The Stress Pattern and Its Acoustic Correlates in Beijing Mandarin

M.C. Lin, J.Zh. Yan, G.H. Sun
Beijing, the People's Republic of China

1. Introduction

Chinese is a tone language, and it also has the feature of stress in syllable-groups (including words and phrases) and sentences. Phonemically, only three different degrees of stress are found: weak stress (i.e. neutral tone), normal stress and contrastive stress.

2. The perceptual result of normal stress

Actually, the syllables in syllable-groups that have neither neutral tone nor contrastive stress do not have the same degree of phonetic stress. The stress in such syllable-groups is defined as normal stress.

In our experiments, 103 two-syllable groups were pronounced with normal stress by m1 and f1 and 154 three-syllable groups were spoken by m2 and f2. The normal stress in the speech sounds of the two-syllable groups and of the three-syllable groups was judged by 8 listeners and by 7 listeners (all phoneticians) respectively.

Figure 1 shows the probability distribution histogram on the perceptual result of normal stress in the two-syllable groups judged by 8 listeners. From Figure 1 we can see that in 103 two-syllable groups, there were 95 groups pronounced by m1 and 92 groups done by f1 in which the second syllable was judged as having the normal stress by the great majority of 8 listeners.

8 students of linguistics were asked to pronounce the same two-syllable groups and judge normal stress of his or her own speech sounds. The perceptual results of normal stress are represented in Figure 2. Figures 1 and 2 identically demonstrate that the second syllable was judged by the great majority of the listeners as having normal stress.

Some scholars claimed that the contrast between the second syllable and the first syllable with normal stress does exist in such two-syllable groups like 工事 'fortification' vs. 攻势 'offensive', 报到 'register' vs. 报道 'report', 公鸡 'cock' vs. 攻击 'attack', 散步 'take a walk' vs. 散布 'spread', 生气 (v.) 'get angry' vs. 生气 (n.) 'vitality'. In order to verify this claim, we put these two-syllable groups into sentences. They were then pronounced by m1 and f1. The results show that the second syllable was often judged as having normal stress by our informants. We conclude that in two-syllable groups, normal

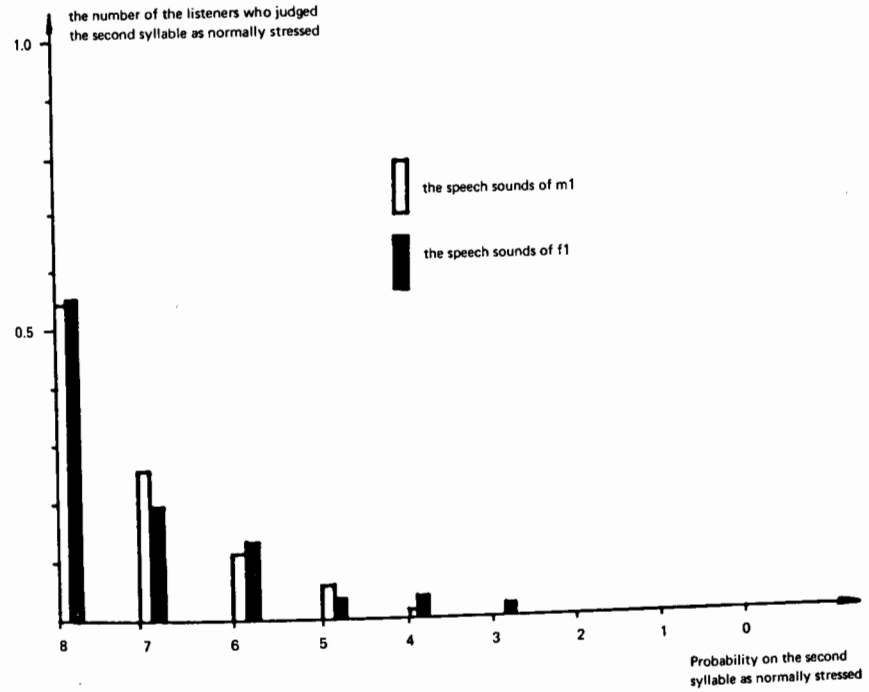

Figure 1. Probability histogram on the perceptual data by 8 phoneticians.

