODE" has been prepared under my supervision and guidance.*

Savithri. S.R

MYSORE

MAY, 1995

Dr. S.R. SAVITHRI
LECTUTER
DEPARTMENT OF SPEECH SCIENCES
ALL INDIA INSTITUE OF
SPEECH AND HEARING
MYSORE -570 006

DECLARATION

I hereby declare that this dissertation entitled ***"CROSS-MODAL PERCEPTION OF AUDITORY AND ORTHOGRAPHIC MODE"*** *is the result of my own study under the guidance of Dr. S.R.* ***SAVITHRI,*** *Lecturer, Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any university for any other diploma or degree.*

MYSORE *(REG* ***NO. M 9315)***

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INTRODUCTION

INTRODUCTION

Speech perception is a specialised aspect of a general human ability, the ability to seek and recognize patterns. These patterns can be acoustic, visual or a combination of the two. (Borden & Harris, 1981).

Speech can be perceived via the auditory mode, visual mode or multiple modes [auditory, visual, tactile] out of which auditory mode is the primary mode of speech perception. In orthographic perception, images are acquired through visual experiences, reading specific words and they are formed in memory through amalgamation process in which the various identities of words are merged so that the images come to symbolize these other identities. The process of images serve to guide spelling as well as word recognition.

Multimodal "perception of speech occurs when perception through any one of the mode is not adequate. The extent to which simultaneous use can be made of two or more sense modalities in speech perception has not yet been fully explored. Among auditory-visual, auditory-tactile and visual-tactile modes, the auditory-visual mode is known to be the most effective for multi-model perception of speech. The tactile mode provides little cues for the perception of speech when compared to auditory and visual modes.

In the year 1976, McGurk and McDonald demonstrated a previously unrecognized influence ot vision upon speech perception. On being shown a film of a young Woman's talking head in which repeated utterance of the syllables, [ba] had been dubbed onto the lip movement for [ga], normal adults reported hearing [da]. When a visible talker and his or her apparent acoustic output are mismatched in an experiment, as in the so called "Me Gurk Effect" [McGurk and McDonald 1976, McGurk and McDonald 1978], phonetic information recovered optically may override that recovered acoustically.

Frost and Katz (1989) investigating the influence of simultaneous presentation of printed and spoken words reported that the presence of printed words enabled the subjects to separate the speech from the noise and hence to perceive it. Fowler and Dekle (1991) conducted three experiments to investigate the basis of "McGurk effect". Their experiment aimed at investigating the mode of integration of optically specified syllables with acoustically specified syllables.

Two hypothesis were putforth to explain this viz,

1) McGurk effect arises when optical acoustic cues for a syllable are associated in memory.

2} McGurk effect arises when cross-modal information familiar or not, is convincingly about the same articulatory speech event in the environment.

To test the hypothesis, three experiments were conducted. The first experiment involved the pairing of acoustic and orthographic syllables ie., a cross modal pairing familiar to subjects, the purpose that their association was by convention rather than by lawful causation (Campbell, 1989). The second experiment was complementary to the first i.e, a cross modal pairing unfamiliar to subjects and was a lawful pairing. This involved the pairing of acoustic and manually felt syllables. The expectation was that if McGurk effect is because of the association of the cross model cues in memory [Hypothesis I], then the influence of written syllables on heard syllables should occur, but an effect of felt on heard syllables should be weak or absent [As the felt syllables are not in memory]. On the other hand, if the McGurk effect arises when the cross-modal information is about the articulatory speech event in the environment, then felt syllables should effect what listeners hear but not the written syllables.

The result of expteriment I indicated that

1) the cross modal effect of felt on heard syllables is present in unexperienced subjects suggesting that McGurk effect arises in the absence of experience in the paired acoustic and felt syllables and.

2) the felt syllables effect judgements of heard syllables and viceversa suggesting considerable integration of the information from the two modalities.

The results of experiment II revealed that McGurk like effect occurs when information from the two modalities are conjoint, lawful consequences of the same enviornmental event and they do not occur based only on association in experience that is stored associations are not sufficient for an event. Also, perception of speech syllables doesn't require prior existence in the memory of a photo type. The study indicated cross-modal influences of auditory and orthographic and auditory and felt syllables.

Sekiyama and Tohkura (1991) conducted a study in Japanese subjects to find out McGurk effect in non English listeners and reported a very low percent of the influence of visual stimuli on auditory stimuli.

The present study aimed at evaluating the cross-modal perception of auditory and orthographic stimulus in non English listeners. Specifically 10 Hindi speaking normal adults were perceptually evaluated for synchronized audio-visual (orthographic) meaningful Hindi words to see whether the McGurk effect arises due to association in memory.

REVIEW

CHAPTER — II

REVIEW OF LITERATURE

Speech perception accounts for how the listener recovers the phonetic structure of an utterance from the acoustic signal during the course of language processing In the early years, speech perception was believed to be a purely acoustic phenomenon, but more recently perception is a specialized aspect of general human ability, the ability to seek and recognize patterns. These patterns can be acoustic, visual, tactual or a combination of the above.

Speech perception can either be unimodal or multi/cross modal. Unimodal perception refers to the use of a single modality [auditory, visual or tactile] and multi/cross modality perception refers to the use of more than one modality. This can be either auditory-visual, auditory-tactile or visual-tactile.

As this study deals with the auditory and orthographic modes in isolation and in combination, the literature will be reviewed under the following headings :

I. Auditory perception

II. Orthographic perception

III. Auditory - Orthographic perception

I. Auditory Perception:

Auditory perception of speech is a complex behaviour. An adequate computational framework (the computer based systems) for the explanation of mechanism of speech perception is lacking. One of these machine - based speech recognition system as model of speech perception is given by Elman and McClelland (1984). It is an interactive activation model of speech perception, called as TRACE model.

Memory TRACE:

The TRACE model attempts to incorporate dynamic memory (in which incomplete portions of past inputs can be filled in as the information that specifies them becomes available) into an interactive activation system.

It is proposed that speech perception takes place within a system that possesses a dynamic representational space that serves much the same function as the blackboard suggesting new hypothesis, and revising the strengths of others suggested by other processing levels. This buffer can be visualized as a large asset of banks of detectors for phonetic features and phonemes and imagine that the input sweeps out a pattern of activation through this buffer. That is, the input at some initial time t_0, would be directed to the first bank of detectors, the input at the next time slice would be directed to the next bank, and so on. These banks are all dynamic; that is, they contain nodes that interact with each other so that processing will continue in them after bottom-up input has ceased. In addition to the interactions within a time slice nodes would interact across slices. Detectors for mutually incompatible units would be mutually inhibitory, and detectors for the units representing an item spanning several slices would support each other across slices. It is assumed in this model that information written into a bank would tend to decay, but that the rate of decay would be determined by how strongly the incoming speech pattern set up mutually supportive patterns of activation within the trace.

Above the phoneme model, it is presumed that there would be detectors for words. These, of course, would span several slices of the buffer. It seems unreasonable to suppose that there is an existing node network present containing nodes for each word at each possible starting position in the buffer. It seems, then, that the model requires the capability of creating such nodes when it needs them, as the input comes in. Such nodes, once created, would interact with the phoneme buffers in such a way as to insure that only the correct sequence of phonemes will strongly activate them. Thus, the created node for the word cat, starting in some slice will be activated when there is a /c/ in the starting slice and a few subsequent slices, an /a/ in the next few slices, a /t/ in the next few, but will not be excited [except for the /a/] when these phonemes occur in the reverse order.

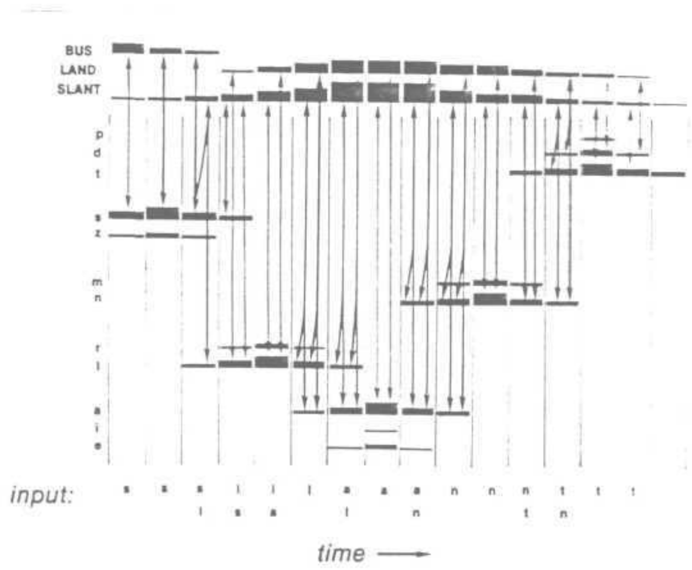

Fig. I : Partial view of the TRACE System

A simplified picture of the TRACE model is shown in figure. 1. Time is represented along the horizontal axis, with successive columns for individual memory traces. Within each trace there are nodes for features and phonemes, but only phoneme nodes are shown here. The activation level of each of these nodes (and of the word nodes above) is shown as horizontal bar; thicker bars indicate greater levels of activation.

