Tonal Perception in Cantonese-speaking Aphasics

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A dissertation submitted in partial fulfilment of the requirements for the Bachelor of Science (Speech and Hearing Sciences), The University of Hong Kong, April 30, 1992.

ABSTRACT

The extent and nature of tonal perception impairment were studied in normal subjects and Cantonese-speaking aphasics. Foury-four subjects paticipated in the study: 30 normal controls, two non-aphasic brain-damaged subjects (dysarthrics), four anomic, five transcortical motor and three Broca's aphasics. Two tasks were administered to all subjects: a tone identification task and the So & Varley Lexical Comprehension Test (So & Varley, 1991). Results revealed that tonal perception was disrupted in the aphasic subjects in both phonological processing and lexical processing levels. Overall aphasic severity, but not aphasic type, correlated with tonal perception abilities in aphasics. There was also a significant correlation between tonal processing abilities and the presence of general auditory comprehension disorders in both lexical and spontaneous speech levels. Normal performance by the non-aphasic brain-damaged subjects indicated that tonal perception disruption is a consequence of language pathology after brain-damaged rather than brain-damage per se.

INTRODUCTION

In speech, prosodic features refer to the variations of the duration, amplitude and fundamental frequency of the speech waveform. The principal linguistic correlates of these attributes include stress, intonation, tone, length and rhythm (Gandour, Petty & Dardarananda, 1988). In recent years, speech prosody has become an increasingly useful medium for studying the role of the left and right hemispheres in the control of these acoustical properties and for studying language processing in brain-damaged subjects.

Most of the studies of perception and production of speech prosody in brain-damaged subjects have been conducted with native speakers of English (Behrens, 1985; Emmorey, 1987; Shapiro & Danley, 1985). By contrast, very little information is available about speech prosody in brain-damaged subjects who are speakers of a tone language.

In 1980, Naeser & Chan reported that a 56-year-old left-brain damaged aphasic had impaired perception on all four Mandarin tones since she performed significantly poorer than normal controls in the same test. No information was given concerning the pattern of tonal confusions.

April & Han (1980) studied the tonal perception ability in a crossed nonfluent Cantonese-English bilingual aphasic patient. A tonal discrimination test was administered (pairs of Cantonese words minimally distinguished by tones were used) and the patient was required to determine whether the two presented tones were different or not. April & Han reported that the patient scored seven out of ten in the discrimination task. However,no normal comparative data were reported in their study.

Gandour & Dardarananda (1983) employed a tonal identification test to study the tonal perception abilities of Thai aphasics. Three sets of stimuli were included in the test (two real-speech, one synthetic speech): in each condition, the aphasics were asked to identify a presented target from a total choice of five Thai words which are minimally distinguished by tones. They concluded that all the four left-brain damaged aphasic patients performed significantly poorer than either the normal or the right brain-damaged controls.

Yiu (1989) studied the tonal perception and production abilities of Cantonese-speaking aphasic subjects. Three tests were used in the perception part: tone identification test, tone recognition test & tone discrimination test. He concluded that tonal disruption is impaired in aphasics regardless of the type and severity of aphasia.

In 1984, Packard found that a group of nonfluent aphasics performed significantly worse in a discriminative test of Mandarin tones than either the right brain-damaged or control group.

In their experimental study of Chinese patients with right hemisphere lesions, Hughes, Chan & Ming (1983) found that all 12 subjects performed reasonably well in identifying the four Mandarin tones and their performance was not significantly different from that of the seven normal control subjects.

All these studies seemed to support the findings of Van Lancker & Fromkin (1973, 1983) who concluded that pitch discrimination was lateralised to the left-hemisphere when pitch difference was linguistically processed.

However, the results of some of these studies may have been confounded by other factors such as choice of subjects and stimuli.

The subject in April & Han's study was a Cantonese-English bilingual while Naeser & Chan's patient spoke as many as three dialects (tridialectal). Given such complications, it is very difficult to conclude whether the identified impairment in tonal perception was due to language pathology (resulted from damage to the language-dominant hemisphere) or was just a result of language interference. Yiu (1989) claimed that dialect does have an influence on tonal perception in normal subjects and it may therefore be expected among aphasic ones.

Many of the previous studies on tonal perception or production used written words as stimuli (e.g. Gandour & Dardarananda, 1983). This might be a problem for the aphasics because dyslexia is a common disorder associated with aphasia. Hence, errors revealed on a tone test may be the result of dyslexia rather than tonal perception difficulties per se.

Given the presence of confounding variables and limitation of research studies in this area, we are in obvious need of more studies of the perception of tone in aphasic speakers of a tone language, especially Cantonese in which the number of researches done so far is very limited.

