CHAPTER FIVE

EXTRALINGUISTIC TENDENCIES IN RHYTHMIC PARSING

1.0 INTRODUCTION[1]

Stress imposes rhythm on language and by doing so raises questions about the relationship between rhythm in language and rhythm in other domains. Some recent versions of metrical theory are based on claims about this relationship. Recall from chapter one that the modifications of metrical theory proposed in Hayes (1987) are in part motivated by claims about the nature of extralinguistic parsing. Hayes (1987: 286) notes that the proposed templates are "in a sense 'designed' to satisfy the law of iambic and trochaic rhythm." This law says that "iambic rhythm inherently involves uneven duration, with long, more prominent elements last; whereas trochaic rhythm involves even duration" (ibid.). It is also noted there that this law can be demonstrated if "subjects listen to a sequence of beeps that alternate either just in duration or just in intensity, and are asked to group the beeps into pairs" (ibid.).

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[1] Although he was not officially a committee member, Kerry Green, Ph.D., of the Department of Psychology at the University of Arizona is responsible for facilitating the transformation of chapter five from an idea into reality. He provided, inter alia, access to the necessary equipment and to the University of Arizona subject pool. For this I am grateful. Tom Bourgois also gave crucial support in the development of this project.

In this chapter, the methodology and results of a study focussing on the "law of iambic and trochaic rhythm" are presented. This is construed as the first study of an emerging program for the replication and extension of work by Woodrow (1909, 1911, 1951), to be discussed below. The research was conducted in the fall of 1990 at the University of Arizona. Its appearance in this dissertation is motivated from two perspectives. First, the theory presented here in chapter one, and illustrated in chapters two and three, is based on a claim that there are right–headed feet which are both even and uneven and that there are left–headed feet which are both even and uneven. In other words, the claim is made that there is a symmetric inventory of foot types; this claim stands in contrast to recent work on the topic of foot inventories. That recent work, as noted, is based on experimental evidence and the inclusion of this study here is therefore partially motivated by the need to reconcile the claim for a symmetric inventory against the experimental evidence.

The second motivation for including this study here is because it facilitates the analysis of other approaches to metrical structure assignment. For example, the law of iambic and trochaic rhythm appears in Hammond (1990) as a crucial component in the analyses of some languages. The presentation of this study, then, is an opportunity to investigate the experimental basis grounding other recent proposals.

The chapter proceeds as follows. The articles by Woodrow are reviewed in §2. §3 presents an outline of the questions to be investigated, the subjects, the materials, and the procedure. The results are presented in §4 and the conclusions in §5. A copy of the instructions for the subjects appears in §6.

2.0 Woodrow (1909, 1911, 1951)

Research on questions related to temporal perception conducted in the early part of this century has enjoyed a recent revival in the context of metrical theory. The specific work focussed on is by Woodrow (1909, 1911, 1951). To provide the context for the study presented in this chapter, Woodrow's work is reviewed here.

Woodrow (1951) includes a section on rhythm which is the source of the generalizations recently taken into metrical theory. It is in this article that Woodrow makes the broad claim that the grouping which a subject will give for a series of stimuli is largely a function of the characteristics of the stimuli. His generalizations are in some cases vague; however, this vagueness accurately reflects his view that there are some subjective factors which affect the grouping. The following quote is typical of Woodrow.

> [W]ith equal temporal spacing, and not too fast a rate, and every second sound louder than the others, the series of sounds tends to be heard in groups of two, with the louder sound beginning the group. (1951: 1232)

The preceding quote claims that subjects hearing a rhythm in which the length of the stimuli is constant and the loudness is varied will judge the pattern to have a trochaic rhythm. Judgements such as "not too fast a rate" are left undefined in this article, as are any specific details about the nature of the stimuli or the extent of the variation and manipulation of the stimuli.

The following quote also comes from Woodrow (1951). Here we find the proposal regarding the connection between iambic rhythm and manipulations of the relative length of the stimuli. Note that all other factors, including the temporal separation of the stimuli are held constant.

> As regards the effect of the relative duration of the stimulus, when intensity and temporal spacing are uniform, if every second sound is longer, the probabilities are in favor of an iambic grouping. (p. 1233)

A third quote from Woodrow (1951) synthesizes the observations and claims of the preceding quotes. His words here are a concise summary of the position which Woodrow reached in his work on this topic.