Along the bottom is shown sample input. The input is presented here in phonemic form for ease of representation; it would actually consist of the excitations from the (missing) feature nodes, which in turn would be excited by the speech output.

Because the input as shown could be passed in different ways, the word nodes for slant, land and bus all receive some activation. Slant is most heavily activated since it most closely matches the input, but the sequence 'bus land' is also entered. Presumably, context and higher-level information are used to provide the necessary input to disambiguage the situation.

The TRACE model permits ready extension of the interactive active approach to the perception of multiword input.

The auditory mode is the primary mode of speech perception. For hearing impaired individuals the residual hearing is regarded as potentially most important because it is the only one directly capable of appreciating the primary characteristics of communicative speech, which are acoustic. Hearing is particularly sensitive to temporal events within the frequency range 80 - 8000 Hz [Geldard, 1970].

Miller and Nicely (1955) found that listeners can identify the manner of production even when place cues are masked, which distinguishes the labials [p, b] from alveolars [t, d] and palatals velar stops [k, g] are apparently more resistant to the masking effect of noise.

Many studies have shown that the severity of speech problem tends to vary with hearing level. Speech and language pathologists have long been interested in the relationship be tween discrimination and production of speech sounds. Speech sound discrimination is a form of auditory perception in which the listener/speaker distinguishes between sounds in the language and formulate a perceptual concept of the sound contrasts of language.

From a clinical perspective, such a skill includes the ability to detect differences between particular target sounds and the error productions that may be substituted for such sounds. Clinicians have been interested in whether or not articulation errors may reflect impaired speech sound discrimination ability.

Some evidence is available to support the hypothesis that children can perceive certain phonological contrasts of their language when begin to speak. Indeed, experiments have indicated that infants under 1 year of age are able to make acoustical discriminations between speech sounds. [Eimas, Siquieland, Jusczyk, Vigorito, 1971; Butterfield and Cairns 1974]. Speech sound discrimination experiments with preschool children approximately 2 years old and older have indicated that they can make certain phonological distinctions. Barton [1976] has cautioned, however, that speech sound discrimination experiments have not discriminated that children beginning to speak can perceive all of the relevant phonological contrasts.

In recent years research into the auditory perceptual development in infants and young children has continued. However, the applicability of the findings of normal auditory perceptual development to the speech-impaired population is unclear. It is uncertain whether inferences can be drawn between normal and defective speakers in terms of perceptual development.

Various investigations regarding the relationship between articulation and discrimination have revealed that the normal individuals performed better on discrimination tests when compared to defective speakers. [Travis and Rasmus, 1931; Kranvall and Diehl, 1954; Clark, 1959; Reid, 1947b; Carrell and Pendergast, 1954].

Several other researchers have obtained findings that do not show a relationship between discrimination and speech sound productions [Hall, 1938; Hansen, 1944; Mase, 1946; Prins, 1926b[1] Garret, 1969 and Veatech 1970]. Locke (1980) conducted a study to indicate that many children can correctly discriminate sounds that they produced in error.

The more recent research work is focussed on fine-gained auditory discrimination [Elliot et al 1993] to see the effect of voice onset time (VOT), closure duration (CD), preceeding vowel duration, transition duration etc. on the perception of stop consonants/fricatives/vowels.

II. Orthographic perception:

Schematic representation of information processing model for reading [Massaro (1980) is discussed below.

A printed pattern is first tranduced by the visual receptor system and the feature detection probe detects features which are then stored in preperceptual visual storage. One of the simplest views of the contribution of orthographic structures is that experience with written language modifies the feature detection process. Given this view, it is possible that orthographic structure enhances the visual feature analysis of the letters in a string. Familiar or frequent orthographic contexts might facilitate feature analysis of the component letters. Orthography may be exploited to guide feature analysis, recognition of some letters may guide the feature analysis of other letters in the pattern [Massaro (1980)].

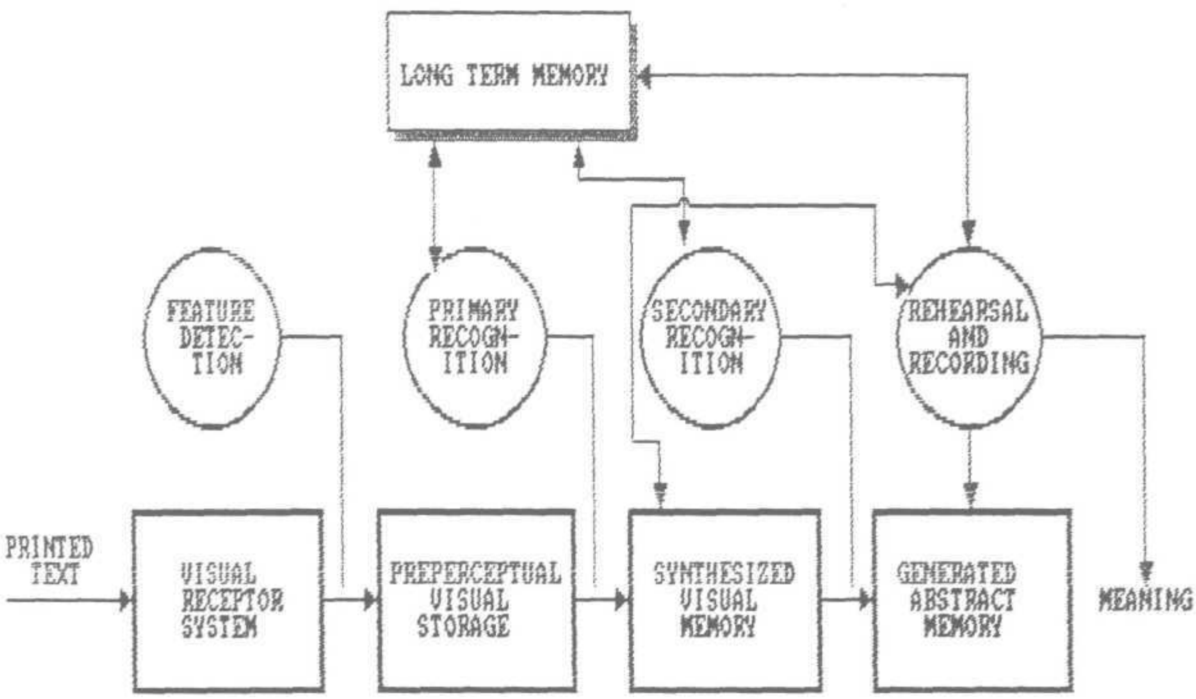

Fig.2 Schematic representation of information processing model for reading - Massoro (1980)

Accordingly, readers would resolve a greater number of letter features or would obtain better resolution of the features to the extent that the string contains common letter sequences. Orthographic structures directly modify the featural processing of visual information that the reader has available in reading.

Images are acquired through visual experiences, reading specific words and they are formed in the memory. The presence of images serves to guide spelling as well as word recognition processes. Support for the claim that orthographic representations are essentially visual can be drawn from other sources. Studies by Baron (1977), Brooks (1977), Summers et al (1973), Kirnser (1973) and Mc Clelland (1977) indicate that there is a component of word memory that is purely visual rather than phonemic and that is specific to the original form of the word scan.

As the present study deals with Hindi, the orthography of Hindi is described herewith. Herrick (1974) gave the taxonomy of alphabets and scripts in which he describes the Hindi script as follows :

Family	:	Brahmie
Genera	:	Devanagaroid
Script	:	Devanagari
Alphabet	:	Hindi

Hindi uses the Devanagari writing system. The Hindi writing system is considered to be semisyllabic, i.e., it has syllable - like properties as well as properties of an alphabetic script. There is a direct correspondence with letters and sounds in Hindi and very little ambiguity.

Karanth (1992) reported that English was alphabet script and Hindi has semisyllabic script. In Hindi, there is almost a one-one graphemic - phonological equivalence, expressed in syllable structure with the regular signs of vowels being attached to the basic consonant form. Each of the vowels, in addition to its primary syllabic form, has a secondary intrasyl labic form which is used in writing CV syllables. These intrasyllabic forms are attached to the consonant in accordance with certain regular rules - above and / to the right of the consonant grapheme. Similarly, all consonants have a secondary conjunct form to be used when the consonant appears as the second or third consonants in CCV or CCCV syllables. The conjunct forms are mostly tranceted forms of their primary forms - apparent in some and inherent in others. Consequently, each syllables form can be analysed into its consonant and vowel components. It is therefore possible to read this scripts phonetically.

