ABSTRACT
This study conducts a psycholinguistic experiment using the concept-formation paradigm to probe perception of tones across different syllable types. Native-speaking subjects were trained to perceive tonal identities in Taipei Taiwanese and then tested with novel tokens comprising checked versus non-checked pairs to see if comparable tonal values across distinct syllable types are categorized as ‘having the same tone’. The results of our experiment indicate that ‘tonal identity’, like other concepts formed by human categorization, has its fuzzy edges. Extracting and establishing tonal identity becomes increasingly difficult as syllable structures become more different.

SUBJECT KEYWORDS
Psycholinguistics, Concept-formation experiment, Taiwanese, Tonal categorization

1. INTRODUCTION
If a linguist working on a tone language discovers that the tone value (i.e. pitch register and contour) of a certain checked syllable (i.e. one that ends in a stop coda) is the same as, or very similar to, that of a non-checked (henceforth: smooth) syllable, is s/he dealing with two separate tones or just a single tone? This turns out to be a much more complicated phonological issue than it appears at first blush. To begin with, there is a striking phonetic distinction between checked and smooth syllables in terms of duration: checked tones are normally very short and abrupt. Hence it seems natural that checked tones should sound qualitatively different from smooth tones. However, does this justify treating a non-tonal property of syllable-type (checked vs. smooth) or duration (short vs. long) on a par with normal tonal properties having to do with modulations of fundamental frequency (cf. Gandour 1983:150)? There has been a deep-rooted Chinese phonological tradition
that regards checked syllables exactly as a distinct kind of ‘tone’ namely the
so-called ‘entering tone’ (入聲), in paradigmatic contrast with the smooth-syllable
tones. The tradition is so tenacious that many modern Chinese linguists adhere to it
without questioning its adequacy (Tung et al. 1967, Zhang 1983, Chen 1987). Since
quite early on, however, this convention has been called into question by some
scholars (Forrest 1973:65, Wang 1958:102, footnote 4, for a most definitive
statement of this position, see Zong 1984); others have further proposed to directly
subsume checked tones and smooth ones of comparable tonal values under the same
Interestingly, there is also a case of the same linguist shifting, in an interval of six
years, from the ‘reductionist’ position back to the conventional one (Cheng 1968,
1972). Apparently, what motivated him to change back to the more traditional
categorization is the fact that checked tones often behave differently in tone sandhi
from smooth tones, even if their citation tone values are comparable. This view,
quite unrelated to conformity to time-honoured phonological traditions, reflects a
characteristic concern of orthodox generative phonology to look beyond surface
contrasts and capture generalizations at the systematic phonemic (i.e.
morphophonemic) level. Similar arguments have been raised concerning whether or
not, for example, the final [–t] in Rad ‘wheel’ in German belongs to the ‘same
phoneme’ as the final [–t] in Rat ‘advice’. The answer, of course, depends on what
one’s definition of the phoneme is; that is, whether one refers to taxonomic or
systematic phonemes (or, for that matter, tonemes). Given the increasing evidence
that surface phonemic contrasts represent true intuitions whose psychological reality
can be probed via experimental means (Jaeger 1980), it may serve us well to
temporarily put aside the issue of tonal morphophonemics (i.e. sandhi behavior) and
find out first of all if some checked and smooth tones belong to the same unit of
surface taxonomic tonemes. Yet another factor further complicates the issue. In many
tone languages in the world, tonal contrasts are either absent or drastically reduced in
checked syllables. Checked syllables thus form environments where tones are
neutralized. A Praguvian or Firthian phonologists would therefore probably frown
upon any attempt to directly equate entitles in an environment of neutralization with
entitles outside of that environment. However, it has been shown that native speakers
can indeed phonemicize ‘archiphonemes’. Jaeger (1986:221-4) reports that subjects
in her concept formation experiments clearly categorize the [k] after initial [s-] in
English with the /k/ phoneme. Read (1971) draws the same conclusion from studying
the spontaneous spellings of preliterate English-speaking children. So,
paper-and-pencil analyses aside, can external evidence be found to show whether
native speakers categorize checked tones with smooth tones of comparable tonal qualities? In other words, do checked tones intuitively represent distinct percepts in speakers’ tonal categorization?

To seek tentative answers to these questions, a psycholinguistic experiment was conducted in this study using the concept-formation experimental paradigm, which has proven to be an extremely valuable tool in linguistic research (Jaeger 1986; Wang 1996, 2001). The basic assumption behind concept-formation experiments is that people have in their minds categorical concepts that can be brought to consciousness by being trained to inductively arrive at the desired category via guided discrimination between positive and negative tokens of that category. They can then be asked to apply the concept formed in this tacit fashion to judge the membership status of new stimuli whose categorization is at issue, and finally to try to verbalize the concept involved. The basic objective of this study is then to train subjects to perceive tonal identities in the target (i.e. their native) language, and then to test them with novel tokens consisting of checked versus smooth syllable pairs to see how these disputed cases are categorized.