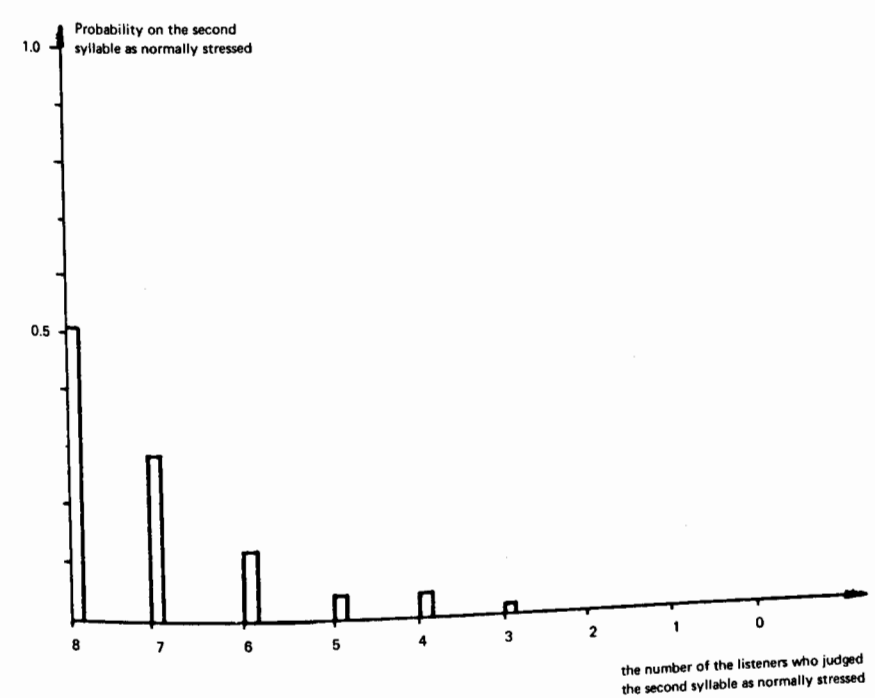

Figure 2. Probability histogram on the perceptual data by 8 students.

stress usually occurs on the second syllable. It is also the case that there is no such a two-syllable group in which the first syllable carries normal stress.

In three-syllable groups, normal stress is usually on the last syllable. Which is more stressed, the first syllable or the second one? The judgement is not consistent.

3. The acoustic data on normal stress

Figure 3 indicates the relative distribution of syllable duration in the two-syllable groups. There were 71 groups pronounced by m1 and 84 groups by f1 in which the duration of the second syllable was longer than that of the first one. Correlation coefficients of .82 for m1 and .80 for f1 were found between the normal stress and syllable duration.