III. Auditory - Orthographic Perception:

The mode or strategy of reading is known as phonic mediation or less formally, reading by ear [Ellis (1984)]. It is a strategy a reader can use when he or she encounters an unfamiliar word on a printed page - i.e., 'sound it out' and discover whether the word sounds familiar even -when it doesn't look familiar. The process of reading by ear can be represented as a diagram.

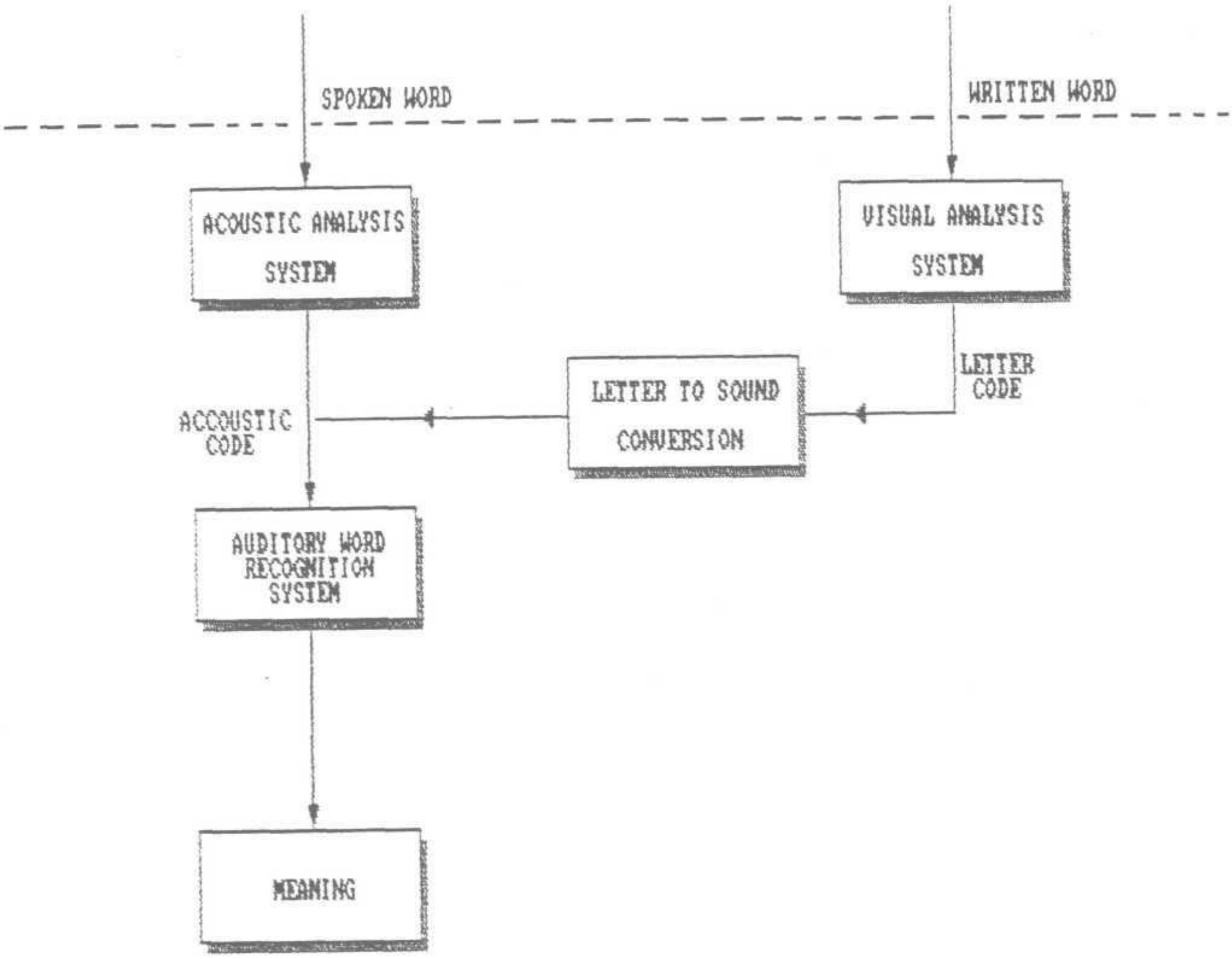

Fig. 3. A model for phonetically mediated Reading, or "Reading by Ear" (Ellis, 1984)

As in figure 3, the first thing one must do with a written word is to identify its component letters. With clear print, this is no problem, but if one is reading ornate script or untidy handwriting letter identification can be far from easy. Just as a sound wave must first be analyzed by an acoustic analysis system so a printed word must be analyzed by a visual analysis system, whose job is to identify letters and create an internal letter code. In the case of reading by ear, the letter code must then be translated by letter - sound conversion process into an acoustic code which can be identified by the auditory word recognition system.

It is universally accepted that when skilled readers recognize familiar words, they do so "by eye" rather than "by ear" that is readers recognize known words visually as familiar letter strings. This amounts to the proposal that readers build up recognition units which recognize the written form of familiar words. These are like the auditory word recognition unit. As a new word becomes familiar through repeated encounters, a visual word recognition unit is created whose job is to respond to, or be activated by the newly learned word each time it is encountered on the printed page.

Once the visual word recognition unit is established that word need no longer be sounded out before being identified. When words are recognized visually as wholes, it is more important that they should be visually distinct than that they should be regular.

Speech perception is normally regarded as a purely auditory process. In 1976, McGurk and McDonald reported a study demonstrating a previously unrecognized influence of vision upon speech perception. It seems from an observation that, on being shown a film of a young women's talking head in which repeated utterances of the syllables [ba] had been dubbed on to lip movements for [ga] normal adults reported hearing [da]. With the reverse dubbing process a majority reported hearing [bagba] or [gaba]. When these subjects listened to the soundtrack from the film, without visual input, or when they watched untreated film, they reported the syllables accurately as repetitions of [ba] or

[ga]. These findings have important implications for the understanding of speech perception.

To further confirm and generalize the original observation, new materials were prepared. A woman was filmed while she fixated a television camera lens and repeated ba-ba, ga-ga, pa-pa or ka-ka. Each utterances was repeated once per second, with an interval of approximately 0.5 secs between repetitions. From this master recording, four dubbed video-records were prepared in which the original vocalizations and lip movements were combined as follows :

1) ba-voice/ga-voice
2) ga-voice/ba-lips
3) pa-voice/ka-lips
4) ka-voice/pa-lips.

Dubbing was carried out so as to ensure within the temporal constraint of tele-recording equipment, that there was audio-visual coincidence of the release of the consonants in the first syllable of each utterance. Each recording comprised three replications of its a-v composite, four different counter-balanced sequence of recoding (1) - (4) were prepared, each with a 10 sec gap of blank film between successive segments. The recordings were suitable for relay via a 19 - inch television monitor; a - v reproduction was of good quality.

21 preschool children (3 - 4 years) 28 primary school

children (7-8 years) and 54 adults (18 - 40 years) were tested. The adult sample was predominantly male; three were approximately equal number of boys and girls in younger samples. Subjects were individually tested under two conditions.

1) visual where they were instructed to watch the film and repeat what they heard the model saying,

2) auditory only, where they faced away from the screen and again had to repeat the model's utterances. Every subject responded to all four recordings [1-4 (above)], under each condition, each time in a different sequence, sequence of presentation was counter-balanced across subjects.

For the purpose of analysis, a correct response was defined as an accurate repetition of the auditory component of each recording. Under the audio alone condition, accuracy was high with average of 91, 97 and 99 % for preschool school aged and adult subjects respectively; errors were unsystematic. Under the a-v condition where subjects heard the original sound track, errors were substantial. For preschool subjects average error rate was 59%, for school children - 52% and for adults 92%.

The meaning of auditory and visual categories is self-evident. A "fused" response is one where information from the two modalities is transformed into something new with an element not presented in either modality, whereas a 'combination' response represents a composite comprising relatively unmodified elements from each modality. Responses which could not be unambiguously assigned to one of these four categories were allocated to a' small, heterogeneous 'other' category. Results showed that 98% of adult subjects gave fused responses to the ba-voice/glips presentation and 59% gave combination responses to its complement. The effect was also generalizable atleast to other stop consonants. 81% of adults gave a fused response to pa-lips/ka-voice and 77% gave combination responses to its complement. The effects, however were more pronounced with ba/ga than with pa/ka combinations; the latter comment applies to all ages.

It was found that the auditory perception of adult subjects was more influenced by visual input than was that of subjects in the two younger groups; the latter did not differ consistently from each other. It was interesting to note that where responses were dominated by a single modality, this tended to be the auditory for children and the visual for adults. However, it should also be noted that the frequency of fused response to ba-voice/ga-lips and pa-voice/ka-lips presentation was at a substantial level for preschool and school children alike. These auditory-visual illusions, therefore, are observable across a wide age span, although there clearly are age-related changes in susceptibility to them, particularly between middle childhood and adulthood.