2. THE TARGET LANGUAGE

The target language explored in this study is a variety of southern Min spoken in urban Taipei (henceforth TT, for Taipei Taiwanese). The following is a synopsis of the phonological system of this variety of Taiwanese:

(1) Initials:
\[
/p/, /ph/, /b/, /m/, /l/, /th/, /n/, /l/, /ts/, /s/, /k/, /g/, /h/
\]

(2) Finals:
(a) open non-nasalized finals
\[
/a/, /i/, /u/, /e/, /o/
\]
\[
/ai/, /au/, /ui/, /i/au/, /ia/, /io/, /ue/
\]
\[
/iau/, /uai/
\]
(b) nasalized finals:
\[
/á/, /ú/, /ó/
\]
\[
/áú/, /úú/, /iu/, /íu/, /úá/, /íá/
\]
\[
/íáu/
\]
(c) finals with consonantal codas:
\[
/ap/, /am/, /at/, /an/, /ak/, /a/, /ip/, /im/
\]
\[
/it/, /in/, /ik/, /i/, /ut/, /un/, /ok/, /oŋ/
\]
\[
/ut/, /uan/, /iap/, /iam/, /iat/, /ian/
\]
\[
/iak/, /ian/, /iok/, /iön/
\]
(d) syllabic nasal finals:
\[m/, \eta/\]

(3) Tones:

(a) non-checked tones:

<table>
<thead>
<tr>
<th>Tone Class</th>
<th>Value (Citation)</th>
<th>Value (Sandhi)</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yin Ping</td>
<td>high level 44</td>
<td>mid level 33</td>
<td>/to44/'knife’刀</td>
</tr>
<tr>
<td>Yang Ping</td>
<td>mid rising 24</td>
<td>low falling 21</td>
<td>/to24/’picture’圖</td>
</tr>
<tr>
<td>Yin Shang</td>
<td>high falling 53</td>
<td>high level44</td>
<td>/to53/’island’島</td>
</tr>
<tr>
<td>Yin Qu</td>
<td>low falling 21</td>
<td>high falling 53</td>
<td>/to21/’jealous’妒</td>
</tr>
<tr>
<td>Yang Qu</td>
<td>mid level 33</td>
<td>low falling 21</td>
<td>/to33/’surname’社</td>
</tr>
<tr>
<td>Yin Ru</td>
<td>mid falling 31</td>
<td>high falling 53</td>
<td>/to31/’table’桌</td>
</tr>
</tbody>
</table>

(b) checked tones:

<table>
<thead>
<tr>
<th>Tone Class</th>
<th>Value (Citation)</th>
<th>Value (Sandhi)</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yin Ru</td>
<td>mid falling 31</td>
<td>high level44</td>
<td>/kut31/’bone’骨</td>
</tr>
<tr>
<td>Yang Ru</td>
<td>mid level 33</td>
<td>low falling 21</td>
<td>/kut33/’slippery’滑</td>
</tr>
</tbody>
</table>

The phonology of TT outlined above is very simple in comparison with other varieties of southern Min. With special reference to the tone system, the following characteristics are noteworthy.

(1) The citation Ru tones are quite stable in their tonal qualities; thus Yin Ru is always mid falling 31, while Yang Ru is always mid level 33. The striking variation patterns reported in Tung 1967:17-18 are not observed in my own limited survey of TT speakers.

(2) In tone sandhi, the Yin Ru tone exhibits a split: Yin Ru syllables that used to have the \(\text{-}\) Coda change from mid falling 31 to high falling 53 (e.g. /\text{a}21 \text{pe}31/ 阿伯 ‘father’s elder brother’ → /\text{pe}53 \text{k0}44/ 伯公 ‘grandfather’s elder brother ’); whereas checked Yin Ru syllables change from mid falling 31 to high level 44 (e.g. /\text{pai}21 \text{kut}31/ 排骨 ‘spareribs’ → /\text{kut}44 \text{thau}34/ 骨頭 ‘bone’). Historically, this split seems to be a compensatory change conditioned by the loss of \(\text{-}\) in word-internal environments; similar splits in the Yin Ru tone class have been noted in many other varieties of Southern Min (Tung 1960:741,796,853; Ting 1970: 39).

(3) The syllables that etymologically should end in \(\text{-}\) have become open syllables in this variety of Taiwanese. One of the important phonological consequences of the loss of \(\text{-}\) is that open syllables belonging to the Yin Ru tone class have inherited a distinct tonal value (same as that found on checked syllables of the Yin Ru tone class), namely mid falling 31. In other words, a six-way tonal contrast
in open-syllable citation forms has evolved in TT, with *three contrastive falling tone contours*. Consider the following minimal triplets:^7

<table>
<thead>
<tr>
<th>Yin Shang:</th>
<th>Yin Ru:</th>
<th>Yin Qu:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ka⁵³ ‘grind (meat)’</td>
<td>pa⁵³ ‘full 飽’</td>
<td>pa³¹’hundred 百’</td>
</tr>
<tr>
<td>‘yín’</td>
<td>‘yín’</td>
<td>‘yín’</td>
</tr>
<tr>
<td>ka³¹ ‘cover 蓋’</td>
<td>pa³¹’hundred 百’</td>
<td>pa²¹’soundrel 霹’</td>
</tr>
</tbody>
</table>