Figure 4 shows the relative distribution of syllable duration in the three-

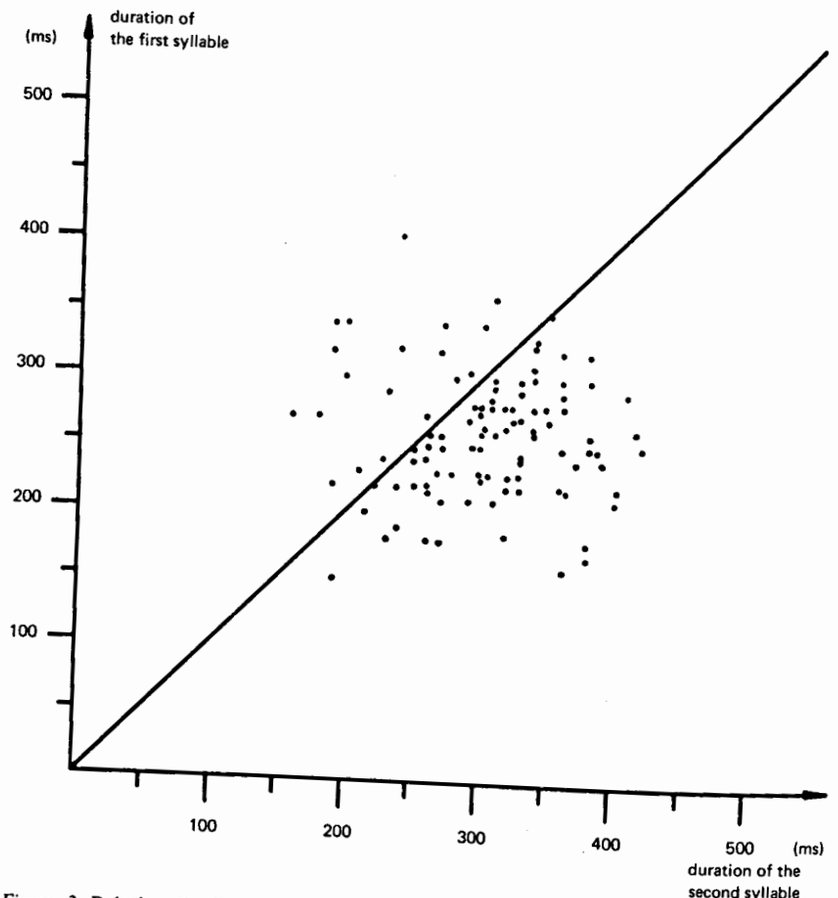

Figure 3. Relative distribution of the syllable duration in two-syllable groups by m1, f1's is similar to m1's.

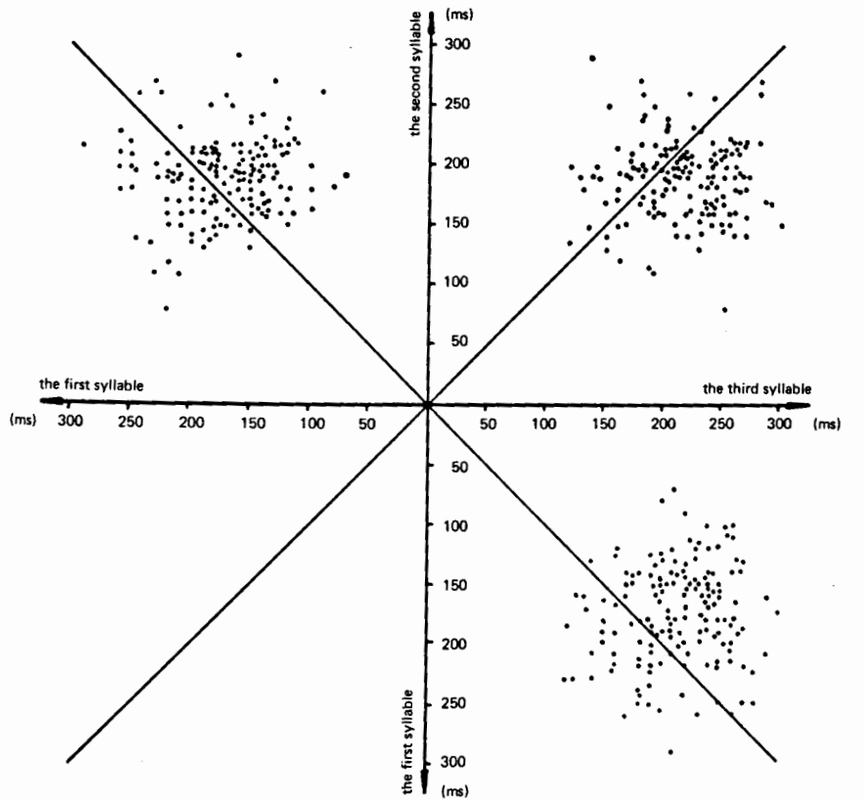

Figure 4. The relative distribution of the duration in three-syllable groups by m2, f2's is similar to m2's.

syllable groups. The duration in the great majority of the third syllables is longer than that of either the first one or the second one, not only for m2 but also for f2. It must be pointed out that the duration in the majority of the second syllables is longer than that of the first one.

