Quantifying Reading Comprehension with Prosody

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Abstract

Prosody in oral reading has been found to correlate with reading comprehension skill, especially in young developing readers. In order to examine this correlation in adults' reading, this study examines the differences in the prosody of four adult readers (two readers with good comprehension and two readers with poor comprehension), with the goal of quantifying this reading skill through prosody. The subjects were all previously recorded reading three stories each which were then labeled using the ToBI framework. Prosodic boundaries, pitch accents, sentence-final intonation contour, and disfluencies were all analyzed for each reader. Results show quantitative differences between readers with different skills even when individual variation exists between readers of the same group, suggesting that reading skill might be able to be diagnosed through the study of an individual's prosody.

1. Introduction

In developing readers, fluency in oral reading has been found in recent studies to contribute to overall reading skill (Rasinski, 1994; Fuchs et al. 2001). This fluency is defined by the National Institute of Child Health and Human Development [NICHD] (2000) as the ability to read quickly, accurately (word decoding), and in the case of oral reading, reading with prosody. However, Kuhn, Schwanenflugel, & Meisinger 2010 define reading fluency more concisely: "Fluency combines accuracy, automaticity, and oral reading prosody, which, taken together, facilitate the reader's construction of meaning. It is demonstrated during oral reading through ease of word recognition, appropriate pacing, phrasing, and intonation. It is a factor, in both oral and silent reading, that can limit and support comprehension." Apart from the more systematic approach to reading fluency by measuring word decoding and speed, the part prosody plays in reading fluency and comprehension is still not clear (e.g. Schwanenflugel, et.al. 2004).

1.2 Prosody and Prosodic Structure in Reading

This study will focus on the prosody produced in reading where both prominence and phrasing, along with some of prosody's correlates such as speech rate, pause, and intonation contour, will be examined.

The term prosody in this paper will refer to the suprasegmental structure in speech that conveys phrasing and prominence. Phrasing happens when an utterance is "chunked" into processable units (Cutler, Dahan, & Donselaar 1997,Frazier, Carlson, & Clifton 2006, Krivokapić 2007a,b)[1] and prominence serves to highlight the focus of an utterance or new information (Bolinger 1972, Halliday 1967)[2]. Phrasing in this prosodic structure[3] can be classified into two distinct categories of units, intonational phrases (IP) and intermediate phrases (iP). Because of the hierarchical nature of this model for prosodic structure, IP and iP are ordered as higher units over lower units, respectively, one branching into (i.e. dominating) the others, as seen in Figure 1 below. In order to be an IP, the unit needs to contain at least one nuclear pitch accent (e.g. most prominent segment), a phrase accent, and a boundary tone. The iPs, on the

[1, 2] As reported in Krivokapić (in press)

[3] The terms and model used to describe prosodic structure will be that of Beckman & Pierrehumbert (1986).

other hand, have to have at least a pitch accent (e.g. prominent segment, not necessarily the most prominent) and a phrase accent.

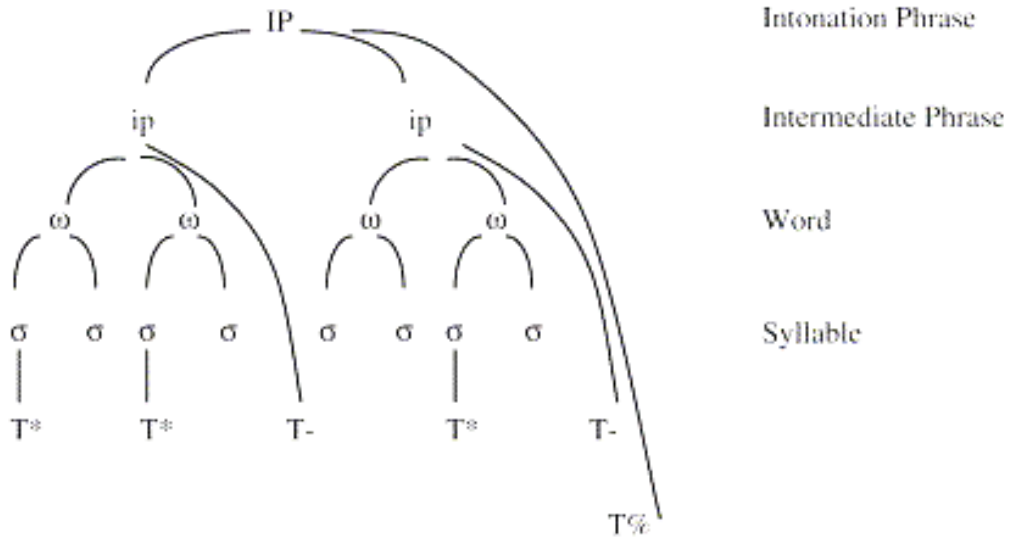

Fig. 1 - Schematic representation of Prosodic Structure. (T* is a nuclear pitch accent, T- is a phrase accent, and T% is a boundary tone.) (Krivokapić, in press)