3. THE EXPERIMENT

3.1 Methodology

We see from the above description of TT tones that the *Yang Ru* and *Yang Qu* tones share the same tonal value (mid level⁵³), whereas the *Yin Ru* tone value (mid falling ³¹) is similar but not identical to those of two smooth tones, *Yin Shang* (high falling ⁵³) and *Yin Qu* (low falling ²¹). These particular tones were chosen to be the focus of this study. Specifically, we aimed in this experiment to train linguistically naïve speakers of TT to inductively acquire the concept ‘having the same tone’; we subsequently gave them a test to find out if they perceived *Yang Ru* and *Yang Qu* tones as belonging to the same toneme while at the same time categorized *Yin Ru* differently from both *Yin Shang* and *Yin Qu* tones.

3.1.1 Subjects

There were altogether eight subjects, four males and four females, all young adult native speakers of Taiwanese from Taipei, roughly between the ages 25 and 33. They were selected from a larger group of graduate students and/or spouses who have lived at Taipei throughout most of their lives; the screening was done via a brief interview the purpose of which was to make certain that a potential subject’s speech indeed contained the TT tone system described above. This screening process reduced greatly the number of potential subjects but was considered absolutely necessary, because we knew from personal experience that many Taiwanese speakers in metropolitan Taipei have parents from other localities of the island, and hence would have been using at home varieties of Taiwanese that are tonally different from TT.^8

3.1.2 Design of the Recorded Stimulus Tape

In constructing the stimulus tape, the *word-pair format* was used (cf. Jaeger 1986: 227-228). The stimuli in both the learning and the test sections consisted of pre-recorded pairs of (mostly) disyllabic compound words. For each pair, the two compounds were spoken once, followed by a repetition of the final syllables in each word. Take the following pair for example,
The recorded sequence was

\[
\text{sio}^{33} \text{ tsiu}^{53} \rightarrow \text{gia}^{21} \text{ tshiu}^{53} \rightarrow \text{tsiu}^{53} \rightarrow \text{tshiu}^{53}
\]

Subjects were asked to compare and make a judgement on the tonal identity of the two repeated final syllables. There were 25 pairs of words in the learning section designed to gradually teach the concept ‘sameness of tone’ regardless of segmental differences. This was done by presenting positive tokens (those bearing the same tone) with increasingly different syllable structures. Thus we proceeded from complete syllable-wise identity (\(\text{hu}^{33}--\text{hu}^{33}\)), to partial identity (\(\text{tsiu}^{53}--\text{tshiu}^{53}; \text{tsap}^{31}--\text{tsat}^{31}\)) and finally to markedly dissimilar syllables (\(\text{liam}^{33}--\text{li}^{33}\)). For negative tokens (those bearing different tones), we kept segmental differences to a minimum to help subjects concentrate on tonal distinctions. Feedback (‘same’ or ‘different’) was provided in the five-second interval after each pair. In the subsequent test section, we recorded another 25 similar word pairs with no feedback, including 13 test tokens and 5 control tokens, intermingled with 7 filler tokens of the type presented in the learning section. The control tokens contained new contrasts not encountered in the learning section that exhibited even greater divergence in syllable structure, such as syllabic nasals (/\(\text{m}^{53}\)--/\(\text{liau}^{42}\)/), nasalized versus oral vowels (/\(\text{s}^{\tilde{1}u}^{33}\)--/\(\text{siu}^{33}\)/), and a bare vowel nucleus versus an initial plus a triphthong (/\(i^{12}\)--/\(\text{siau}^{42}\)/)

A few words about the motivation behind this design are in order. First of all, the advantage of presenting tokens in terms of compound words or short phrases rather than monosyllables is that the former have uniquely identifiable meanings while bare monosyllables could lead to confusion since they more often than not involve homonymy and lexical ambiguity. We therefore presented these phrases or compound words first and then repeated the target syllables embedded in them, hoping that in this way it would be easier for subjects to listen actively and subjectively (instead of passively and objectively) and make perceptual judgements by directly activating their own mental lexicon and phonology. On the other hand, because of pervasive tone sandhi phenomena, most syllables in Taiwanese carry two tonal values, namely the citation and sandhi tones. It is possible, as Hsieh 1976 argues, that rather than having one stored and the other derived by rule, both tonal values may be stored in the mental lexicon. In order to counter this problem of
‘two-valued images’, we had done three things to make sure subjects always thought only of the citation value for any given syllable: (1) present the stimuli in spoken rather than written form; (2) restrict the desired tokens only in final position; and (3) repeat the final syllables in each pair. There are some other reasons why we decided not to present stimuli in written characters. The influence from orthography has been the most serious factor affecting the results of many psycholinguistic experiments on the phonology of languages with alphabetic writing systems (Jaeger 1980:250). The Chinese writing system is based on a combination of phonograms and ideograms, and thus only indirectly related to the actual sounds represented. However, the potential problems with using written characters in our case are (1) Taiwanese has until recently remained an unwritten language, thus most Taiwanese speakers find it difficult to associate Chinese characters directly with spoken Taiwanese words, even when their cognacy with Mandarin Chinese is straightforward. The difficulty is compounded by the many common spoken words in Taiwanese of obscure etymological origin, with no conventionalized characters to unambiguously represent them. (2) Taiwanese being a typical southern Chinese dialect with an intricately stratified lexicon, many characters come to have both colloquial and literary readings. For example, the colloquial reading of the character ㄆ ‘three’ is [sə¹⁴] while the literary is [sam⁴⁴]. So given all of these factors potentially at play, subjects would most probably have been helplessly baffled if they had been asked to arrive at phonological percepts of TT by means of stimuli presented in written Chinese characters.