The peak intensity in the second syllable in the great majority of the two-syllable groups or in the third syllable in the great majority of the three-syllable groups is not higher than that of the first one or the preceding ones. This can be seen in Figures 5 and 6.

The pitch contour of the last syllable in the two-syllable groups or in the three-syllable groups frequently approximates the tone pattern of the syllable in isolation. But there is a variation between the pitch contour of the first syllable in the two-syllable groups and that of the first two syllables in the three-syllable groups and their standard tone pattern. These facts are illustrated in Tables 1 and 2, in which the average pitch for each syllable is given.

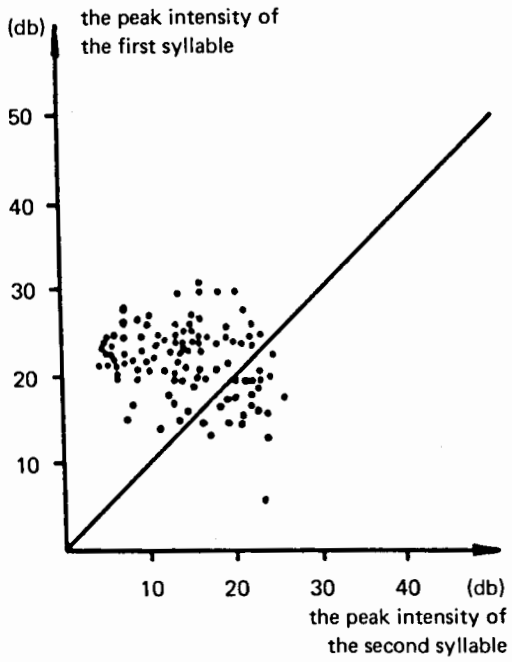

Figure 5. The relative distribution of the peak intensity in two-syllable groups by m1, f1's is similar to m1's.

From the above analysis, it is concluded that in a syllable group the last syllable is the syllable with the normal stress. The acoustic correlates of normal stress are given below: the pitch contour of the syllable with normal stress approximates its tone pattern in isolation; its duration is longer; as for peak intensity, it takes little part in normal stress.

4. The acoustic properties of neutral tone

The acoustic characteristics of neutral tone (cf. Lin and Yan, 1980) will be presented here briefly. A syllable with neutral tone loses the original tone pattern of the syllable, and the duration is shortened by an average of 50%, compared with the stressed syllable. When a syllable is pronounced with neutral tone, the tongue position of the main vowel more or less shifts toward that of the central vowel. But its peak intensity is not always decreased. These results come from the acoustic data of 29 minimal stress pairs, for example, 东 西 'east and west' vs. 东 ·西 'thing', 兄 弟 'brothers' vs. 兄 ·弟 'younger brother', 莲 子 'lotus seeds' vs. 帘 ·子 'curtain', 火 烧 'to burn' vs. 火 ·烧 'baked wheaten', 老 子 'the philosopher Lao-zi' vs 老 ·子 'a father' and 大 意 'main paints' vs. 大 ·意 'careless', etc. In each of these pairs, the three constituents (the initial, the final and the tone) of the first syllables are the same, but the second syllables, with identical initial and final constituents, can be