> We may say that, with equal temporal spacing, a regularly recurring, relatively greater intensity exerts a group-beginning effect, and a regularly recurring, relatively greater duration a group-ending effect. (p. 1233)

Woodrow clearly takes the position that the characteristics of the stimuli will usually affect the grouping which a subject will report for two stimuli. However, the absence of "strongly rhythmical objective characteristics" (p. 1233) opens the door to the influence of subjective factors. These nature of these subjective factors is not explored in his work.

Woodrow (1909) and Woodrow (1911) report earlier research, including detailed discussion of various studies and specific characterizations of the stimuli which were used in those studies. In Woodrow (1911), the effects of pitch on the grouping of series of tones are investigated. An experiment was conducted in which stimuli of three different pitches were presented in different patterns and with different intervals between the pitches. Woodrow shows that varying the intervals between the pitches does affect the perceived pattern, but that the pitch has no predictable effect on the pattern. Based on the results of his experiment, Woodrow (1911: 59) claims that "pitch cannot in the case of a single subject be a reliable or constant determinant of rhythm." Already, in this article from 1911, Woodrow makes unambiguous claims which later emerge as the law of iambic and trochaic rhythm. He states that "[i]ntensity has a group-beginning effect: duration, a group-ending effect: pitch, neither a group-ending nor a group-beginning effect" (1911: 77).

3.0 AN EXPERIMENT

3.1 Motivation/Goals

There are two motivations for this study. The first is to attempt to replicate the claims mentioned in §1 above, namely the claim that elements of uneven duration will be grouped iambically and elements of even duration trochaically. The second motivation is to attempt to identify any patterns and their sources that may emerge with the goal of extending research on rhythm. The technological resources for conducting this research are dramatically more sophisticated than those which Woodrow had available. With the MacRecorder software used in this work, precise manipulations of duration, intensity, and pitch are possible. Patterns can be repeated for subjects without any variation in the pattern. There is no noise generated by presenting the tones. In light of these advancements, the study here should be an improvement on Woodrow's work from the perspective of control of the stimuli.

The study is designed to identify correlations between variations in pitch and length with tendencies to parse a string iambically or trochaically. The broadest goal is to determine whether in fact strings in which prominence is indicated with length are parsed iambically and strings in which prominence is otherwise indicated are parsed trochaically.

3.2 Materials

The study was conducted by presenting subjects with stimuli which were generated using the MacRecorder software. The software allows the generation of strings of tones in which the length and pitch of the tones can be precisely manipulated. Twelve series of tones were presented to subjects. These stimuli had alternating patterns in which pitch or length was varied. Each of the twelve stimuli is described below.

The stimuli can be organized into four groups. Within each group, one stimulus parameter or dimension is manipulated; different parameters are manipulated across groups. Within the first group of three stimuli, the "absolute length" of the tones varies, i.e., the stimuli are strings of tones which are identical in pitch and length. The length is different for each stimulus. The length of the intervening silence equals the length of the tone. In the second group of three, the "relative length" of the tones to one another is varied while pitch and the length of the intervening silence are held constant. In the third group, the length and pitch of the tones is held constant and the relative length of the intervening silence is manipulated. The final group is like the first one insofar as the length of the tones and silence is equal; in this group, two pitches for the tones are used in an alternating pattern.

Group 1, Stimulus #1: A series of tones of .25 seconds each with .25 seconds of intervening silence. All tones were 480 Hz.

Group 1, Stimulus #2: A series of tones of .35 seconds each with .35 seconds of intervening silence. All tones were 480 Hz.

Group 1, Stimulus #3: A series of tones of .15 seconds each with .15 seconds of intervening silence. All tones were 480 Hz.

Group 2, Stimulus #1: A series of alternating tones, half of which were .25 seconds and half of which were .20 seconds. There was .30 seconds of silence between all tones and all tones were at 480 Hz.

Group 2, Stimulus #2: A series of alternating tones, half of which were .30 seconds and half of which were .20 seconds. There was .30 seconds of silence between all tones and all tones were at 480 Hz.

Group 2, Stimulus #3: A series of alternating tones, half of which were .35 seconds and half of which were .20 seconds. There was .30 seconds of silence between all tones and all tones were at 480 Hz.