In a tone language such as Cantonese, pitch variation at syllable level serves to change the lexical meaning of words. Being a phonological attribute, lexical tone thus serves as a good parameter for research in understanding the relationship between prosodic disruption and brain impairment. Since the comprehension impairment observed in nearly all aphasics may reflect deficits in different levels of processing (phonological, syntactic and semantic) of verbal language,

investigation of aphasic deficits at a specific level of processing can give one insight into the underlying mechanism of the perceptual impairment of spoken language.

Along the line of research in phonological processings, attention has also been given to the investigation of the relationship between disorders of phonological and general disorders of auditory comprehension.

Both Blumstein, Baker & Goodglass (1977) and Basso, Casati & Vignolo (1977) ruled out the possibility that comprehension disorders in posterior aphasia were due to phonological impairment.

On the other hand, Tallal & Newcombe (1978) showed a correlation between semisyntactic CV-syllable tests and performances obtained on the Token Test. Miceli, Gainotti & Caltagirone (1980) found a partial correlation between disorders of phonological analysis (Phonemic Discrimination Disorder) and general disorders of auditory comprehension. Both of these studies suggested that phonological processings contributed to the overall auditory comprehension deficits in aphasics.

Very few studies have tried to investigate the relationship between deficits in tonal processing and general auditory comprehension problems. Recently, Yiu (1989), in his study of tonal disruption in Chinese (Cantonese) aphasics, concluded that there was no correlation between tonal perception difficulties and auditory comprehension abilities as measured in the Cantonese Aphasic Battery (CAB).

Owing to the controversy still evident in the literature, an aim of the present study is to evaluate the relationships

between phonological impairment (tonal processing deficits) and the presence of general comprehension disorders.

In summary, the overall objectives of the present investigation were:

1) to determine the extent and nature of impairment in the perception of Cantonese tones by monolingual-adult Cantonese-speaking aphasic subjects;
2) to determine the extent to which a deficit in tone perception reflects general brain damage or is a consequence of language pathology (aphasia) by comparing the performance of brain-damage aphasics with brain-damage nonaphasics (dysarthrics) patients;
3) to study the relationships between tonal perception deficits and the presence of general comprehension disorders in Cantonese-speaking aphasics.

METHOD

Subjects

Thirty normal subjects, two brain-damaged non-aphasics (dysarthrics) and twelve brain-damaged aphasics served as voluntary participants. All participants were monolingual Cantonese speakers and had Cantonese as the mother tongue. All subjects passed a hearing screening test (Pure Tone Average < 30dBHL) done prior to the actual experiment. Normal subjects had no known or reported brain-damage and language deficits. All the brain-damaged aphasics had a post-onset time of more than three months so that they would be more stable neurologically and the experimental results be more reliable. All the brain-damaged subjects had no apparent limb apraxia and visual inattention problem as these might interfere with

performance. The Cantonese Aphasic Battery (CAB) was administered to all the brain-damaged subjects. A cut-off score of 96.4 (Yiu, 1989) was used to determine whether the brain-damaged subjects were aphasics or not (dysarthrics). The aphasic subjects were classified by the CAB into different types according to their performance in different sections in the Battery. Three aphasic types were included in the present study: anomic, Transcortical Motor (TM) and Broca's aphasics. The normal, dysarthric and aphasic subject groups were not significantly different from one another in age ($F(2,41) = 1.44$, $p < .05$). Moreover, age was not significantly different among the three aphasic types ($F(2,9) = 0.47$, $p < .05$).

Materials

A tone identification task was used to study subjects' tonal perception abilities and confusion patterns. Subjects were asked to discriminate among a total of six photos each depicting a Cantonese words with one of the six Cantonese tones: tone 1 (high level), tone 2 (high rising), tone 3 (mid level), tone 4 (low falling), tone 5 (low rising) and tone 6 (low level). The Cantonese words depicted were minimally distinguished by tones. The syllable structure /ji/ was used as the root word. A total of 30 randomly ordered items were included in this task. The So & Varley Lexical Comprehension Test (So & Varley, 1991) was used to assess subjects' level of breakdown in lexical comprehension. By including tonal, semantic and segmental distractors, the results of this test could give indication to the source of lexical comprehension errors (Bishop & Byng, 1984). This test consisted of 39 test plates. Each plate contained four items: the target, one tonal distractor, one semantic

distractor and one segmental distractor. The stimuli in the tone identification task and So & Varley Lexical Comprehension Test (So & Varley, 1991) were played back on a Sony TCD-6 cassette recorder at a comfortable intensity level during the experiment. The stimuli, produced by a female voice, were recorded on a SONY TC-D-5M cassette recorder using TDK AR-X 60 cassette tapes in a sound-proof room. The Cantonese Aphasic Battery was used to assess the brain-damaged subjects' ability in language comprehension and expression. For the purpose of this research, only items in the auditory comprehension and verbal expression sections were administered. The auditory comprehension section tested the subjects' abilities in comprehending words, Yes/No questions and commands. The verbal expression section consisted of repetition, naming of daily objects, word fluency, sentence completion and responsive speech tasks; it also consisted a section to evaluate subjects' spontaneous speech with respect to the information content and level of fluency. The CAB gives Aphasic Quotient (AQ)sub-scores in each section and a total AQ score which is an indication of the overall level of severity of aphasia (Kertesz, 1979).