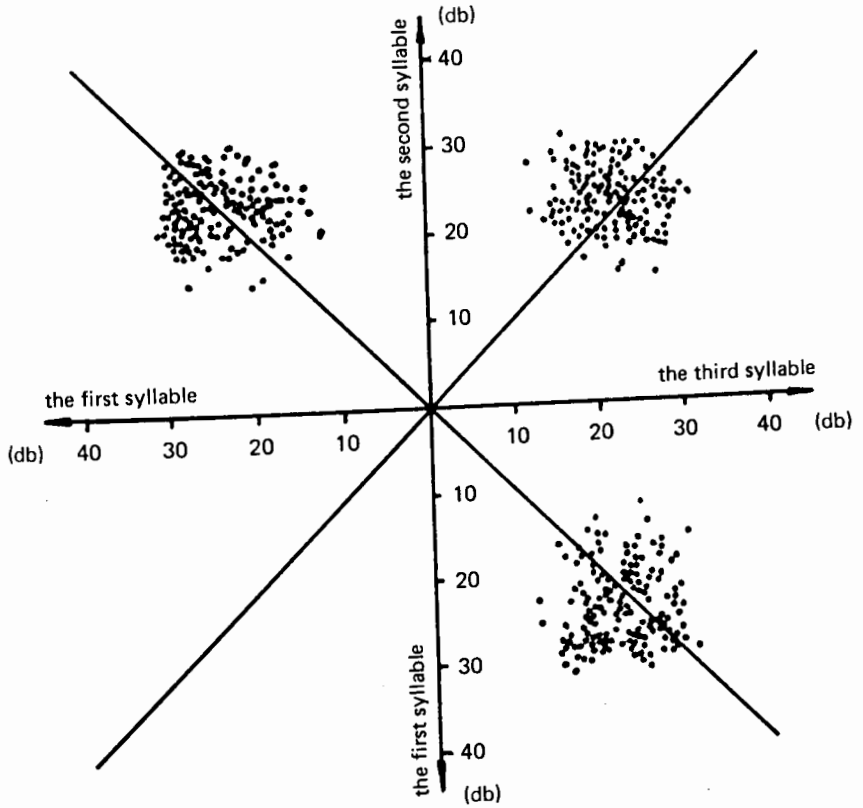

Figure 6. The relative distribution of the peak intensity in three-syllable groups by m2, f2's is similar to m2's.

pronounced with normal stress or neutral tone. To mark a neutral tone, a dot has been placed before the Chinese character.

As for the contrastive stress, it implies that an emphasis is put on some syllable or syllable-group.

Table 1. The average pitch* and its tone in two-syllable groups

m speaker		tone arrangement	f speaker	
the average pitch and its tone			the average pitch and its tone	
the first syllable	the second syllable		the first syllable	the second syllable
178-179*	174-170	tone 1 + tone 1	221-221	224-222
55**	55		55	55
194-195	122-165	tone 1 + tone 2	225-226	170-219
55	35		55	35
188-189	128-83-115	tone 1 + tone 3	224-225	168-92-147
55	312		55	312
188-187	192-87	tone 1 + tone 4	228-229	252-131
55	51		55	51
138-187	179-179	tone 2 + tone 1	176-249	243-241
35	55		35	55
134-192	118-158	tone 2 + tone 2	174-240	171-224
35	24		35	35
135-199	125-90-124	tone 2 + tone 3	169-243	127-92-139
35	313		35	112
114-179	190-90	tone 2 + tone 4	171-240	262-126
25	51		35	51
141-112	158-163	tone 3 + tone 1	178-147	224-225
42	44		32	55
144-109	112-167	tone 3 + tone 2	178-147	155-228
42	25		32	25
118-190	118-86-121	tone 3 + tone 3	167-247	149-93-135
25	213		35	211
131-99	181-87	tone 3 + tone 4	187-149	242-134
31	51		42	51
189-109	157-157	tone 4 + tone 1	231-149	220-226
52	44		52	55
196-110	100-154	tone 4 + tone 2	231-155	158-212
52	14		52	35
196-110	104-82-114	tone 4 + tone 3	242-152	143-82-156
52	212		52	212
210-113	179-90	tone 4 + tone 4	250-165	234-130
52	51		53	51

* Pitch = fundamental frequency (Hz).
** The value on the five-point scale.