Group 3, Stimulus #1: A series of tones of .25 seconds each with the intervening silence alternating between .20 seconds and .25 seconds. All tones were at 480 Hz.

Group 3, Stimulus #2: A series of tones of .25 seconds each with the intervening silence alternating between .20 seconds and .30 seconds. All tones were at 480 Hz.

Group 3, Stimulus #3: A series of tones of .25 seconds each with the intervening silence alternating between .20 seconds and .35 seconds. All tones were at 480 Hz.

Group 4, Stimulus #1: A series of tones of .20 seconds each with intervening silence of .20 seconds. The pitch of the tones alternated between 470 Hz and 475 Hz

Group 4, Stimulus #2: A series of tones of .20 seconds each with intervening silence of .20 seconds. The pitch of the tones alternated between 460 Hz and 475 Hz.

Group 4, Stimulus #3: A series of tones of .20 seconds each with intervening silence of .20 seconds. The pitch of the tones alternated between 450 Hz and 475 Hz.

For each stimulus, the order in which the tones were presented was counterbalanced by presenting half of the subjects with long or high tones first in the series and presenting short or low tones first to the other half. Each series had fourteen tones. After the tones and silences were concatenated into the series, MacRecorder's "smoothing" utility was applied. This does not affect the pitch or length, but simply eliminates any "click" at the boundaries between the tones and the silence.

3.3 Subjects

The study was presented to thirteen subjects drawn from the undergraduate subject pool at the University of Arizona. The participants were self–selected and received course credit for their participation. Ten of the thirteen were male; the subjects were between eighteen and twenty years old, with the exception of one who was thirty. All subjects were required to be native speakers of English to control for influence from the stress pattern of the subject's language. An information sheet, completed by all subjects, confirmed that all used English at home; the English spoken by the two subjects who reported knowing Spanish did not show influences of Spanish prosody.

3.4 Procedure

The experiment was conducted in the University of Arizona Speech Perception Laboratory. Subjects were instructed that they would hear a number of stimuli having one of two rhythmic patterns. Either the stimulus would have strong beats followed by weak ones or it would have weak beats followed by strong ones. They were instructed that some of the stimuli would be easier than others and that if they were uncertain, they should make their best guess. In addition, they were instructed to listen to the entire series before presenting their decision and that the series could be played as many times as necessary for them to form a judgement.

The "forced choice" format was used because allowing subjects to answer with a third "uncertain" category raises two problems. With this option, subjects will tend to give an answer only in those cases of which they are certain, so data allowing a determination of which stimuli show stronger or weaker effects would be lost. Secondly, forcing subjects to make a choice may reveal preferences of which the subjects are unaware. If the subjects actually do not have any inclination either way, their answers across the four repetitions for that particular stimulus will be random, resulting in a chance 50% performance.

The subjects reported their decision by tapping the heard pattern on the table in front of them. If they decided that the series was an iambic pattern, they tapped a weak tap followed by a stronger one; if they decided that it was trochaic, they tapped a strong tap followed by a weaker one. The tapping patterns were demonstrated to them. Before beginning with the twelve stimuli described above, two sample stimuli were played and the subjects were asked to tap their decisions about the samples.

Each subject sat in a small testing room containing a Macintosh computer, amplifier and headphones. The subjects sat at a small desk with their backs to the experimenter and the Macintosh computer. The stimuli were presented to the subjects through the amplifier and headphones. The subjects were given the twelve stimuli in four repetitions without intervening breaks. The stimuli were presented in random order within each repetition. The subjects' responses were recorded on an answer sheet, writing "R" (for a "right–headed" constituent) when they identified the second beat as prominent and "L" when they identified the first beat as prominent. The entire experiment last approximately 30 minutes.

4.0 RESULTS

With this study, it was possible to replicate some of Woodrow's results and it was possible to identify some influences of the manipulated variables. Table 1 presents the mean trochaic response across the three tones in each of the four tone groups. The differences across the three stimuli within each of the four groups were analyzed using four one–way within–subject ANOVAs were run on the three tones in each of the four stimulus groups. These ANOVAs revealed no significant difference across the three tones in any of the four groups. (All F's < 1.3, $p > .28$). This is probably due to the fact that the three stimuli within a group varied with respect to the amount of variation along a particular dimension.