It was found that they do not habituate overtime inspite of having the objective knowledge of the illusions involved. By merely closing the eyes, a previously heard [da] becomes [ba] only to revert to [da] when the eyes are open again.

Contemporary, auditory - based theories of speech perception were inadequate to accomodate these new observation; a role for vision [i.e, perceived lip movements] in the perception of speech by normally hearing people was clearly illustrated. Findings suggested that in the absence of auditory input, lip movements for [ga] were frequently misread as [da] while those for [ka] were sometimes misread as [ta] . [pa] and [ba] were often confused with each other but were never misread as [ga, da, ka or ta] . It was also know that, in auditory terms, vowels earning information for the consonants which immediately preceed them. If it is speculated that the acoustic waveform for [ba] contains features in common with that for [da] but not with [ga] , then a tentative explanation for one set of the above illusion was suggested, Thus, in a ba-voice/ga-lips presentation, there is visual information for [ga] and auditory information with features common to [da] and [ba] . By responding to the common information in both modalities, a subject would arrive at the unifying percept [da]. Similar reasoning would account for the [ta] response under pa-voice/ka-lips presentation.

By the same, it was argued that with ga-voice/ba-lips and ka-voice/pa-lips combinations the modalities are in conflict, having no shared features. In the absence of domination of one modality by the other, the listener has no way of deciding between the two sources of information and therefore oscillates between them, variously hearing [pabga] [papka] and so on. The authors suggested that more refined experimentation are necessary to clarify the nature and ontogenetic development of the illusions and that their generality needs further investigations.

In the McGurk effect, an audio-visual incongruent stimulus is defined as a stimulus where audio and visual information are incongruent in terms of the place of articulation and more narrowly, whether the place is labial or non-labial.

The phonetic information recovered optically may override that recovered acoustically. This as mentioned earlier, is particularly likely to occur when the phonetic information is for consonantal places of articulation close to the front of the speaker's mouth. Accordingly, optical "tap" paired with acoustic "map" may be reported as "nap" with voicing and nasality consistent with the acoustical signal and place of articulation consistent with the optical display. Remarkably, the crossmodal influence, phenomenally is not due to hearing one utterance, seeing another and reporting some compromise. Rather the visible utterances generally changes what. the listener experiences hearing [Liberman 1982; Summerfield 1987]. Accordingly the visual influence remains when subjects are instructed to report specifically what they heard rather than what the speaker said [Summerfield and McGrath, 1984] and it remains even after considerable practice attending selectively [Massaro, 1987].

Frost and Katz (1989) conducted a study to see the influence of simultaneous presentation of printed words on the perception of speech. They presented printed words and spoken words simultaneously and asked subjects to judge whether the words were same or different. The experiment included a condition in which the speech was degraded severely by added signal-correlated noise [a broadband noise with the same amplitude envelop as the stimulus].

Nevertheless, the subjects found the task fairly easy, and the average error rate was only 10%. In a subsequent pitot study; the same authors presented the subjects simultaneously with both degraded speech and degraded print. Here subjects' performance was close to chance. The subjects' phenomenological description was that they often could not hear any speech at all in the auido input; Whereas previously, when clear print matching a degraded auditory word was presented simultaneously, they reported no difficulty in identifying the degraded word. Thus, it seemed as if the presence of the printed word enabled the subjects to separate the speech from the noise and hence to perceive it much more clearly. There is another possibility however; subject's introspections may have reflected merely an illusion caused by the correspondence between the print and the amplitude envelop of the masking noise, which was identical with that of the speech. That is, subjects might have thought they heard speech even if the masking noise alone had been presented accompanied by "matching" print.

Fowler and Dekle (1991) investigated the basis for the "McGurk" effect whereby optically - specified syllables experienced synchronously with acoustically specified syllables integrate in perception to determine a listener's auditory perceptual experience. They hypothesised that

1) the effect arises when optical and acoustic cues for a syllable are associated in memory and

2) the effect arises when cross-modal information, familiar or not is convincingly about the same articulatory speech event in the enviornment. Experiments contrasted the cross-modal effect of orthographic syllables on acoustic syllables, presumed to be associated in experience and memory with that of haptically - experienced and acoustic syllables, presumed not to be associated.

In the experiments conducted by them, they attempted to distinguish the two accounts by looking for cross-modal influences on speech perception from two new sources each of which captures one but not the other, distinctive aspect of the McGurk paradigm that might account for the cross-modal influences there.

One situation was meant, on one hand, to capture the association in experience and hence in memory, of an acoustically - specified utterance with a specification in another modality. On the other hand, it was meant to exclude association via conjoint lawful specification of a common enviornmental event. To achieve this, they paired spoken syllables with matched or mismatched orthographic representations of syllables. The subjects who were college students have been readers of an alphabetic writing system for over a decade, and they experience redundant pairings of sight and sound whenever they read aloud or else see a text that someone else is reading aloud. Although listeners may be less experienced with sound spelling pairings than with pairings of the sound and sight of a speaker, their experience vith the former pairings are sufficient that a spoken monosyllabic word can activate its spelling for a listener.

The second experimental situation they had devised was meant to be complementary to the first. That is, they established a cross-modal pairing that is unfamiliar to subjects, but that is a lawful pairing, because the same enviornmental event gives rise to structure in the two different media. In this situation they paired acoustically - specified syllables with matched and mismatched manually - felt, mouthed syllables. The subjects must have had considerably less experience of that sort than they have had either seeing and hearing spoken utterances or seeing and hearing text being read.

The expectations were as follows :

If the operative factor in the McGurk effect is the association in memory of cross-modal cues available during events in which speech occurs, then an influence of written syllables on heard syllables should occur, but an effect of felt on heard syllables should be weak or absent. If the operative factor is, instead, the common causal source in the enviornment of the acoustic and optical structure, then felt syllables will affect what listeners report hearing, while orthographic representation of spoken syllables will not. Alternatively of course, both (or neither) factor may be important.

They tested these predictions by looking for cross-modal haptic and orthographic influences on identifications of heard syllables and for reverse effect of heard syllables on reports of felt and read syllables. In the orthographic condition, a 63 - item test order determined which orthographic syllable would be paired with each acoustic syllable. This sequence was also random, but now with the constraint that each felt syllables be paired with each synthetic syllable once in each third of the test order.

Each subject participated in three tests, synthetic syllables alone, synthetic syllables paired with printed syllables [orthographic] and synthetic syllables paired felt syllables [Tadoma]. The order of the conditions was counter-balanced, with two subjects experiencing each order.

Subjects were seen individually. They first heard the end point syllables from the synthetic speech continuum. The end points were identified for them and played several times. Subjects were told that the speech was produced by a computer and that they would be identifying syllables like the ones they had just heard in subsequent tests.

In the auditory test, subjects were seated in front of the CRT screen. Printed on the screen was the message "Press Return To Proceed". To initiate each trial, subjects pressed the return key. On each trial, one synthetic syllable was presented over the loudspeaker. Subjects made their responses by circling printed "B" or "G" on an answer sheet; they were instructed to guess if necessary and then to continue the test at their own pace by pressing the return key for each trial.

In the orthographic condition the test was similar except that when the return key was pressed, a printed syllable appeared on the screen with its onset simultaneous with the onset of the synthetic syllable. The printed syllable remained on the screen until the subject pressed the return key for the next trial. Subjects were instructed to watch the screen as the printed syllable was displayed. They then made two responses, first writing either "B" or "G" under the heading "saw" indicating which syllable they had seen. Subjects were told explicitly that the acoustic and spelled syllables were independently paired so they should always make their "heard" judgement on what they had heard independently of what they had seen and viceversa for the "Law" judgement. As in the auditory condition, they were instructed to guess if they were unsure of the syllables they had heard on seen on any trial.

In the Todama condition, the model stood facing the CRT screen with loudspeaker directly in front of her at about waist level. The subjects received no instructions at all how to distinguish felt "ba" from "ga". The subject stood with his or her right hand in a disposable glove placed over the lips of the model. After presentation of paired felt and heard syllables, subjects indicated to a second experimenter which syllable "ba" or "ga", they had heard and then which syllable they had felt, in each case guessing if necessary. They made there responses by pointing to printed syllables on a sheet of paper. The printed syllable "BA" or "GA" appeared twice, on the left, under the heading 'heard' and on the right, under the heading "felt". Experimenter then marked the answer in the sheet as in orthographic condition.

The most important outcome of the experiment was that a strong cross-modal effect on judged spoken syllables occured in one cross-modal condition, while at most a marginal effect occured in the other. In particular, a highly significant effect occured when mouthed syllables were felt simultaneously with an acoustic presentation of similar syllables, but a marginal or non significant effect occured when syllables were printed. They interpreted this difference as evidence favouring accounts of speech perception in which perceptual objects are the phonetically significant vocal tract actions that cause structure in light, air and on the skin and joints of the hand. Also, it was found that the cross-modal effect of felt on heard syllables was present in inexperienced, in the very first block of trials in which they participate. This suggests that the effect arises in the absence or near absence of experience in which the acoustic and haptic information is paired. Accordingly, they concluded that joint specification of an enviornmental event doesn't require specific learning to be effective in perception.