Procedures

Each subject was tested individually in a quiet room. In the tone identification task and So & Varley Lexical Comprehension Test (So & Varley, 1991), subjects were asked to point to the appropriate photo upon hearing recorded stimuli. An example of the stimuli is:

Cantonese (Phonetic Transcription)	Target Word
[tsi_2 ha_5 ji_2 pei_2 $ŋ^{\gamma}_5$ $t^{h}ɐi_2$]	[ji_2]
'指 吓. 椅 俾 我 睇'	'椅'

In English, this means, 'Point to the chair for me.' The target chair is embedded in a carrier phrase as this provided the subjects with cues of the relative pitch range of the speaker. Different sections in the CAB had a different set of standardised instructions and method of calculating the scores. The whole experimental procedure lasted for about 45 minutes. Special attention was given to avoid overloading and fatique in the aphasics and therefore for some of the aphasic subjects, the CAB was administered on a separate day.

RESULTS

Tone Identification Task

Overall Identifiability of Cantonese Tones

The mean correct scores (out of 30) and the correpsonding correct percentage scores were tablulated for each group of subjects.

Table 1

Mean scores on the Tone Identification Task

	Cases	Mean (out of 30)	Percentage
Normal	30	27.53	91.77
Dysarthrics	2	28.50	95.00
Aphasics	12	18.08	60.27
Anomic	3	23.75	79.17
Transcortical Motor	5	16.20	54.00
Broca	4	13.67	45.57

The aphasics scored less (mean score = 18.08) than either the normals (mean score = 27.53) and dysarthrics (mean score = 28.50). One-way analysis of variance (ANOVA) followed with a post hoc Tukey's Test revealed that the aphasics as a group performed significantly poorer than either the normals or dysarthrics ($F(2,41) = 52.85$, $p < .00001$). All three aphasic types were also found to perform significantly poorer than either the normal or dysarthric subjects ($F(4,39) = 95.02$, $p < .0001$). The dysarthrics were not significantly different from the normal subjects.

Among the different aphasic types, the anomics scored highest (mean score = 23.75) followed by TM (mean score = 16.20) and then Broca's (mean score = 13.67). One-way ANOVA followed with a post hoc Tukey's Test revealed that the anomics scored significantly higher than both the TM and Broca's aphasics ($F(2,9) = 12.75$, $p < .05$). Performance of the TM and Broca's aphasics did not differ from one another significantly.

The aphasics' performance revealed that the less severe aphasic subjects (anomics, mean AQ score = 86.8) scored higher on the tone identification task than the remaining two aphasic types (TM, mean AQ score = 60.1 and Broca, mean AQ score = 52.9). A Pearson product-moment correlation test was employed to study the correlation between tone identification scores and the total AQ scores of the aphasic subjects. Results revealed a substantial correlation between the two measures which is significant at the .001 level ($r = 0.8842$, $p < .001$).

From previous analysis (One-way ANOVA of tone identification scores of different aphasic types), aphasic type was also found to be a variate of performance in the tone

identification task. Further analysis was therefore done to evaluate the effects of aphasic type and aphasic severity on performance in tone identification. An analysis of covariance (ANCOVA) was performed. Total AQ scores of the aphasic subjects were used as a covariate in the procedure to remove it as a possible source of bias in the comparison among aphasic types. Results of the analysis indicated that when AQ score was controlled as a covariate, the aphasic type had little effect on tone identification scores (F (1, 11) = 0.445 , $p < .05$). Conversely, AQ score itself had a significant effect on the tone identification scores (F (2, 11) = 31.852 , $p < .0001$). This suggests that overall aphasic severity, rather than aphasic type, affects aphasics' performance in tone identification.

Tonal Confusion Patterns

To study the tonal confusion patterns in different subject groups, confusional matrices were constructed. In order to determine whether a confusion made on each tone was significant or not, the following computation based on Fok (1974) was done:

$$(N-n)/5 + 1.96 \{ [(N-n)/5] \times [1 - (N-n)/5N] \}^{\frac{1}{2}}$$

where n = no. of correct identification ; N = column total

Table 2 shows the confusional matrices of different subject groups. In each matrix, scores in the diagonal are correct reponses while off-diagonal ones are wrong responses (tonal confusions). The significant tonal confusions were indicated by raw scores while the non-significant tonal confusions were indicated by asterisks (*). The short forms HL, HR, ML, LF, LR, LL are the descriptive terms for the fundamental frequency height and contour pattern of each

tone: HL (High Level); HR (High Rising); ML (Mid Level); LF (Low Falling); LR (Low Rising); LL (Low Level).