	Stimulus 1	Stimulus 2	Stimulus 3
Group 1	59.62	67.31	71.15
Group 2	46.15	38.46	32.69
Group 3	57.69	50.00	59.62
Group 4	51.92	57.69	44.23

Table 1

Because there was no statistical significance between the stimuli in each group, the remaining analyses are based on comparing just one of the stimuli from each of the four groups. The one which is used is the stimulus within each group that had the most extreme manipulation. E.g., in group four it is stimulus number three which had the greatest pitch variation. For groups three and four, the third stimulus had the greatest silence differences and pitch differences, respectively. In group two, the third stimulus had the greatest difference in relative length. For group one, we chose stimulus three because it represents a rate which was closest to that of normal speech (cf. Bell 1977). The mean trochaic response to these four tones is presented in Table 2.

	G1, S3	G2, S3	G3, S3	G4, S3
Mean	71.15	32.69	59.62	44.23

Table 2

As noted above, the stimuli in groups one and three tended to be parsed trochaically and those in groups two and four tended to be parsed iambically. A one–way ANOVA on these four stimuli revealed a significant difference across the four groups. ($F = 4.3$, $p < .01$). Post–hoc analyses (Tukey – HSD) revealed significant difference between G1 and G2 ($p < .01$); G1 and G4 ($p < .05$); G2 and G4 ($p < .05$).

5.0 DISCUSSION

The goals for this study were to attempt to replicate earlier findings and to explore further the relationship between the variables and the patterns.[2]

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[2] The question of why there might be such a relationship between various characteristics and the resulting patterns is a independent question that deserves further reflection. Bjørn Lindblom suggests to me the possibility of a relationship between tendencies for phrase final lengthening and the appearance of the long element at the right edge of the group. He notes that an analysis of the utterance of two syllables with contrasting stress patterns supports this view. Specifically, the comparison of an utterance such as "dá da" with stress on the first syllable to the utterance of the same syllables with stress on the second syllable reveals that the syllables are of similar length when the stress is on the first one, but that the second syllable is longer when the stress is on the second one. Any lengthening involved with stress on the initial syllable is countered by the lengthening of the second, unstressed syllable which follows from its phrase final

The significant difference which was found between group one and group two replicates one of the tendencies which Woodrow claimed. In group one, the stimuli were of even duration and the tendency was to produce trochaic responses significantly greater than chance ($t = 3.66$, $p < .01$). In group two, some of the tones were longer than the others; this resulted in a significantly greater tendency to parse them iambically, compared to the tones in group one. Considering only these two groups, we find support for the "law of iambic and trochaic rhythm" insofar as the trochaic pattern of group one involves even duration while the iambic pattern of group two involves uneven duration.

The stimuli in group three were included in the experiment to determine whether manipulations of the length of the silence between tones could be used to force particular grouping patterns. Recall that the lengths of the tones in this groups were of equal duration and that only the length of the silence was varied. There was no significant difference between the results for group one and the results for group three. From this statistical evaluation, we conclude that manipulating the length of the silence between the tones has little effect on the grouping of those tones, over the silence durations used in this experiment.

The analysis of the responses to group four led to unexpected conclusions, in light of Woodrow's results. There was no significant difference distinguishing the results of group two from those of group four. As noted above, the modifications of relative length in group two lead to an increasing strong iambic

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position. When a syllable is both stressed and phrase final, a significant length contrast with the first syllable is generated.

pattern. In Table 1, the decreasing strength of the iambic pattern across the stimuli in group 2 correlates with a decrease in the difference in the relative length of the stimuli. Because there is no significant difference between groups two and four and because both of those groups are significantly different than group one, we conclude that manipulations of the relative pitches of the tones in the stimuli leads to a significant shift towards iambic groupings. This result does not support the generalizations of the "law of iambic and trochaic rhythm." Recall that this law claims that iambic rhythm inherently involves uneven duration. Yet, the results obtained for group four show that the stimulus for which the pitch variation is the greatest is grouped iambically. This result forces a re–evaluation of the generalizations proposed by Woodrow. First, his claim that pitch has no predictable effect on grouping must be reconsidered. Second, it appears that the manipulation of a variable other than length can lead to an iambic pattern.