Second finding of the experiment was that the cross-modal effects in Tadoma condition worked in both directions i.e, the felt syllables affect judgements of the syllable heard, but the acoustic syllable affected judgements of the syllable felt. This suggests considerable integration of the information from the two modalities.

There is an alternative interpretation of the findings in the orthographic condition. With the expectation that Tadoma will lead to cross modal perception and orthographic condition would not, orthographic stimuli were presented for a longer period of time, guaranteeing that subjects would see the syllable and hence maximizing the number of opportunities for a cross-modal effect to occur.

However, the effect of long-duration presentation may have been different than that was expected. Although the subjects were asked to look at the screen as they pressed the return key, (so that they would see the printed syllable simultaneously with rearing the acoustic syllables), they need not have followed it, because the syllable remained on the screen until the next trial was initiated. Further the task of feeling of a mouthed syllable is difficult and attention demanding in a way that the task of looking at a clearly presented printed syllable is not. One consequence may be that the Tadoma task took attention away from the listening task, leaving the acoustically - signaled syllables less clearly perceived and perhaps more vulnerable to influence of information from another modality.

Experiment II was designed to assess the effect of attention on the cross-modal influence of printed syllables on acoustic syllables. Masking was used to force subjects to look at the printed syllable at the same time they were listening to the acoustical signal and to drive performance reporting orthographic syllables down to a level comparable with the nonrandom subject's ability to report the felt syllables.

Subjects were the same as in experiment I. Stimulus material was also the same except they were masked by a row of number signs ("#"). On each trial, a row of four number signs appeared just above the location on the screen where the syllables would be printed.

Simultaneous with presentation of the synthetic speech syllable, either 'BA' or 'GA' was printed on the screen below the number signs; the printed syllables were covered over after 67 ms by another row of number signs. The mask remained on the screen until the subject hit the key for the next trial.

Each subject was tested individually. As in experiment I, the end points of the continuum were played and identified before the main test to allow subjects to become familiar with the synthetic - speech syllable. They were told that they could pace themselves through the experiment by hitting the return key and they were instructed not to leave any blanks on the answer sheet, taking a guess if necessary. In addition, subjects were told that acoustic signals and masked visual signals were independently paired on each trial, and, therefore decisions about them should be made independently.

Results showed that three was no effect of the orthographic syllable on identifications of heard syllables. They were successful in using masking to decrease identifiabiliity of the orthographic syllables to a level comparable to identifiability of felt syllables among non random subjects in the Tadoma condition. In the masking condition, the marginal effect in experiment I disappeared completely in experiment II. McGurk - like effects occur when information from the two modalities are conjoint lawful consequences of the same enviornmental event. They do not occur based only on association in experience. McGurk effect was absent when the visual stimulus was replaced by printed syllables.

Sekiyama and Tohkura (1991) conducted a study on Japanese subjects to findout McGurk effect in non-English listeners. The main purpose of the investigation was to see whether the McGurk effect can be extended to Japanese subjects listening to Japanese syllables.

The audio and video signals of a female talker's speech for 10 Japanese syllables /ba/, /pa/, /ma//wa/, /da/, /ta/ /na/ /ra/ /ga/ and /ka/ was combined on videotapes giving 100 a - v stimuli. These stimuli were presented to 10 Japanese subjects who were required to identify the stimuli as heard speech in both noise added and noise free conditions. For both conditions, the intelligibility of the auditory stimuli was measured by presenting the auditory - alone stimuli. The results showed that, in noise-free condition, the McGurk effect was small and almost limited to audio stimuli of which the intelligibility was less than 100%. In the noise added condition, the mcGurk effect was very strong and widespread. The result indicated that the Japanese McGurk effect is less easily induced than the English one and that it depends on the auditory intelligibility of the speech signal.

There were several inconsistencies between the results of the study by Sekiyama (1991) and those of McGurk and McDonald (1976) . First the results of the noise free conditions indicated that it is much less easy to induce the Japanese McGurk effect than the English one. In the noise free condition, the visual biasing effect was weak and fused responses, if any occured only approximately 20% of the time. The difference between the Japanese and the English McGruk effect is clearly shown by the fact that the Japanese audio /ba/ combined with visual /ga/ was correctly perceived as /ba/, 100% of the time whereas this types of stimulus yielded fused /da/ response 98% of the time for adult subjects of McGurk and McDonald. Although the intelligibility of each syllable used by McGurk and McDonald is not known the description on the averaged intelligibility score of their /ba/ was less than 100%.

Comparison of the results of a-v condition with those of the audio alone condition indicated that the Japanese McGurk effect depended on audio intelligibility. When the audio intelligibility was 100%, the McGurk effect was absent/weak. When intelligibility was less than 100%, however, McGurk effect could be induced.

Another difference between the results of Sekiyama's study and of McGurk and McDonald (1976) was the type of a - v incongruity pair in which visual biasing effects were observed. The original McGurk fusion effect was found only for pairs of bilabials with visual nonbiabilas and the fusion effect was not found for the conversely combined a-v pairs. In the Japanese study, however fusion effects were found symmetric, in both audio labials and visual nonlabials and audio nonlabials and visual labials.

Very few combination responses such as 'bda' for audio /da/ combined with visual /ba/ were observed in the study. On the other hand, McGurk and Mcdonald (1976) reported this types of responses for audio /ga/ with visual /ba/ 54% of time and for audio /ka/ and visual /pa/ 44% of the time. The reason for these differences may be attributed to either/both the articulatory characteristics of Japanese syllables or Japanese listener's perceptual organisation for speech. It should be taken into account the fact that the Japanese phonetic system doesn't allow any consonant clusters in a systematic phonemic level [Chomsky and Halle 1967] .

It appears that the orthography differs from language to language. In the present study Hindi is considered and the McGurk effect of Hindi printed words on spoken Hindi words are evaluated. Also, the hypothesis that McGurk effect arises due to association in memory in evaluated. If the hypothesis is true, then there should be strong cross-model influence of auditory and orthographic stimuli.

METHODOLOGY

CHAPTER III

METHODOLOGY

Material:

Eight meaningful monosyllabic Hindi CVC words with varying initial consonant were selected for the study. The initial consonant comprised of the phonemes /P/ - bilabial voiceless stop, /b/ - bilabial voiced stop, /k/ - velar voiceless stop, /g/ - velar voiced stop, /t/ - alveolar voiceless stop, /d/ - alveolar voiced, stop /m/ - bilabial nasal continuant and /n/ - alveolar nasal continuant and the medial vowels was /a/ - low mid open vowel and the final consonant was the lateral */1/.* Two lists of these CVC Hindi words were prepared, one for auditory presentation [Hence forth audio-word list] and another for visual presentation [Hence forth the orthographic-word list]. Four lists of words pairs were prepared by taking one word from auditory list and the other from the orthographic list.

In the first list, the word pairs were same, thus forming the catch trials. The list was as follows:

	Auditory	Orthographic
1.	pa : 1	pa : 1
2.	ba : 1	ba : 1
3.	ma : 1	ma : 1
4.	ta : 1	ta : 1

5.	da : 1	da : 1
6.	na : 1	na : 1
7.	ka : 1	ka : 1
8.	ga : 1	ga : 1

Table I : list of word pair used as catch trials

II. Second list was prepared by words from audio and orthographic list which formed minimal pair in terms of manner of articulation. The pairs were as follows :

	Auditory	Orthographic
1.	pa : 1	ma : 1
2.	ba : 1	ma : 1
3.	ta : 1	na : 1
4.	da : 1	na : 1

Table II: minial pairs with manner difference

III. Third list consisted of word pair, which were minimal pairs, with place difference (Table III)

	Auditory	Orthographic
1.	ga : 1	ba : 1
2.	da : 1	ga : 1
3.	ta : 1	ka : 1
4.	ka : 1	pa : 1
5.	ga : 1	pa : 1

6.	ba : 1	ka : 1
7.	ka : 1	ba : 1
8.	pa : 1	ga : 1

Table III - minimal pairs with place difference

IV. Fourth list consisted of word pairs which were minimal pairs with place and manner differences.

In this category, the words differed in both place and manner of articulation. The three places of articulation considered were bilabial, alveolar and velar and the manner differences were introduced using voicing and nasal continuants /m/ and /n/. A total of seven minimal pairs were selected, as follows : [Table IV]

	Auditory	Orthographic
1.	ka : 1	ma : 1
2.	pa : 1	na : 1
3.	ga : 1	ma : 1
4.	ba : 1	na : 1
5.	ma : 1	ta : 1
6.	na : 1	ba : 1
7.	ma : 1	ga : 1

Table IV: Minimal pairs with manner and place differences

The 8 pairs in catch trials will be henceforth called co-operating condition. The four pairs with manner difference will be called conflicting condition I and those with place and manner difference will be called conflicting condition II.