Table 2

Confusion matrices of Control Groups (normal and dysarthric) and different Aphasic Types on the Tone Identification Task

a) Normal

		Actual Tone Presented					
		HL	HR	ML	LF	LR	LL
Response	HL	149					
	HR		135			12	
	ML			136	*		19
	LF	*		*	142		*
	LR		15			138	
	LL			13	7		125
Column Total		150	150	150	150	150	150

b) Dysarthrics

		Actual Tone Presented					
		HL	HR	ML	LF	LR	LL
Response	HL	10					
	HR		9				
	ML			9			*
	LF				10		
	LR		*			10	
	LL			*			9
Column Total		10	10	10	10	10	10

c) Anomics

		Actual Tone Presented					
		HL	HR	ML	LF	LR	LL
Response	HL	19					
	HR	*	17			5	
	ML			14	*		*
	LF				17	*	5
	LR		3	*	*	14	
	LL			5	*		13
Column Total		20	20	20	20	20	20

table continues

d) Transcortical Motor

		Actual Tone Presented					
		HL	HR	ML	LF	LR	LL
Response	HL	14		*	*		
	HR	*	16	*	*	6	*
	ML	5		8	*	*	*
	LF	*	*	*	18	*	7
	LR		5	*	*	12	*
	LL	*	*	8		*	13
Column Total		25	25	25	25	25	25

e) Broca's

		Actual Tone Presented					
		HL	HR	ML	LF	LR	LL
Response	HL	8		*	*		
	HR	*	3	*	*	5	
	ML	*	*	4	*	*	*
	LF	*	*	*	11	*	3
	LR	*	7			5	*
	LL		*	7	*	*	10
Column Total		15	15	15	15	15	15

Both the significant and non-significant tonal confusions made by the normal subjects were confusions between tones with the same contour levels (high rising tone with low rising tone: mid level tone with low level tone) and tones with similar contour levels (low level tone with low falling tone). No significant tonal confusion patterns could be identified in the dysarthric group, but the non-significant confusion patterns also exhibited the above trend.

Like the normal and dysarthric subjects, the anomic aphasics easily confused tones with same or similar contour patterns. In addition, the non-significant tonal confusions made by the anomics indicated that they also confused tones with same or similar fundamental frequency heights (high level

tone with high rising tone; low rising tone with low falling tone and mid level tone with low rising tone).

Most of the significant tonal confusions made by the TM and Broca's aphasics present also in the normal and dysarthric responses. In other words, the TM and Broca's aphasics also tended to confuse tones with same or similar contour levels. However, their overall performance in the tone identification task was rather random and non-significant tonal confusions involved almost every tone. They could not identify any of the tone consistently. This was revealed by the large number of asterisks (*) in their confusion matrices, indicating that tonal confusions occurred in almost every tone.

Performance on Individual Tone

Subjects' performance on individual tones are given in table 3 and graphically presented in figure 1.

Table 3

Rank Order of Individual Tones From Highest to Lowest Mean Scores of Correct Identification Responses

		Cantonese Tones					
	Cases	Tone 1 HL	2 HR	3 ML	4 LF	5 LR	6 LL
Normal	30	1	5	4	2	3	6
Dysarthrics	2	2	5	5	2	2	5
Aphasics	12	2	3.5	6	1	5	3.5
Anomics	4	1	3	4.5	2	4.5	6
TM	5	3	2	6	1	5	4
Broca's	3	3	6	5	1	4	2