Table 2.1. The average pitch and its tone for tone 3 + tone 3 in three-syllable groups

m speaker			tone arrangement	f speaker		
the average pitch and its tone				the average pitch and its tone		
the first syllable	the second syllable	the third syllable		the first syllable	the second syllable	the third syllable
166-166 55	159-163 55	110-70-103 313	tone 1 + tone 3 + tone 3	205-200 55	180-191 55	139-112-142 313
123-162 35	154-156 55	111-77-107 312	tone 2 + tone 3 + tone 3	142-196 35	185-200 55	138-107-138 313
123-158 35	124-104 32	158-154 55	tone 3 + tone 3 + tone 1	154-193 45	138-131 32	181-181 55
137-161 45	134-109 43	113-139 34	tone 3 + tone 3 + tone 2	150-200 35	154-111 41	119-159 24
132-159 45	159-161 55	103-73-102 212	tone 3 + tone 3 + tone 3	150-185 35 135-132 32	185-189 55 132-200 25	138-102-138 313
120-158 35	133-96-118 413	144-77 51	tone 3 + tone 3 + tone 4	138-185 35	150-107-123 312	199-107 51
118-108 52	123-154 35	116-72-92 311 103-103 22	tone 4 + tone 3 + tone 3	208-138 53	154-193 45	138-92-131 312

Table 2.2. The average pitch and its tone for tone 2 on the second syllable with tone 1 or tone 2 on the first syllable in three-syllable groups

m speaker			tone arrangement	f speaker		
the average pitch and its tone				the average pitch and its tone		
the first syllable	the second syllable	the third syllable		the first syllable	the second syllable	the third syllable
160-155 55	134-157 45	153-151 55	tone 1 + tone 2 + tone 1	188-186 55	176-183 45	179-179 55
158-154 35	144-152 55	116-147 35	tone 1 + tone 2 + tone 2	207-185 55	191-198 55	140-188 35
156-156 55	146-158 55	108-86-99 212	tone 1 + tone 2 + tone 3	200-200 55	174-190 45	138-87-126 312
158-158 55	133-157 45	166-79 51	tone 1 + tone 2 + tone 4	200-200 55	163-198 45	208-100 51
123-169 35	147-157 55	159-159 55	tone 2 + tone 2 + tone 1	146-200 35	173-204 45	208-212 55
124-159 35	159-164 55	124-159 35	tone 2 + tone 2 + tone 2	149-207 35	189-191 55	133-180 35
123-162 35	144-154 55	110-85-118 313	tone 2 + tone 2 + tone 3	152-208 35	197-213 55	108-92-138 313
122-154 35	138-154 45	159-77 51	tone 2 + tone 2 + tone 4	46-196 35	62-200 45	215-85 51

Table 2.3. The average pitch and its tone (excluding tone 3 + tone 3) in three-syllable groups

	tone	tone 1	tone 2	tone 3	tone 4
	speaker	the average pitch and its tone			
the first syllable	m	159-158 55	124-161 35	120-113 33	161-105 52
	f	201-198 55	146-196 35	151-134 33	206-132 52
the second syllable	m	159-158 55	133-156 45	115-86-106 312 125-101 32	157-101 52
	f	198-200 55	161-194 45	156-111-124 312 147-117 32	201-121 52
the third syllable	m	157-154 55	117-150 35	109-80-111 213 74-89 12	163-81 51
	f	187-187 55	133-180 35	135-98-133 315	203-104 51

References

Lin, M.C. and Yan, J.Zh. (1980). Acoustic Characteristics of Neutral Tone in Beijing Mandarin, *Dialect*, **3**, August 1980 (in Chinese).