Thus, a total of 27 stimulus pair [eight for catch trials, 4 with manner difference, 8 with place difference and 7 with manner and place difference] were considered. With this 27 stimuli pair, a list of 240 Audio-Orthographic pairs of stimulus was formed by selecting at random.

For orthographic stimuli, these monosyllabic words were written, one on each ivory card [size 3' x 6']. [Appendix I] The letters werae written with utmost clarity with a thickness of 1 cm in black ink. They were videotaped according to the order in the list prepared. The recording was done using a national m-7 movie camera with an in built microphone. A T.V. Zoom lens of the power of 1:12 was used. The cards were focussed from a distance of six feet from the camera. To indicate the serial order, numbers were shown along with the respective stimuli on the right side of the card. A lkw halogen light was used to illuminate the room. To orthographic stimuli were recorded for 1 sec with an interstimulus interval of 2 secs, to allow the subjects to write down the response. The recording was done on video track of the casette National VHS [SPE - 180] by a professional [Hari's Vedios].

For the audio recording, a 23 year old normal female who was a native Hindi speaker practiced the audio word list, while orthographic stimuli were played back for synchronization.

After sufficient practice the subject uttered the appropriate word to be synchronized as soon as the word appeared on the screen of the television. These utterances were recorded on the audiotrack of the same casette. Also, the instructions were recorded and mixed at the beginning of the cassette.

Thus, the audio and orthographic stimuli were approximately synchronized. The 240 word pairs thus recorded formed the material for the study.

Subjects:

Ten Hindi speakers [five males and five females] within the age range of 18 - 25 years served as subjects. All were students from the All India Institute of Speech and Hearing and reported normal hearing and normal or corrected vision.

Method:

The subjects were seated 6 feet away from the Television screen. Three, three and four subjects were tested at one sitting. They were seated in a semi circular pattern to make sure that the T V screen was visible to every one. PHX colour T.V. Philind (model - trend set) and BPL Sanyo VCR (model no. : VHR 1110) were used for the purpose of stimulus presentation. [Appendix II] . Each subject recorded his/her response on a response sheet. Each subject participated in three trials and they were instructed to perform the folowing tasks.

In trial I, the subjects were instructed to record only what they saw, in trial II they were instructed to record only what they heard and in trial III, they were to record what they perceived. A time gap of twenty four to fourty eight hours was given to ensure that the adaptation effect will not be there.

Analysis:

The responses of the subjects were tabulated and analyzed for auditory, orthographic and audio-orthographic stimulus.

The total number of responses for each stimuli for each category [Audito, Orthographic and other] was computed. For eg : In trial III for an audio-orthographic stimulus /pa : 1/ - /ga :1/ if the subject responded as /pa :1/, it was considered as an auditory response. If the response was /ga : 1/, it was considered as an orthographic response and if the response was /da : 1/ it was considered as other response which was neither auditory nor orthographic.

The total number of responses was converted to percent response by the following formula.

$$\% \text{ Response} = \frac{\text{Total number of response}}{\text{Total number of stimulus}} \times 100$$

The average percent response for the subjects was also computed.

RESULTS & DISCUSSION

CHAPTER — IV

RESULTS AND DISCUSSION

I. Responses to orthographic stimuli:

When the orthographic stimuli were t,d,n, maximum percentage responses were obtained followed by p,b,m and k,g obtained least percentage scores. When the orthographic stimuli were t,d,n, 100 percentage resposnes were obtained. However when the orthographic stimulu were k,g, it was observed that confusions were between k and t, k and b and g and k.

ORTHOGRAPHIC	PERCENT RESPONSES	
STIMULI	ORTHOGRAPHIC	OTHERS
g	99.66%	k - 0.33
k	99.33%	t - 0.33
		b – 0.33

Table V : Percent responses for orthographic stimuli

When the orthographic stimuli were p, b, m, p and b stimuli obtained 100% response. However, confusions were noticed between the orthographic stimuli m and g (Table VI) .

ORTHOGRAPHIC	PERCENT RESPONSES	
STIMULI	ORTHOGRAPHIC	OTHERS
P	100	-
b	100	-
m	99.8	g (0.2)

Table VI : Percent response for orthographic stimuli

Individuals varied in their responses. Subjects 2, 3, 4, 5, 6 and 7 scored 100 percent responses. However subjects 1, 8, 9 and 10 had confusions. The confusions were as in table VII.

SUBJECT	INTENDED GRAPHEME	CONFUSED GRAPHEME
1	k	t
8	m	g
9	g	k
10	k	g

Table VII : Confusions in Orthographic Responses

II. Responses to Auditory stimuli

Among the auditory stimuli velars obtained maximum percent response followed by alveolars and the bilabials obtained the least percent response.

STIMULI	AVERAGE PERCENT RESPONSES	
	AUDITORY STIMULI	OTHERS
Velars	98.21	1.79
Dentals	97.39	2.61
Bilabials	95.96	4.04

Table VIII : Percent Response to auditory stimuli

It was observed that, among the velars, maximum percent responses were obtained for /k/ followed by /g/ (table IX).

STIMULI	AVERAGE PERCENT RESPONSES	
	AUDITORY STIMULI	OTHERS
k	99.74	0.36(p) !
g	97.43	0.05(b), 0.07(m) 0.05(d), 0.02(t)

Table IX : Percent response for auditory stimuli

Among alveolars /n/ scored maximum percent response followed by /d/ and /t/ obtained least percent response. Table X shows the percent response.

AUDITORY STIMULI	PERCENT RESPONSE	!
	AUDITORY STIMULI	OTHERS
n	99	l(d)
d	97	0.2(g), 0.01(b)
t	96.33	0.2(k) , 0.1 (p), 0.03(rn)

Table X : Percent response auditory stimuli - Alveolar

Individual responses varied among subjects. Subjects 1, 4 and 7 performed better and subject 8 performed poorly. It was observed that maximum confusions were between /b/ and /m/ followed by /d/ and /g/ and /p/ and /t/. The confusions of individual subjects are in table XI.

SUBJECT	INTENDED PHONEME	CONFUSED PHONEME
1	t	P
	g	d
3	g	d
	k	t
	g	P
5 & 6	d	g
7,8,9 &10	m	b

Table XI : Confusions in Orthographic Responses

It was observed that subject 2 and 4 had varied patterns of confusions.

III. Responses to Audio-orthographic stimuli (A-0).

3.1 : Co-operating condition :

When the A-0 stimuli were from the same place and manner of articulation maximum percent responses was reportd for alveolars followed by bilabials and velars obtained least percent response. Within the alveolars, voiced stops and nasal continuants obtained better responses than the voiceless stops. However, among the bilabials, nasal continuants and voiceless stops obtained better scores than the voiced stops. Among the velars, voiceless stops scored better than voiced stops.

A - 0	stimuli	Percent Response
da : 1	- da : 1	99.0
na : 1	- na : 1	97.0
ta : 1	- ta : 1	96.1
ma : 1	- ma : 1	98.75
pa : 1	- pa : 1	96.6
ba : 1	- ba : 1	95.0
ka : 1	- ka : 1	99.0
ga : 1	- ga : 1	94.4

Table XII : Percent response for various A-0 stimuli

The confusions in audition/orthography were as given in table XIII.

INTENDED PHONEMES AND GRAPHEMES	CONFUSED PHONEMES AND GRAPHEMES	PERCENT
P	d	4
b	t, k, m	3(t) l(k) Km)
m	b	2
n	d	2
t	P	
d	P	1
g	m , d	4(m) l(d)
k	g	1

Table XIII : Confusions in A-0 stimuli

Individual responses varied among subjects. While subjects 1 and 9 had maximum confused responses, subjects 4 and 8 did not have any confusions. Subjects 2, 3, 5, 6 and 10 gave minimal confused responses. It was found that maximum confusions occured between /p/ and /m/ followed by /p/ and /d/; /g/ and /m/; /b/ and /t/ and /t/ and /p/ respectively. Least confusions occured between /k/ and /g/, /n/ and /d/ and /t/ and /m/.

3.2 Conflicting condition I:

(Same place but different manner of articulation for audio and orthographic stimuli).

3.2.1 When the A-0 stimuli were of same place but different manner of articulation, it was found that average percent responses for audio stimuli were better for alveolar - alveolar stimuli pair than that for bilabial - bilabial pair (Table XIV).

A - 0	PERCENT RESPONSE		
	A	0	Others
Alveolar - Alveolar	52.5	46	1.5
Bilabial - Bilabial	48.33	45.55	6.11

Table **XIV** : Percent response for A - 0 stimuli

3.2.2 : Alveolar - Alveolar stimuli:

In this, A-0 pair were ta : 1 - na : 1 and da : 1 - na : 1.