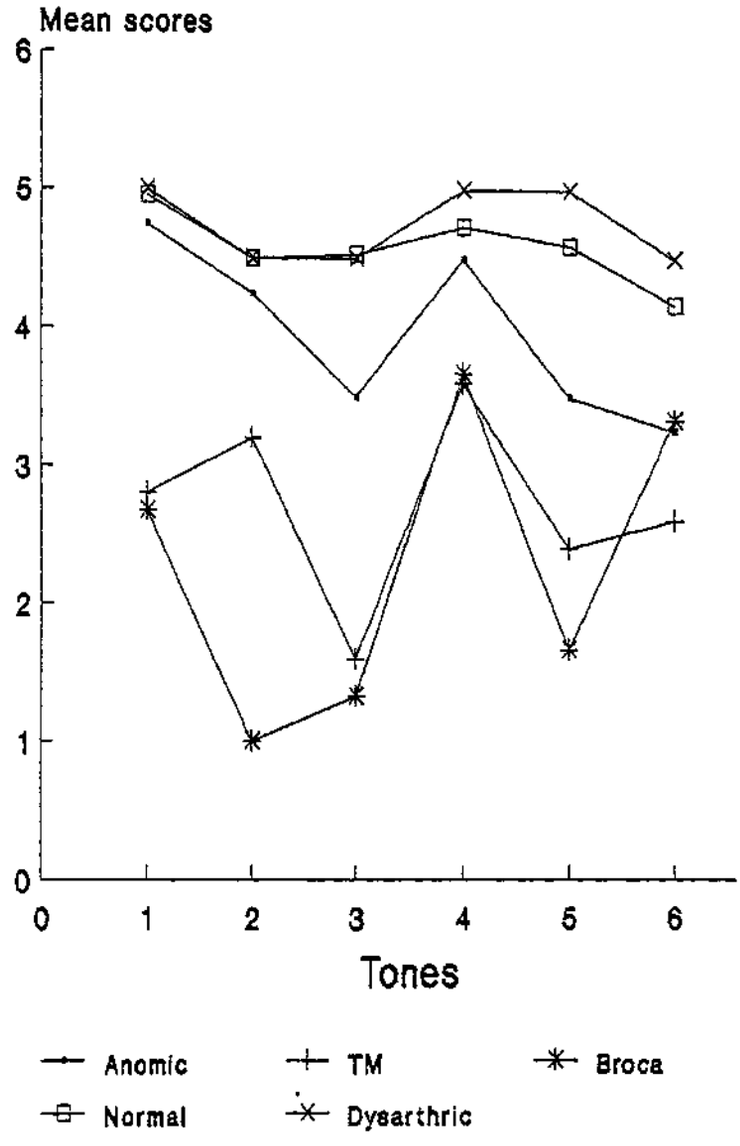

Figure 1. Mean identification score of individual tone in tone identification task

Results of the Friedman Two-way ANOVA revealed that the rank order pattern of the anomics were significantly different from that of the TM (χ^2= 29.62 , df = 5 , p < .001) and Broca's aphasics (χ^2= 31.3 , df = 5 , p < .001). The rank order patterns of the TM and Broca's aphasics were not significantly different from one another (χ^2= -30.43 , n.s.).

So & Varley Lexical Comprehension Test (So & Varley, 1991)

The mean correct scores out of 39 and the correpsonding correct percentage score were tablulated for each group of subjects.

Table 4

Mean scores on the So & Varley Lexical Comprehension Test (So & Varley, 1991)

	Cases	Mean (out of 39)	Percentage
Normal	30	37.03	94.95
Dysarthrics	2	38.50	98.72
Aphasics	12	30.42	78.00
Anomic	3	35.25	90.38
TM	5	28.40	72.82
Broca	4	27.33	70.08

Results indicated that the aphasics scored less (mean score = 30.42) than either the normals (mean score = 37.03) and dysarthrics (mean score = 38.50). One-way ANOVA followed with a post hoc Tukey's Test revealed that the aphasics performed significantly poorer than either the normals or dysarthrics ($F(2,41) = 28.21$, $p < .00001$).
There was no significant difference between performance of the dysarthric and normal subjects.

Among the different aphasic types, the anomics scored highest (mean score = 35.25) followed by TM (mean score = 28.40) and then Broca's aphasics (mean score = 27.33). One-way ANOVA followed with a post hoc Tukey's Test revealed that the anomics scored significantly higher than both the

Transcortical Motor and Broca's aphasics (F (2,9) = 8.36, $p < .05$). Performance of the TM and Broca's aphasics did not differ significantly from one another.

The Pearson product-moment correlation test was used to study the correlation between So & Valey Lexical Comprehension Test (So & Varley, 1991) scores and the total AQ scores of the aphasic subjects. Results indicated that there was a high correlation between the two measures, this is significant at the .001 level ($r = 0.8541$, $p < .001$).

Since both AQ score (an indication of overal aphasic severity) and aphasic types may have an effect on the Test scores, an analysis of covariance (ANCOVA) was performed. Total AQ scores of the aphasic subjects were used as a covariate in the procedure. Analysis results revealed that when AQ Score was controlled as a covariate, aphasic type had little effect on the So & Varley Lexcial Comprehension Test scores ($F(1, 11) = 0.154$, $p < .05$). Conversely, the AQ score itself had a significant effect on the So & Varley Lexcial Comprehension Test (So & Varley, 1991) scores (F (2, 11) = 22.407, $p < .05$).

Error Pattern in the So & Varley Lexical Comprehension Test

Subjects' errors made in the Lexical Comprehension Test can be categorised as tonal, semantic and segmental errors. The error pattern of different subject groups is illustrated in Figure 2.