3.1.3 The Procedure

The experiment was run without the use of any other equipment than the tape recorder. Due to practical problems, we were unable to get together all of the subjects and conduct the experiment all at once. Instead, the experiment was done separately on an individual or small-group basis, the location in most cases being our own apartment. Efforts were made, however, to strictly follow a uniform procedure.

First of all, subjects were distributed blank answer sheets, one for the learning and the other for the test section. They were instructed to wear headphones and listen to the pre-recorded tape. At the beginning of the tape, they heard the following instructions:

INSTRUCTIONS

The following perception experiment aims to discover some properties of the sound system of Taiwanese. In this part, you will be listening to 25 pairs of spoken words in Taiwanese. After each pair of words is read, we will repeat for you
each of the final syllable 33 of the two words. Please try to judge whether these two syllables contain a certain kind of 'sound identity' in your own speech. At the end of each pair there will be a five-second pause, then we will give you our answer. If the pair of syllables in question contains the particular sound identity you will hear 'SAME' otherwise you will hear 'DIFFERENT'. Your job is to gradually figure out what this particular kind of sound identity is. After you have acquired some idea about the nature of this identity, please begin to respond during the five-second pause after each pair. Respond by circling ‘SAME’ or ‘DIFFERENT’ on the correct column of your answer sheet corresponding to the number of the word pair you have just heard, and check your response with the correct answer provided later on the tape. When your responses gradually match completely the answers we give on the tape, you know you have succeeded I accurately identifying the sound identity we have in mind. If your responses are different from the answers on the tape, please try to adjust your working hypotheses until you get successive correct answers.

Part 1: Learning Section

1. sa131 hu33 ‘master’
2. lau31 kui33 ‘glutton’
3. sio31 tsiu53 ‘strong liquor’
4. lao21 ho33 ‘rain (v.)’
5. aŋ21 tau43 ‘red bean’
6. tsa21 tshau33 ‘graze’
7. bua42 hun53 ‘apply face-powder’
8. ui44 khot32 ‘to feel wronged’
9. ba42 hu53 ‘dried meat’
10. kun44 tsui53 ‘boiled water’
11. tsi31 lu33 ‘very hot’
12. aŋ21 khi53 ‘red persimmon’
13. tsa44 tʃ21 ‘breakfast’
14. tsiɔnj44 ku44 ‘lottery ticket’
15. mai42 tʃap22 ‘ignore’
16. iu44 hau21 ‘be filially pious’
17. hui21 tap32 ‘answer’
18. thau21 hia33 ‘forehead’
19. kan33 kho33 ‘suffer’
20. su31 liam33 ‘miss’
21. kam33 tʃo33 ‘licorice’
22. pue42 tiam53 ‘eight o’clock’

1. tau21 hu33 ‘bean curd’
2. kui21 kui33 ‘affluence’
3. gia21 tʃiu53 ‘raise hand’
4. sai33 hu33 ‘master’
5. baŋ44 tau21 ‘mosquito net’
6. tʃiu33 ku53 ‘very long’
7. uan42 hun53 ‘resent’
8. pai21 kʃt32 ‘spareribs’
9. tʃi54 hu53 ‘government’
10. tsu44 tsui21 ‘drunk’
11. to33 sia33 ‘thanks a lot’
12. tʃui22 khi53 ‘tooth’
13. kin44 tʃ 53 ‘hurry back’
14. kau33 ku41 ‘picky’
15. iu41 tʃat32 ‘paint’
16. tʃau33 ‘ineffective’
17. si53 tʃan4 ‘watermelon juice’
18. tʃiu33 kau53 ‘very thick’
19. tʃi53 kho21 ‘warehouse’
20. sia44 li33 ‘write characters’
21. tʃo21 ‘be jealous’
22. po51 tʃua53 ‘newspaper’
23. uan\textsuperscript{42} to\textsuperscript{21} ‘be viciously jealous’
24. iau\textsuperscript{42} kin\textsuperscript{53} ‘important’
25. ak\textsuperscript{21} ku\textsuperscript{33} ‘maternal uncle’

tsap\textsuperscript{21} si\textsuperscript{21} ‘fourteen’
kui\textsuperscript{33} ki\textsuperscript{53} ‘discipline’
sio\textsuperscript{33} kun\textsuperscript{44} kun\textsuperscript{53} ‘scalding hot’