It was found that when the auditory stimuli was voiced alveolar stop and orthographic stimuli was nasal continuant maximum percent responses were obtained for orthographic stimuli. However, when the audio stimuli was voiceless stop, maximum percent responses was obtained for auditory stimuli. (Table XV).

STIMULI	PERCENT RESPONSE		
A - 0	A	0	Others
da : 1 - na : 1	48.0	49.0	3
ta : 1 - na : 1	57.00	43.00	0

Table XV : Percent response for A - O stimuli (Alveolar - Alveolar)

The confusions in audio/orthography were as in table XVI

A - 0 STIMULI	CONFUSED RESPONSE	PERCENTAG!
d - n	b	1
	t	1
	m	1
t - n		

Table XVI: Confusions in A-0 stimuli - Alveolars

3.2.3 : Bilabial - Bilabial :

In this the A-0 pairs were ba : 1 - ma : 1 and pa : 1 - ma : 1. It was found that

1) when the auditory stimuli was voiced or voiceless stop or orthography was nasal continuant maximum percent responses were obtained for the auditory stimuli (Table XVII).

STIMULI	PERCENT RESPONSE			
A - 0		A	0	Others
ba : 1 - ma	1	48.00	47.001	5
pa : 1 - ma	1	48.75	43.75	7.5

Table XVII : Percent response for A - O stimuli

(Bilabial - Bilabial)

The confusions in auditory/orthography were as in table XVIII.

A - 0 STIMULI	CONFUSED RESPONSE	PERCENT
p - m	t	5
	g	1.2
	n	1.2
b - m	n	6.25

Table XVIII : Confusions for A - O stimuli - bilabials

3.3 Conflicting condition II (different place of articulation for A - 0 stimuli) .

The A - 0 stimuli in this conditions were

1) Bilabial - Velar (B - V)

2) Bilabial - Alveolar (B - A)

3) Alveolar - Velar (A - V)

4) Alveolar - Bilabial (A - B) and

5) Velar - bilabial (V - B)

3-3.1 Bilabial - Velar:

When the auditory stimuli was bilabial and the orthographic stimuli had velar place of articulation 50% of the responses were towards auditory stimuli and less than 50% were towards orthographic stimuli. Subjects reported other stimuli also (Table XIX).

STIMULI	AVERAGE PERCENT RESPONSE		
A - 0	A	0	Others
B - V	50	46.5	3.5

Table XIX : Percent response for A - O stimuli (Bilabial - Velar)

In this B - V pair, the stimuli pair (pa : 1 - ga : 1 and ba : 1 - ka : 1) were included. When the audio signal was voiced stop and orthographic stimuli was voiceless, maximum percent responses were obtained for auditory stimuli. However, when the auditory stimuli was voiceless stop and orthographic stimuli was voiced stop, maximum percent responses were obtained for orthographic stimuli (Table XX).

STIMULI A - 0		PERCENT RESPONSE		
		A	0	Others
ba : 1 - ka :	1	53	42	5
pa : 1 - ga :	1	47	51	2

Table XX : Percent response for B - V pair

Confusions in auditory/orthographic stimuli were as in table XXI.

A - O STIMULI	CONFUSED RESPONSE	PERCENT
b - k	g	2
	m	1
	n	1
	P	1
p - g	k	1
	t	1

Table XXI : Confusions in auditory/orthographic stimuli Bilabial - Velar pair

3.3.2 Bilabial - Alveolar :

When the auditory stimuli had bilabial place of articulation and orthographic stimuli had alveolar place of articulation, maximum percent responses were towards auditory stimuli followed by orthographic stimuli (table XXII). Some reported other stimuli.

STIMULI	PERCENT RESPONSE		
A - 0	A	0	Others
bilabial - alveolar	46.31	45.26	8.42

Table XXII : Percent response for A - O stimuli
(bilabial - alveolar pair)

In this condition, the three stimuli pair were ba : 1 - na : 1, pa : 1 - na : 1 and ma : 1 - na : 1. It was found that, when the auditory stimuli was voiced stop and nasal continuant, maximum percent responses were obtained for orthographic stimuli which was nasal continuants. However, though the orthographic stimuli was same as earlier, when the auditory stimuli was voiceless stop, maximum percent response were towards auditory stimuli (table XXIII).

STIMULI	PERCENT RESPONSE		
A - 0	A	0	Others
ba : 1 - na : 1	41.43	55.71	2.85
pa : 1 - na : 1 {	50.00	37.00	13
ma : 1 - na : 1	45.00	50.00	5

Table XXIII: Percent response for A - O stimuli
(bilabial - alveolar pair)

The confusions in audio/orthography were as in table XXIV.

A - 0 STIMULI	CONFUSED RESPONSE	PERCENT
p - n	*m*	12
	d	1
b - n	g(1)	1.4
	t(1)	1.4
m - n	d	0.05

Table XXIV - Confusions in A - O stimuli

(bilabial - alveolar pair)

3.3.3. Alveolar - Velar:

When the auditory stimuli were alveolar and the orthographic stimuli had velar place of articulation, maximum percent responses were towards orthographic stimuli followed by audio stimuli and some responses were reported for other stimuli (Table XXV).

STIMULI	PERCENT RESPONSE		
A - 0	A	0	Others
A - V	45	51.5	4

Table XXV : Percent response for Alveolar - Velar pair

The two stimuli pair were da : 1 - ga : 1 and ta : 1 - ka:l

It was found that when the audio - orthographic stimuli were voiced/voiceless, the maximum percent responses were towards orthographic stimuli (Table XXVI).

STIMULI	PERCENT RESPONSE		
A - 0	A	0	Others
da : 1 - ga : 1	43	51	6
ta : 1 - ka : 1	47 I	52	1

Table XXVI : Percent response for A - 0 stimuli (alveolar - velar)

The confusions in audio/orthography were as follows (table XXVII).

A - 0 STIMULI	CONFUSED RESPONSE	PERCENT
d - g	m	2
	b	2
	t	1
	n	1

Table XXVII : Percentage of confused response in alveolar - velar pair (d - g)

3.3.4 Alveolar - Bilabial:

When the auditory stimuli was alveolar and the orthographic stimuli had bilabial place of articulation, maximum percent responses were towards auditory stimuli (Table XXVIII). Some subjects reported other stimuli also. The stimuli pair was ta : 1 - ba : 1 .

STIMULI	PERCENT RESPONSE		
A - 0	A	0	Others
ta : 1 - ba : 1	56.66	40	3.33

Table XXVIII : Percent response to A - O stimuli
Alveolar - bilabial pair

The confusions in audio/orthographic stimuli were as in table XXIX.

A - 0 STIMULI	CONFUSED RESPONSE	PERCENT
t - b	p	3.33

Table XXIX : Confusions in A - O stimuli
alveolar bilabial pair

3.3.5 Velar - Bilabial:

When the auditory stimuli had velar place of articulation and the orthographic stimuli had bilabial place of articulation, maximum percent responses were towards orthographic stimuli followed by the auditory stimuli. The subjects reported other stimuli also (table XXX).

STIMULI	PERCENT RESPONSE		
A - 0	A	0	Others
Velar - Bilabial	47.12	51.01	1.86

Table XXX : Percent response to A - O stimuli

Velar - Bilabial pair

The following stimuli pair were included in this condition, ka : 1 - ma : 1, ka : 1 - pa : 1, ga: 1 - ma : 1,ga: 1- ba: 1, ga: 1 - pa : 1.

It was found that when auditory stimuli were same i.e, voiceless stops and the orthographic stimuli were

1) nasal continuants and

2) voiceless stops respectively maximum percentage response were obtained for auditory stimuli. However, when auditory, stimuli was voiced stop and the orthographic stimuli were
   1) nasal continuants
   2) voiced stop and
   3) voiceless stop, maximum percentage responses were towards orthographic stimuli (table XXXI).

STIMULI	PERCENT RESPONSE		
A - O	A	O	Others
ka : 1 - ma : 1	53.00	46.00	1
ka : 1 - pa : 1	52.63	45.83	1.05
ga : 1 - ma : 1	45.00	54.00	1
ga : 1 - ta : 1	40.00	57.00	3
ga : 1 - pa : 1	40.00	56.00	4

Table XXXI : Percent response for A - O stimuli (Velar - bilabial)

The confusions in the audio/orthographic stimuli were as follows (table XXXII).

A - O STIMULI	CONFUSED RESPONSE	PERCENT
g - p	m	2
	b	1
		1
g - b	m	3
g - m	b	1
k - m	n	1
k - p	d	I

Table XXXII : Confusions in auditory - orthographic stmuli (Velar - bilabial)

DISCUSSION

It was found that, for the orthographic stimuli, alveolars obtained the best response. It may be the structural properties (simple) of orthography of these stimuli, which lead to maximum percent score for these. For the auditory stimuli maximum responses were obtained for velars [k, g], which may be attributed to the spectra of velars, which is important for the consonant perception.