In this study, we're interested in how these units and its correlates are produced in readers with good and poor oral reading skills. Do they divide their speech into prosodic units differently? Is prominence found in the same places and as many times?

In addition to phrasing and prominence in reading, we will be examining other acoustic correlates of prosody such as duration of speech, speech rate, pauses between phrases, and intonation. In reading, as in speech, duration is affected by stress and speech rate. Typically, stressed words in sentences tend to have longer vowels (Temperlay, 2009), but as Kuhn et al. (2010) notes in a study conducted with children, a child who reads quicker will demonstrate less "stress marking", or prominence marking, and less phrase-final lengthening, which might affect duration of passage reading. This might be attributable to adult readers who experience reading problems. Because of many studies on stress and skilled reading (de Bree, Wijnen, & Zonneveld, 2006; Goswami et al., 2002; Jarmulowicz, Taran, & Hay, 2007; Orsolini, Fanari, Tosi, de Nigris, & Carrier, 2006; Thomson, Fryer, Maltby, & Goswami, 2006; Whalley & Hansen, 2006; Wood, 2006) have noted that skilled reading is related to stress pattern sensitivity in the reader's

language. Kuhn, Schwanenflugel, & Meisinger (2010) then conclude that when monitoring prosody in children's reading familiar stress patterns should be looked at, which can then determine a possible cause for poor reading skill.

Another feature in read speech that we will be examining is pause, specifically of the intrusive, or ungrammatical, kind. Pauses are silences between words and phrases. The slower the speech, the more pauses there will be and also more pausal intrusions (Dowhower, 1987). Pausal intrusions (also including intrusive breath pauses) in this paper will be treated like in Dowhower (1987) which are described as ungrammatically placed pauses dividing a syntactically relevant phrase that should otherwise not be. An example of this is given in (1b), where (1a) is a syntactically appropriate pause and (1b) is an intrusive pause.

(1a) The marmalade is # on the bench.

(1b) The marmalade is on # the bench.

The last two features to observe when looking at prosody in oral reading are phrasing and intonation contour. In this study we will be examining how phrasing and intonation manifests in readers of different reading skills. Pauses are correlated with phrasing, and since pauses tend to mark the end of phrases, inappropriate pausing will lead to inappropriate phrasing. Therefore if there is to be fluency in reading, as described earlier, phrasing would need to be appropriate (Dowhower 1991). When looking at intonation in here we will be focusing on phrase-final intonation contours. The intonation contour is an important feature that affects phrasing. As reported in Dowhower (1991), it is shown that stronger syntactic boundaries are accompanied by more dramatic F_0 phrase-final falls on the final word (Snow & Coots, 1981). Specifically relevant to this paper, because of what we will be looking at, is the fact that there is grammatical information that can be obtained from intonation pattern, such as the default indication of declarative statements in which there is a falling pitch contour.

1.3 Prosody and Reading Comprehension

It is understood that as far as attaining appropriate prosody for children it can be a difficult task when developing their reading skills. Thus their reading in the beginning might sound more like a citation of words. It has been shown that repeated readings aid in developing

fluency (LeVasseur, et.al 2008), where as mentioned earlier prosody plays an important role in. Other studies, such as LeVasseur, et.al (2006), LeVasseur, et.al (2008), and Rasinski (1994), have shown that manipulating the text by chunking it to preserve major syntactic or prosodic boundaries, imitating prosodic reading, helps young readers' fluency. This underlines the importance of prosody in reading fluency. Because of this importance, it can be assumed that there is a link between prosodic reading (a feature in fluent reading) and reading comprehension.