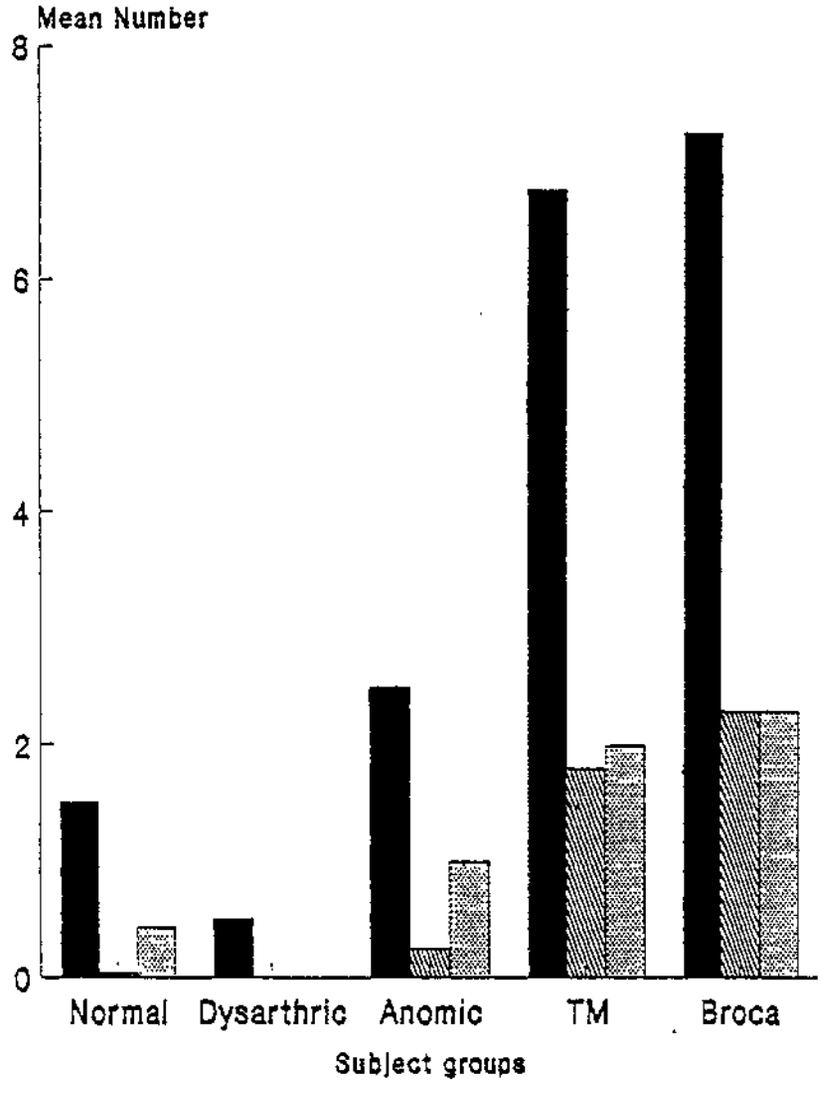

Figure 2. Error pattern on the So & Varley Lexical Comprehension Test (So & Varley, 1991).

Across all error types (tonal, segmental and semantic), all aphasic types made more errors than either the normal or dysarthric group. Errors made by the normals and dysarthrics were predominantly tonal errors while segmental and semantic errors were almost negligible in number (respectively 13 and one in a total of 1170 responses in normals, none out of a

total of 78 responses in the dysarthric group). The error pattern of the anomics was qualitatively similar to that of the normals: most of the errors were tonal ones while semantic error had the least number. The other two aphasic groups (Transcortical Motor and Broca's) also made a greater number of tonal errors compared with semantic and segmental ones. However, within both groups, the semantic and segmental errors made were quite similar in number.

Relationship between tonal perception deficts and the presence of general comprehension disorders

This was evaluated by comparing the aphasics' performance in the tone identification task with performances in the So & Varley Lexical Comprehension Test (So & Varley, 1991) and the auditory comprehension section of the Cantonese Aphasic Battery.

The Pearson product-moment correlation test revealed a high correlation between the scores in the tone identification task and So & Varley Lexical Comprehension Test (So & Varley, 1991) (r = 0.7781 , df = 10 , $p < .01$). The Pearson product-moment correlation test was also used to compare subjects' performances in the Tone Identification Test and the auditory comprehension section of the Cantonese Aphasic Battery, a high correlation coefficient which is significant at a .01 level was revealed (r = 0.7248 , df = 10 , p .01).