Feedback answers:
1. same 2. different 3. same 4. same 5. different
6. same 7. different 8. same 9. same 10. different
11. same 12. different 13. different 14. same 15. same
16. different 17. same 18. same 19. different 20. same
21. different 22. same 23. same 24. same 25. different

After the subjects reached our pre-determined criterion ‘20 trials in a row with two or fewer errors’, we proceeded immediately to the test section with the newly acquired concept still fresh in the minds of our subjects. Through the headphones, they then heard the following instructions for the test section:

Now, we are going to give you a little test. Likewise, you will hear another 25 pairs of spoken Taiwanese utterances. Each pair may or may not contain the same ‘sound identity’ you just figured out. You should answer just as you have been doing. However, this time we will not tell you whether your answer is correct or not. You will only hear the number, the pair of utterances, and the two repeated final syllables. Then we will pause to give you ample time to make your response. Please base your judgements on what you learned about this ‘sound identity’ from the previous practice and respond as accurately as you can. When you have finished answering one pair, please signal to us to proceed to the next pair by nodding your head.

Part 2: Test Section

1. ba\textsuperscript{53} hu\textsuperscript{53} ‘dried meat’
2. o\textsuperscript{33} bak\textsuperscript{33} ‘black ink’
3. ko\textsuperscript{44} ue\textsuperscript{63} ‘talk’
4. tai\textsuperscript{21} liok\textsuperscript{33} ‘mainland’
5. tsit\textsuperscript{21} pa\textsuperscript{31} ‘one hundred’
6. su\textsuperscript{35} liam\textsuperscript{33} ‘yearn, miss’
7. pho\textsuperscript{53} i\textsuperscript{63} ‘sofa’
8. tsai\textsuperscript{53} sik\textsuperscript{32} ‘colour’
9. kha\textsuperscript{44} hat\textsuperscript{32} ‘threaten’
10. lau\textsuperscript{21} hu\textsuperscript{53} ‘bleed’

tau\textsuperscript{21} hu\textsuperscript{33} ‘bean curd’
bin\textsuperscript{33} ba\textsuperscript{33} ‘dream (v.)’
tsir\textsuperscript{33} ue\textsuperscript{33} ‘very narrow’
guan\textsuperscript{21} lo\textsuperscript{33} ‘forgive’
tsi\textsuperscript{21} pa\textsuperscript{53} ‘be full (satisfied)’
tsi\textsuperscript{21} liap\textsuperscript{33} ‘a piece of’
kh\textsuperscript{44} sia\textsuperscript{53} ‘go mad’
tai\textsuperscript{21} uan\textsuperscript{21} si\textsuperscript{42} ‘Taiwan’
h\textsuperscript{33} han\textsuperscript{21} ‘rare’
ith\textsuperscript{44} hu\textsuperscript{53} ‘bandit’

(D) (D) (S) (TEST) (TEST) (D) (TEST) (TEST) (C) (TEST) (D)
3.2 Results and Discussion

Of the eight subjects who participated in this experiment, only one failed to form the correct category, which is tonal identity or ‘the same tone’. Her responses to the test section will therefore excluded from the statistics below. Of the seven subjects who succeeded in forming the category, five requested help during the learning section. Most of the help requested was repetition of some tokens or explanation as to what we meant by ‘sound identity’. Some of our subjects had misunderstood their task, thinking they were supposed to judge whether the pronunciations of the stimuli were identical to theirs or not. After we clarified what we really wanted them to do, they were all able to follow the learning section and reach criterion (20 trials in a row with two or fewer errors) toward the end of the learning section.

The responses to the stimuli in the test section are shown in the Table below:

<table>
<thead>
<tr>
<th>Stimuli Number</th>
<th>Correct Responses</th>
<th>Incorrect Responses</th>
<th>N</th>
<th>%Correct Responses</th>
<th>%Incorrect Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>#3</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>#5</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>83%</td>
<td>17%</td>
</tr>
</tbody>
</table>
It turned out that most of our subjects were able to correctly perceive tonal identity of the above filler words. When we double-checked with the subjects that gave the few wrong answers, they had no problem recognizing their mistakes and attributed them to inadvertence.

Table 2: Responses to Control Tokens, Test Section

<table>
<thead>
<tr>
<th>Stimuli Number</th>
<th>Correct Responses</th>
<th>Incorrect Responses</th>
<th>N</th>
<th>%Correct Responses</th>
<th>%Incorrect Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>#7</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>#14</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>#16</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>#20</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>#23</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>71%</td>
<td>29%</td>
</tr>
</tbody>
</table>

The control tokens in the test section all consisted of tonally identical pairs of syllables. As expected, the greater differences in segmental structure of these tokens led to higher percentages of incorrect tonal identification. It is worthy of note, for example, that three out of seven subjects judged the tones of the syllabic nasal /ŋ/ in number 20 to be different from /t/ in number 20 to be different from /t/ in number 20 to be different from /t/ in number 20 to be different from /t/, apparently because the overall dissimilarity of syllable types exerted some interference on the correct perception of tonal identity. Incidentally, most subjects later recognized their errors upon hearing the tokens more attentively for a couple of times and asked that their responses be corrected accordingly.