This experiment has clarified a number of issues which will be pursued in future research. The variety of stimuli which could be presented in this experiment was constrained to limit the time of the experiment for the subjects and to be able to investigate manipulations within each group. Since these manipulations have been shown to produce no significant differences, future work can present a greater variety of stimuli without using within-group manipulations. There are many potential pattern–influencing characteristics which can be investigate in future studies which will be modelled on the methodology of the present study. The following are some candidates for future research topics.

- Length, pitch and amplitude are the commonly cited correlates of stress in languages and the experiment here has investigated only length and pitch. Future studies must investigate the relationship between amplitude and grouping effects.

- None of the patterns presented in this study involved only independent manipulations of length and pitch. Future research should test for effects due to combinations of the three variables, e.g. lengthening and lowering.

- The results from Group four showed that variations in pitch lead to iambic groupings; one goal of future research is to determine the degree of variation necessary to get stronger tendencies.

- We would also like to present stimuli like those in Group one, but with significantly shorter silences to see if rhythms with timing patterns closer to natural speech reveal any tendencies.

- Language itself must be the basis for future experiments. One of the goals of this research is to determine whether there is any influence from the native language of the subjects on the way which the stimuli are perceived. To investigate this, we will do experiments with subjects whose native languages have different stress patterns than English and with subjects who speak languages which instantiate prosodic variation without stress, e.g., speakers of tone languages.

- Finally, methodologies may be varied, as well as varying the stimuli which are presented within the currently proposed methodology. One alternative methodology may be to use natural speech rather than synthetically generated tones. The speech of a language with a clear rhythmic pattern, or with identifiable combinations of variation in length and pitch could be low–pass–filtered.[3] The result could then be used as a stimulus in a study. This would facilitate further analysis of the cues which are relevant for rhythmic parsing and it would facilitate a comparison of the results of this study to a phonologically motivated perspective on the rhythmic system of the language.

[3] This suggestion was originally put to me by Tony Woodbury.

6.0 APPENDIX: INSTRUCTIONS

This is an experiment on how you perceive the rhythm of tone sequences. In this experiment, you will be presented with sequences of two tones with different durations, amplitudes, or frequencies. We want you to listen to each sequence, and then make a decision about the beat pattern of the alternating tones. For example, one possibility is that you will hear a repeating pattern of a strong beat followed by a weak beat such as the following: ** *Demonstrate on the table* **. The other possibility is that you will hear a weak beat followed by a strong beat such as: ** *Demonstrate on the table* **. *Repeat the two options several times until the subject "hears" the difference.*

Your task is to listen to each sequence and decide which beat pattern best characterized what you hear in the tone sequence. We want you to indicate your choice by tapping out the beat pattern on the table in front of you, in the manner just demonstrated. Either a strong followed by a weak beat, or a weak beat followed by a strong beat.

Each tone sequence will last about four seconds. We want you to listen to the whole sequence, and then tap our your decision. If you want, the sequence can be played again to help you make your decision. For some of the tone sequences, it will be easy to determine the beat sequence. Others, however, will be more difficult. If, after hearing the same sequence several times you are unable to come to a firm decision, just make your best guess.

We will now give you some examples of the tone sequences to practice on.

Practice trials.

Any questions?

We will now start the actual experiment. Remember, wait until you hear the entire sequence before making your decision and tapping out your response. If you can't hear a clear beat sequence, just make your best guess.

Follow–up questions:
1) Did you hear any beat sequences other than the two which you responded with? If so, please tap them out now.

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VITA

Curtis Calvin Rice was born in Johnson City, New York, USA, on July 21, 1962, the son of Calvin and Patricia Rice. After graduating from Mayo High School in Rochester, Minnesota, in 1980, he studied at Augsburg College in Minneapolis. Following his 1984 graduation from Augsburg with a Bachelor of Arts degree in philosophy, he received a Fulbright Grant to begin graduate work in philosophy at the University of Louvain, Belgium. He began studying at the University of Texas in the fall of 1985 to pursue a degree in linguistics. During the summer of 1986, he was a student at the Russian School at Middlebury College and during the summer of 1987 he studied at the Linguistic Society of America's Summer Institute at Stanford University.

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Since May 27, 1989, Curt has enjoyed the inestimable treasure of being married to Tove Irene Dahl, Ph.D., without whom he would not have reached this page.

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