DISCUSSION

Nature & Extent of Tonal Perception Deficits in Aphasics

Results in the tone identification task revealed that the aphasics as a group and all the three individual aphasic types performed significantly poorer than the normal and brain-damaged non-aphasic (dysarthric) groups. The dysarthrics

were not significantly different from the normal subjects. Among the aphasic subjects, the overall aphasic severity rather than aphasic type affects subjects' performance in tone identification. These suggest that tonal perception problem is a consequence of language pathology after damage to the language-dominant hemisphere which, in most right-handed subjects, is the left cerebral hemisphere. The finding of impairment in tonal perception in Cantonese aphasics with unilateral left-hemisphere damage is compatible with the results of Van Lanker & Fromkin (1973, 1978) dichotic listening studies on the perception of Thai tones. Van Lancker & Fromkin (1973) found that normal Thai speakers show a right ear advantage when the pitch difference was linguistically processed. Their results coupled with the present study clearly indicate that the perception of pitch contrast is lateralised to the left hemisphere when the pitch variations serve to minimally distinguish words for native speaker of a tone language. The finding of a tone perception deficit in left brain-damaged Cantonese aphasics is also compatible with the hypothesis that the left hemisphere is dominant for analytic processing. It is assumed that linguistic processing is an analytic mental activity (Gandour & Dardarananda, 1983). Thus, Cantonese aphasics with left unilateral brain damage in this experiment exhibited tonal perception deficits on the perception of tones present in a linguistic context.

Inspection of the confusion matrices of different subject groups revealed that both the normal and dysarthric subjects easily confuses level tone with level tone, rising tone with rising tone and level tone with falling tone.

These findings were similar to those in Fok (1974). Fok (1974) claimed that normal subjects' confusions were confined to tones with similar Fx patterns: high rising tone was easily confused with low rising tone and the mid level tone was easily confused with the low level tone. Also, the low falling tone and low level were confused with one another as the level tones were in fact slightly falling (Fok, 1974). Similar to the those found in the normal and dysarthric subjects, most of the tonal confusions made by the anomics were on tones with same or similar contour patterns. In addition, the anomics also confused tones with similar fundamental frequency heights. This suggests that both fundamental frequency height and contour pattern of tones are susceptible to disruption in aphasics.

The TM and Broca's groups are discussed together since previous analysis indicated their performance in the tone identification task were not significantly different from one another. Besides, their confusion matrices were very similar qualitatively. Both groups made a significant number of confusions in the tone pairs which were also difficult for the other three subject groups (i.e. between tones with similar contour patterns). However, the overall performance of these two aphasic groups were abnormal in the sense that their identification were very random - tonal confusions involved almost every tone. They were unable to identify consistently any of the six tones. Fok (1974) suggested that Cantonese speakers perceived tones in terms of separate features or dimensions (fundamental frequency height and contour pattern) in making their identifications. If the normals had perceived each tone as a unitary whole, then upon making a

mistake, they should have been as likely to guess one tone as any other. The later condition was exactly what happened in these two aphasic groups. Their performance revealed that all the six tones were more or less equally likely to be confused with one another. The ability to analyse tones into seperate features for identification seems to be degraded in these two aphasic groups. In therapy, one might explore the possiblility of providing tonal cues for the aphasic subjects who have problems in this area. One might supply cues as to whether a particular word presented has a high level tone, a low rising tone and so on. However, since most native Cantonese speakers lack the explicit metalinguistic knowledge of the structure of Cantonese tones, one might need to assess this before attempting therapy. In summary, all aphasics have tonal perception impairment but the degree of impairment varies with aphasic severity. For the more severe aphasics (TM and Brocas - since they have lower AQ scores), the ability to analyse tones into seperate features (fundamental frequency heights and contour patterns) for identification is impaired. They tend to perceive each tone as a unitary unit and hence all tones are more or less equally likely to be confused with one another. The less severe aphasics (anomics - having higher AQ scores) demonstrates ability to analyse tones into seperate features, nevertheless, they easily confuse tones with similar fundamental frequency heights and contour patterns. This suggests that both the frequency height and contour pattern are susceptible to dusruption. The fact that aphasic type has no effect on aphasics' performance in the tone identification task can be seen as an evident against the syndrome approach in

aphasia which describes a unique set of aphasic behaviours in terms of a syndrome (e.g. Broca's aphasic. Wernicke's aphasic. etc.) while individual differences are neglected. It is important to consider individual differences while describing aphasic behaviours. It is important to consider other parameters such as the overall aphasic severity.

Regarding the overall rank order of individual tones, the anomic group had a rank order pattern significantly different from that of the TM and Broca's aphasic groups. The patterns of the TM and Broca's aphasics were not significantly different from one another. This might suggest that the six different Cantonese tonese were not perceived as having similar difficulty level by different aphasic subjects. Despite this, further inspection of the rank order patterns revealed that for all the subject groups, tone 1 (high level) and tone 4 (low falling) had consistently high (rank 1 and 2 respectively in normal, dysarthric and anomic groups; rank 1 and 3 respectively in T.M. and Broca's groups) mean identification scores. The high level tone and low falling tone respectively have the highest and lowest relative pitch values among the six Cantonese tones. This may suggest why these two tones are so prominent to the subjects during the identification task. This may also suggest that perhaps the tones occupying the two extreme ends of the register of the voice range are more easily recognised and hence more robust to disruption after damage to the language dominant hemisphere.