Table 3: Responses to Test Tokens, Test Section

<table>
<thead>
<tr>
<th>Stimuli Number</th>
<th>Correct Responses</th>
<th>Incorrect Responses</th>
<th>N</th>
<th>%Correct Responses</th>
<th>%Incorrect Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>#2</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>#4</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>#6</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td>#8</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>29%</td>
<td>71%</td>
</tr>
</tbody>
</table>
Tokens number 2,4,6 and 11 aimed to test tonal identity of checked versus smooth mid level (⁸³) tones. All in all, subjects’ judgements here seem to split between positive and negative identifications (16 positive versus 12 negative responses, or 57% versus 43%), although a slightly more percentage of responses favour positive identifications. Similarly, token 21 is of special interest since this pair dealt with a smooth (open-syllable) mid falling tone (/pa₃¹/ ‘hundred’ < /pa₃¹/ ultimately from *pak) with a checked mid falling tone (/khak₃¹/ ‘shell’) 83% of the responses positively identified these two tones. On the other hand, tokens number 8,9, and 13 tested perception of potentially different checked mid falling (⁸³) and smooth high falling (⁵³) tones. Here exactly two thirds of the responses (14 out of 21 or 75%) show negative identification. Likewise, tokens number 15, 17, 22 and 24 tested how subjects would identify checked mid falling (⁸³) and smooth low falling (²¹) tones. Again, an even greater majority of responses favoured negative identification (23 out of 28 or 82%).

Category Name and Discovery Strategies
At the interview phase of the experiment, we requested the subjects who successfully formed the concept to name and describe the ‘sound identity’ that they learned to discriminate. Most of them mentioned terms like yǐndiào 音調 ‘tone of voice’, shēngyīn gāodi 音音高低 ‘height of voice’ or musical concepts like yǐnjué 音階 ‘musical scales’; two subjects even came up with sophisticated English terms like ‘intonation’ and ‘tone’. It is clear, then, that for speakers of tone languages the concept of tone is highly accessible to consciousness and quite easily codable. We then consulted them whether they used any strategies to help them arrive at tonal categorizations. Some reported that they drew on their explicit knowledge of Mandarin tones (which is part of the educational background of all educated Taiwanese). Many told us they found it useful to iconically trace the registers and directions of tones by moving their hands in the air.¹³ One female subject was able to completely extract the tone melodies from the rest of the syllable by humming to herself the tones of the tokens she heard on the tape. No wonder she responded
accurately to all of the filler and control tokens, and, importantly, it is also she who categorized the test tokens entirely in accordance with our expectations; namely, the checked (Yang Ru) and smooth (Yang Qu) mid level\(^{13}\) tones as one and the same tone and the Yin Ru (mid falling\(^{31}\)), Yin Shang (high falling \(^{53}\)), and Yin Qu (low falling\(^{21}\)) as three distinct tones.

However, when we consulted with subjects who perceived checked and smooth mid-level tones as different, they were generally quite reluctant to modify their first judgements. Most of them were able to perceive phonetic identity of these two types of syllables in terms of pitch height and contour, yet almost unanimously they would point out that checked syllables ‘sounded so short’, hence incompatible with smooth tones having the same pitch value. Some of these subjects were, unfortunately, not consistent in this kind of judgement, since we can see from Table 3 above, two of the subjects who categorized /bak\(^{33}\)/ and / baN\(^{33}\)/ (token pair#2) as belonging to different tones positively responded to the tonal identity of /liam\(^{33}\)/ and /liap\(^{33}\)/ (token pair #6).

5. CONCLUSIONS

This experiment is probably one of the first attempts to probe tonal perception and categorization by means of the concept formation paradigm. What is of special interest is that the target language in this case study is an unwritten language whose speakers are nevertheless literate in a related language that in turn uses a logographic writing system. We have seen that although our subjects were not subject to the same orthographic influences as literate speakers of languages with alphabetic writing systems would, care must be taken in designing the presentation of the stimuli so that other potentially tempering factors (tone sandhi, lexical stratification, etc.) could be reduced to a minimum.

In general, the results of this experiment suggest that divergent syllable structures definitely affect tonal identification. This is evident from the response patterns of the control tokens vis-à-vis the test tokens we have seen above. It seems true that the concept of ‘tonal identity’, like all other concepts formed by human categorization, has its fuzzy edges. When the syllable structure becomes increasing different, particularly when other prosodic features like duration are also involved, it becomes increasingly difficult to extract and thereby establish tonal identity. Thus, although our results do not directly support the view that speakers readily categorize checked and non-checked tones with similar register and contour as the same phonemic tone, they do not rule this out as a possibility. Recall that there was indeed a slight majority of responses (16 out of 28 or 57%) that positively identified the checked (Yang Ru) with the smooth mid level (Yang Qu).
There are several ways to follow up on this experiment in the future. We would like, first of all, to recruit more participating subjects to increase the significance of the statistics. We also think that the lack of prior experiences in manipulating multiple tonal distinctions in checked syllables (a neutralizing environment!) may also contribute to the difficulty in identifying tones across syllable types (checked versus smooth). So, for instance, if subjects learn to extract the six smooth TT tones by humming (a strategy used effectively by one of our subjects) and then to try applying and perceiving these tones in checked syllables before they are asked to do the same test, would identifiability with smooth tones improve? It would also be enlightening to work on tone languages (such as Cantonese and Tai-Kadai languages) in which vowels contrast in length in checked syllables, to see if subjects can more readily identify long checked tones and smooth tones of comparable values. These are some areas well worth looking into in future experiments.