However, when the Audio-Orthographic stimuli were same, maximum responses was reported for alveolars. As it was found that alveolars obtained maximum response in orthographic condition, it may be the combined influence of alveolar orthography and the acoustical property of alveolars which makes them distinct.

When the A - 0 stimuli were from the same place, but different manner of articulation, maximum response was reported for alveolars, which were auditory stimuli. This may be because of the distinct acoustic property of alveolars.

It was very interesting to find that, when the A - 0 stimuli were from different place of articulation maximum responses were reported for alveolar - bilabial pair (auditory stimuli), but least responses was reported for alveolar - velar pair (for auditory) stimuli. For orthographic stimuli maximum responses were obtained for velars in alveolar - velar pair and least responses were obtained for bilabials in alveolar - bilabial pair. Also, it was found that Bilabial - alveolar pair obtained maximum. Even though, alveolars response in 'other' category responses indicating that the subjects confused Bil-alveolar maximally obtained maximum response in orthographic condition, in A— O mode, it wa found that they were confused when paired with bilabials.

In orthography maximum confusions were between /k/ and /t/. To find out the confusions among Hindi graphemes, a study was conducted using the orthographic stimuli, in 20 normal adults who were not speakers of Hindi. The material was the graphemes used in the study. The subjects were visually presented with two graphemes at a time and were instructed to report whether they were same or different. Those graphemes which were reported to be similar were considered to be the grapheme which are likely to be confused. It was found that maximum confusions were reported between /t/ and /n/, followed by /p/ and /m/ and /g/ and /m/. Though, maximum comparisons are not reported for /k/ and /t/ in the study they were the graphemes maximally compared. Table XXXIII shows the graphemes in Hindi script.

The results revealed that McGurk effect was absent or the orthographic stimuli did not interfere with the auditory stimuli when synchronized. This is in consonance with the study by Fowler and Dekle (1991). Thus, it can be concluded that McGurk effect between orthographic and auditory stimuli doesn't arise from association in memory.

This has implication in rehabilitation- As there is no cross model influence, it can be suggested that simultaneous orthographic presentation can be given along with auditory stimuli during speech and language intervention programmes, while dealing with hearing impaired, aphasics and dyslexics. However, care should be taken while presenting orthographic stimuli. Similar graphemes should be avoided in the first instant and those which are very distinct should be provided. It is further suggested that the confusions between graphemes in various languages be investigated.

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSIONS

The study was aimed at investigating the McGurk effect of orthographic stimuli on auditory stimuli presented simultaneously and to test whether it arises due to association in memory.

Eight meaningful monosyllabic Hindi *CVC* words with varying initial consonant were selected for the study. The phonemes /p/ - bilabial voiceless stop, /b/ - bilabial voiced stop /k/ - velar voiceless stop g-velar voiced stop /t/ - alveolar voiceless stop /d/ - alveolar voiced stop, /m/- bilabial nasal continuant and /n/ - alveolar nasal continuant comprised the initial consonant and the medial vowels was /a/ - low mid open vowel and the final consonant was the lateral /1/.

Two lists of these CVC Hindi words were prepared i.e, audio word list and visual word list. Four lists of word pairs were prepared by drawing one word from auditory list and the other from the orthographic list. In the first list, the word pairs were same, which formed the catch trials. For eg : Pa : 1 Pa : 1 [Auditory-orthographic pair]. Eight such word pairs comprised the list. In the second list, four word pairs were included which were minimal pairs in terms of manner of articulation. For eg : pa : 1 - ma : 1 [auditory - orthographic stimuli]. Third list consisted of eight word pairs, which were minimal pairs with place difference. For eg : ga : 1 - ba : 1 [auditory - orthographic stimuli].

In the fourth list, seven minimal pairs which differed in terms of both place and manner of articulation. The three places of articulation considered were bilabial, alveolar and velar and the manner differences were introduced using voicing and nasal continuants /m/ and /n/. For eg : ka : 1 - ma : 1 [auditory - orthographic stimuli].

The eight pairs in catch - trials were called co-operating condition. The four pairs with manner difference were called conflicting condition-I and those with place and place and manner difference were called conflicting condition-II. Thus a total of 27 stimulus pairs [eight for catch trials, four with manner difference, eight with place difference and seven with manner and place difference] were considered. With this 27 stimuli pair, a list of 240 auditory - orthographic pairs of stimulus was formed by selecting at random.

For orthographic stimuli, these monosyllabic words were written with a thickness of 1 cm in black ink, one on each ivory card [size 3' x 6']. They were videotaped according to the order in the list, using a National M - T movie camera with an inbuilt microphone. The cards were focussed from a distance of six feet from the camera, in a room illuminated with a 1 kw Halogen light. They were recorded for 1 sec with an intrastimulus interval of 2 sees, to allow the subjects of write down the response. The recording was done on video-track of the cassette National VHS [SPE - 180] by a professional.

For the audio recording, a 23 year old normal female who was a native Hindi speaker, after sufficient practice, uttered the appropriate word to be synchronized as soon as the word appeared on the screen of the television. These utterances were recorded on the audio-track of the same cassette. Thus, the 240 word pairs which were approximately synchronized, comprised the material for the study.

Ten Hindi speakers [five males and five females] within the age range of 18-25 years served as subjects, who reported normal hearing and normal or corrected vision. Three, three and four subjects were tested at one sitting, and were seated six feet away from the television camera, in a semicircular pattern to make sure that the TV screen was visible to everyone. Each subject participated in three trials and they were instructed to perform the following tasks.

In trial I, the subjects were instructed to record only what they saw, in trial II, the subjects were instructed to record only what they heard and trial III, they were to record what they perceived. The responses of the subjects were tabulated and analyzed for auditory, orthographic and audio-orthographic stimulus.

The total number of responses for each category [Audio, orthographic and other] was computed. The total number of responses was converted to percent response by the following formula.

$$\text{Percent response} = \frac{\text{Total number of response} \times 100}{\text{Total number of stimulus}}$$

The average percent response for the subjects was also computed. The results revealed the following :

For the orthographic stimuli, the best responses were obtained for alveolars (t, d, n). For the auditory stimuli, maximum responses were obtained for velars (K, g).

When the A - 0 stimuli were same, maximum responses was reported for alveolars. When the A - 0 stimuli were from different place of articulation, maximum responses was for auditory stimuli. When A - 0 stimuli were from different place of articulation, maximum responses was reported for alveolar - bilabial pair (for auditory stimuli) and least responses was reported for alveolar - velar pair [for auditory stimulus]. For orthographic stimuli maximum responses were obtained for velar in alveolar - velar pair and least responses were obtained for bilabial in alveolar - bilabial pair. Other responses were reported maximally for bilabial - Alveolar pair indicating that the subjects confused bilabial - alveolar maximally.

In the orthography maximum confusions were between /k/ and /t/, /m/ and /g/ and /k/ and /g/. This may be because of the similarity of these graphemes.

The results revealed that McGurk effect was absent or the orthographic stimuli did not interfere with the auditory stimuli when synchronized. This is in consonance with the study by Fowler and Dekle (1991). Thus, it can be concluded that McGurk effect between orthographic and auditory stimuli doesn't arise from association in memory.

This has implications like, simultaneous presentations of orthographic stimuli and auditory stimuli during speech and language intervention programs; while dealing with hearing impaired, aphasics and dyslexics. However, similar graphemes should be avoided in the first instance and those which are distinct should be provided. It is suggested that the confusions between graphemes in various languages be investigated.

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APPENDIX- I

APPENDIX – I

Egs of ORTHOGRAPHIC STIMULI

ढाल

ताल

माल

APPENDIX - II

APPENDIX II - RESPONSE SHEET

Name :
Age / Sex :
Mother tongue :
Education :

1	25	49	73	97	121	145	169	193	217
2	26	50	74	98	122	146	170	194	218
3	27	51	75	99	123	147	171	195	219
4	28	52	76	100	124	148	172	196	220
5	29	53	77	101	125	149	173	197	221
6	30	54	78	102	126	150	174	198	222
7	31	55	79	103	127	151	175	199	223
8	32	56	80	104	128	152	176	200	224
9	33	57	81	105	129	153	177	201	225
10	34	58	82	106	130	154	178	202	226
11	35	59	83	107	131	155	179	203	227
12	36	60	84	108	132	156	180	204	228
13	37	61	85	109	133	157	181	205	229
14	38	62	86	110	134	158	182	206	230
15	39	63	87	111	135	159	183	207	231
16	40	64	88	112	136	160	184	208	232
17	41	65	89	113	137	161	185	209	233
18	42	66	90	114	138	162	186	210	234
19	43	67	91	115	139	163	187	211	235
20	44	68	92	116	140	164	188	212	236
21	45	69	93	117	141	165	189	213	237
22	46	70	94	118	142	166	190	214	238
23	47	71	95	119	143	167	191	215	239
24	48	72	96	120	144	168	192	216	240