Relationships between Tonal Perception Deficits and the presence of general Comprehension Disorders

Having identified that tonal perception dificits is evident in aphasics, this section aims to evaluate any possible

relationship between tonal perception deficits and the presence of general comprehension disorders. This was done by comparing aphasic subjects' performances in the tone identification task which was primarily a measure of tonal perception difficulties with performances in two other tests: the So & Varley Lexical Comprehension Test (So & Varley, 1991) and the Auditory Comprehension section of the Cantonese Aphasic Battery. The So & Varley Lexical Comprehension Test (So & Varley, 1991) assessed subjects' comprehension of lexical items while the auditory comprehension section in the CAB assessed comprehension at the single word, sentential and spontaneous speech levels.

Aphasics' performance in the So & Varley Lexical Comprehension Test (So & Varley, 1991) reveals that lexical comprehension is disrupted as a result of aphasia and this ability was correlated to overall aphasic severity. Quantitatively, the Spearman product-moment correlation test revealed a high and significant correlation between aphasics' scores in the Tone Identification Test with those in the So & Varley's Lexical Comprehension Test. Qualitatively, error patterns identified in the Lexical Comprehension Test revealed that, despite the presence of other distractors such as semantic and segmental ones, the errors made by all the aphasics were predominantly tonal errors. This might suggest that tonal perception is particularly susceptible to disruption compared to perception of semantic and segmental information during the lexical comprehension processing. There was also a high correlation between aphasics' performances in the tone identification task and the auditory comprehension section of the CAB. However, this correlation was lower

($\underline{r}$ = .7248 vs. $\underline{r}$ = .7781) than that between tone identification scores and scores in the So & Varley Lexical Comprehension Test (So & Varley, 1991). This is understandable since: while phonological processing is the major pre-requisite in lexical comprehension, comprehension at sentential and conversation levels is a much more complex procedure. Besides processing at a phonological level, subjects had to process other linguistic and extra-linguistic information such as previous language knowledge, integration of segmental information, interpreting the contextual cues and so on. All these put a high cognitve demand on a subject during comprehension at sentential or spontaneous speech levels.

Conclusion/Further Investigation

The present study has provided information about the nature and extent of tonal perception impairment in Cantonese-speaking aphasics, and the relationship between tonal perception deficits and the presence of general comprehension disorders in aphasics.

This information is valuable for the understanding of the nature of phonological processing disruptions and the source of auditory comprehension deficits in aphasics. It is valuable for designing treatment targets directed to the area of deficit. For example, if tonal perception rather than semantic deficits is contributing to auditory comprehension disorders, if would be more effective to target therapy at tonal perception.

The present study is only a small-scale one. Because of time constraint, only a limited number of subjects were included. For further research in this area, inclusion of

more varieties of aphasic types such as Wernicke's and Conduction aphasics would help to substantiate the present findings that subjects of different aphasic types do not behave significantly different from one another. Moreover, inclusion of right brain-damaged subjects would be valuable to test out the hypothesis that tone perception is specific to subjects with damage in the language-dominant hemisphere. Besides, as a complete test of Van Lancker and Fromkin's (1978) hypothesis that the linguistically processed pitch contrast is lateralised to the left hemisphere, one can study aphasics' perception of pitch contrast in a non-linguistic context such as musical notes of different frequency levels. If the hypothesis is valid, then the aphasics should have intact ability in perceiving tonal contrast in the non-linguistic context because such information is processed in the right hemisphere. It would also be interesting to study the relationship between tonal perception and production abilities in aphasics. Research comparing the perception and production of phonological units can help to evaluate the concept of parallelism in aphasiology which claim that deficits in comprehension will closely parallel those in production independant of the linguistic task, since both processes are governed by a central language system (Lesser, 1989). The results of such findings would be of great implication to the rehabilitation of tonal perception in aphasics.

ACKNOWLEDGEMENT

I would like to thank the following people who have given advice and help in completing this study.

First thanks go to my supervisors, Professor Ann Zubrick and Dr. Harrison, for their valuable comment on the design of the research.

Thanks to Dr. S. F. Lam and Ms. Lena Mak of the MacLehose Medical Rehabilitation Centre for their help in providing brain-damaged subject for the experiments.

Thanks to Ms. Polina Chan for her assistance in arranging brain-damaged subjects in the Tang Chi Ngong Polyclinic.

I also owe thanks to all the normal and brain-damaged subjects who have participated in the study.

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