Our experiment, despite the restricted scope and uncertainties that remain, has produced meaningful hints toward resolving the tonemicization controversy raised in the beginning of this paper. This, in turn, demonstrates the potential usefulness of the concept-formation experimental paradigm in finding empirical support for linguistic claims.

APPENDIX I

Tone Sandhi Rules Involving Paradigmatic Neutralization in Taipei Taiwanese

(1) Tone sandhi before the diminutive suffix /-a^53 (仔):

Rule (1.a) Non-falling tones → mid level~mid rising tone

Examples:

<p>| | | | | |</p>
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<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>YIN PING</strong></td>
<td>kam^44</td>
<td>→</td>
<td>kam^24</td>
<td>a^53 仔 ‘orange’</td>
</tr>
<tr>
<td><strong>YANG PING</strong></td>
<td>ü^24羊</td>
<td>→</td>
<td>ü^24a^53羊仔 ‘sheep; goat’</td>
<td></td>
</tr>
<tr>
<td><strong>YANG QU</strong></td>
<td>pʰ^33鼻</td>
<td>→</td>
<td>ph^24a^53鼻仔 ‘nose’</td>
<td></td>
</tr>
<tr>
<td><strong>YANG RU</strong></td>
<td>ap^33盒</td>
<td>→</td>
<td>ap^24a^53盒仔 ‘box’</td>
<td></td>
</tr>
<tr>
<td></td>
<td>io^33藥</td>
<td>→</td>
<td>io^24a^53藥仔 ‘drug’</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tsʰio^33席</td>
<td>→</td>
<td>ts/io^24a^53席仔 ‘mat’</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tsio^33石</td>
<td>→</td>
<td>tsio^24a^53石仔 ‘pebble’</td>
<td></td>
</tr>
</tbody>
</table>
(2) Tone sandhi of first syllables of three-syllable elaborate expressions:

Rule (2.a): Non-falling tones → mid rising tone
Examples:
- **YIN PING** sio^44^4 ^v^33^33^33^33^33
  → sio^24^24^24^24^24^24
  'hot'
- **YANG PING** a≥^24^24^24^24^24^24
  → a≥^24^24^24^24^24^24
  'red'
- **YANG QU** ta^33^33^33^33^33
  → ta^24^24^24^24^24^24
  'heavy'
- **YANG RU** tit^33^33^33^33^33
  → tit^24^24^24^24^24^24
  'straight'
- **pe^33^33^33^33^33**
  → pe^24^24^24^24^24^24
  'white'

Rule (2.b) Falling tones → copy of tone value of second syllable (regular sandhi value):
Examples:
- **(YIN) SHANG** te^42^42^42^42^42^42
  → te^44^44^44^44^44^44
  'short'
- **YIN QU** sue^33^33^33^33^33
  → sue^33^33^33^33^33
  'small'
- **YIN RU** siap^31^31^31^31^31
  → siap^44^44^44^44^44
  'astringent'
- **kʰua^31^31^31^31^31**
  → kʰua^33^33^33^33^33
  'wide'

APPENDIX II:
Experimental Instructions: Chinese Version

說明 (INSTRUCTIONS)
第一部分：觀念學習 (Part 1: Concept Learning)

以下這個語音辨別實驗，目的在幫助我們瞭解台語語音系統上的某個特點。首先，我們請你聽二十五組台語語詞。當每組語詞念完後，我們會再把該組的兩個字重複念一次，請你練習辨別這兩個字是否有相同字的相同性。接下來，會有五秒鐘的問隔時間，然後我們會告訴你我們的答案；如果這兩個字具有我們心目中的這種語音相同性，你會聽到【相同】；相反，你會聽到【不同】。你所做的，就是逐漸辨別出這種語音特點來。當你聽過幾組語詞，漸漸對這個特點有了概念之後，請試著在關係時間之內根據你的判斷開始作答。作答的方式是：在答案紙正確題號之右圈選【相同】或【不同】，然後再和錄音帶上的答案核對。當你的答案與錄
NOTES

1. Another popular reason for maintaining the ‘checked tones’ as a separate tonal category is that this treatment facilitates recognition of patterns of diachronic tonal developments and synchronic tonal correspondence between related languages. For example, in the Zhuang language spoken in China, the phonetic pitch values of the historical tone class 7 (checked) is identical to that of tone class 5 (smooth) at Wuming 武鸣 but that of tone class 3 (smooth) at Tiandong 田東. So, keeping the checked tone as a separate category helps to simplify tonal correspondence rules across Zhuang dialects (Ouyang 1979:361). The problem then is, given the trade-off, whether it is justifiable to sacrifice synchronic analytical adequacy for expediency in diachronic/ comparative descriptions.

2. On the other hand, we have extensive evidence that two other major sandhi rules in TT can be stated in most general and revealing terms only if the distinction between checked and smooth tones is disregarded. Both sandhi rules involve neutralization of tonal contrasts. One applies to syllables before the diminutive suffix/-a^53/, the other applies to the first syllable of a reduplicated three-syllable elaborate expression. For both rules, the only relevant dimension has to do with pitch contour, regardless of syllable type. For all non-falling tones, including the high level (44), mid level (33), and mid rising (24) smooth tones as well as the checked mid level (33) tone, neutralization leads to uniform mid rising (24) tone. All falling tones, including the low falling (11), high falling (55), and mid falling (33) smooth tones, as well as the mid falling checked tone, behave exactly alike: they all neutralize to high level (44) before the diminutive suffix/-a^53/, while the first syllable of three-syllable elaborate expressions simply copies the tone value of the second syllable (which has the regular sandhi tone value). What is important is that generalizations are stated
here without mentioning any non-pitch information such as duration or syllable structure (checked versus smooth). For concrete examples of these two intriguing tone sandhi rules see Appendix I.

3. The southern Min dialect in Taiwan (often known as Taiwanese) is far from internally uniform. Several varieties spoken in different areas on the island can be recognized. And it would be easy to falsify the statement “... there isn’t any difference between the values of citation tones in Zhangzhou 蕃州腔 and Quanzhou 泉州腔 varieties (of Taiwanese)” (Zhang 1983:12). For information on the distribution and linguistic differences between these varieties, see Ang 1992. The most comprehensive study of northern Taiwanese to date is Tung et al. 1967, which was based mainly, but not exclusively, on the speech of a female Taipei resident. Important differences between TT and the conglomerate variety reported in Tung’s monograph are noted below. For information regarding TT, I have relied heavily on my wife Shuchen Chang, who is a fluent native speaker of TT. Since she was obviously too biased as regards the content and objectives of the study she did not serve as one of the subjects of this experiment, so as to avoid the pitfalls of self-fulfilling predictions. I am indebted to her for her painstaking assistance in designing and implementing the entire experiment, and for supplying me with consistent and clear judgments and insightful observations.

4. In Shuchen’s speech, the two finals /iat/ and /ian/ underwent monophthongization and became /et (n)/.

5. In this paper, the Chao tone letters are used (1 = low pitch, 5 = high pitch) for indicating tonal values. Traditional labels are used for names of tonal classes; they reflect the four Middle Chinese tones: Ping (Level), Shang (Rising), Qu (Going), and Ru (Entering), together with a later phonologically conditioned split into higher (Yin) and lower (Yang) registers. Synchronize, these tone class names are supposed to be classificatory, rather than descriptive, labels.

6. In the speech of Yîlân 宜蘭, very close to that of Lôngxî 龍溪 (linguistically akin to Zhângzhōu 漳州 described in Tung 1960, the glottal stop coda has dropped in the Yang Ru but are still pronounced in the Yin Ru words (Prof. Paul Ren-Kui Li, personal communication).

7. Cf. Ting 1982:634 for the similar development of a new open-syllable tone (high level) in the Chêngmài 澄邁 dialect of southern Min spoken in Hainan.

8. The major divergences among tone systems of most varieties of Taiwanese have to do with the sandhi-ed Yang Ping and the checked tones.

9. While the rules determining tone sandhi are subject to complicated syntactic conditioning (Chen 1987), for our purposes we can just work with the simplified principle that a syllable assumes a citation tone in isolation and pre-pausally, and a
sandhi tone elsewhere.

10. Good examples would be /sui⁴¹/ ‘beautiful’ or / tsia³³/ ‘eat’.

11. For the Chinese version of these two sets of instructions actually recorded and used in the experiment, see Appendix II.

12. We did not use the technical term yīnjié 音節 ‘syllable’; instead, we chose the non-technical and neutral term zì 字, which may refer to ‘word’, ‘syllable’, or ‘written character’.

13. In the learning and especially test sections, we also observed many subjects unconsciously moving their fingers in the air with the rises and falls of the pitches they heard.

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台灣閩南語聲調的歸類：一個概念形成的個案研究

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台灣中央研究院

題要
本文採用概念形成實驗法，進行一項檢驗舒促音節聲調感知之心理語言實驗。通過訓練台北地區閩南語母語人士分辨聲調異同，並使其參與辨識音節舒促不同之錄音樣本，以探索受試者是否將其歸類為「同調」。試驗結果說明，正如人類形成其他概念一樣，「同調」概念也具有模糊性。音節結構差別愈大，建立「同調」概念便愈為困難。

關鍵詞
心理語言學，概念形成實驗，台灣閩南語，聲調歸類