However, since we know fluent reading is not just prosodic reading, more evidence to show how prosody manifests itself with reading skill is needed. Fodor (2002) shows that prosody can be used to disambiguate prosodically ambiguous sentences in silent reading. The latter lends evidence to a link between reading prosody and understanding what is being read. On the other hand, in another study, experiments with children reading conducted by LeVasseur et al. (2006) found no direct or significant indirect link between their prosody and their reading comprehension. Schwanenflugel et al. (2004) conducted experiments where word-decoding and reading comprehension in children were assessed and the suprasegmental features of oral reading (e.g. pauses between units) were measured in young children's reading. They found evidence where faster decoding speed of words contributed positively to reading comprehension, but only minimal evidence was found to show that prosody was an "important mediation" of reading comprehension skill. However, they showed that children with faster decoding speed were more likely to read prosodically than children with slower decoding speed. Does this mean that varying prosody can predict varying reading comprehension skills? Why not just stick with more direct measures of reading comprehension skill (e.g. reading comprehension test)? Fuchs et al. (1988), as reported in Fuchs et al. (2010), found a bigger average correlation between oral reading fluency and reading comprehension than with other direct methods of scoring reading comprehension. The latter serves as evidence that prosody in reading may be predicting reading comprehension.

Other specific evidence in prosody shows that there were more instances of pausal intrusions in children with poorer reading comprehension skills (Eagan, 1975). Some studies that also imply a correlation between prosody and reading comprehension (Clay & Imlach, 1971; Dowhower, 1987) also found that children with greater speed, accuracy, and comprehension in

reading were more likely to produce more "appropriate" phrase-final intonation contours than children who read slower, less accurately and comprehended less.

As shown, most of the aforementioned studies were done on very young developing readers, and there is limited information on how adults' prosody and comprehension of text relates, especially adults with lower reading skills. That is why in the current paper we examined young adults' prosody and how it might vary between readers with different comprehension skills when other factors of reading fluency like word decoding should not be a problem. We will examine whether or not measuring prosody can predict reading comprehension skills, serving as a way of quantifying reading skills. We predict that quantifiable differences will exist between readers of different skill levels. The differences in prosody between readers of different skill levels will be in the form of their phrasing, amount of disfluencies (e. g. hesitations, long pauses, self-corrections), presence and placement of pitch accents, and F_0 phrase-final contour variation between readers.

2. Experiment

2.2 Participants

The four participants whose data is presented in this paper were chosen from a pool of other subjects' data who had been collected for another study by Van Dyke, Johns, & Kukona (in prep). They are all native English speakers from the New Haven, CT area. They were all matched for word decoding skills and chosen for this study because of their different levels of comprehension skills (See Appendix I) determined through The Gray Oral Reading Test (GORT-4), a standardized test for reading skills, in the Van Dyke, Johns & Kukona (in prep) study. Of the four, two are good comprehenders and the other two are poor comprehenders. The good comprehenders are GC77 (22 years old, male, 15 years of school) and GC65 (22 years old, female, 17 years of school), and the poor comprehenders are PC63 (21 years old, female, 11 years of school) and PC74 (17 years old, male, 11 years of school).

2.3 Materials

Recordings

The recordings used in this study were of self-paced readings of the same three short stories (see Appendix II) found in GORT-4.

Gray Oral Reading Test 4 (GORT-4)

This is a standardized test that measures oral reading skills such as the rate (time it took to read a story), accuracy (measure of ability to pronounce words correctly in story), fluency (rate and accuracy scores combined), comprehension, and overall reading ability (fluency and comprehension scores combined).

2.4 Transcription and Method

The recordings were all individually transcribed in Praat, a free, downloadable phonetics software, where they were labeled in tiers using the ToBI framework (Beckman & Ayers Elam 1997), a prosodic labeling system.

Tones and Break Indices: ToBI

The prosodic labeling system which was used in this study is based on the intonation model described in Section 1.2 and on work done by Price, Ostendorf, Shattuck-Hufnagel, and Fong (1991) and Wightman et al. (1992) on break indices, as reported in Krivokapić (in press). In ToBI, the break indices mark the prosodic "chunking" of words that divide them into the hierarchical units in prosodic structure, corresponding to prosodic categories, in a scale from 0-4. In ToBI the highest indices correspond to IP (break index 4) and iP (3). Break index 1 denotes prosodic word boundaries and break index 0 marks clitics (e.g. flaps) between words. Other break indices and variations to break indices mark disfluencies in speech such as hesitations and prolongations (eg. 3p, 2p, 1p etc.) and break index 2 indicates a disparity between tonal properties and the perception of the prosodic break. ToBI also provides a systematic approach to marking disfluencies and other interruptions to the flow of speech which was also used in this study. Figure 2 is an example of this kind of labeling.

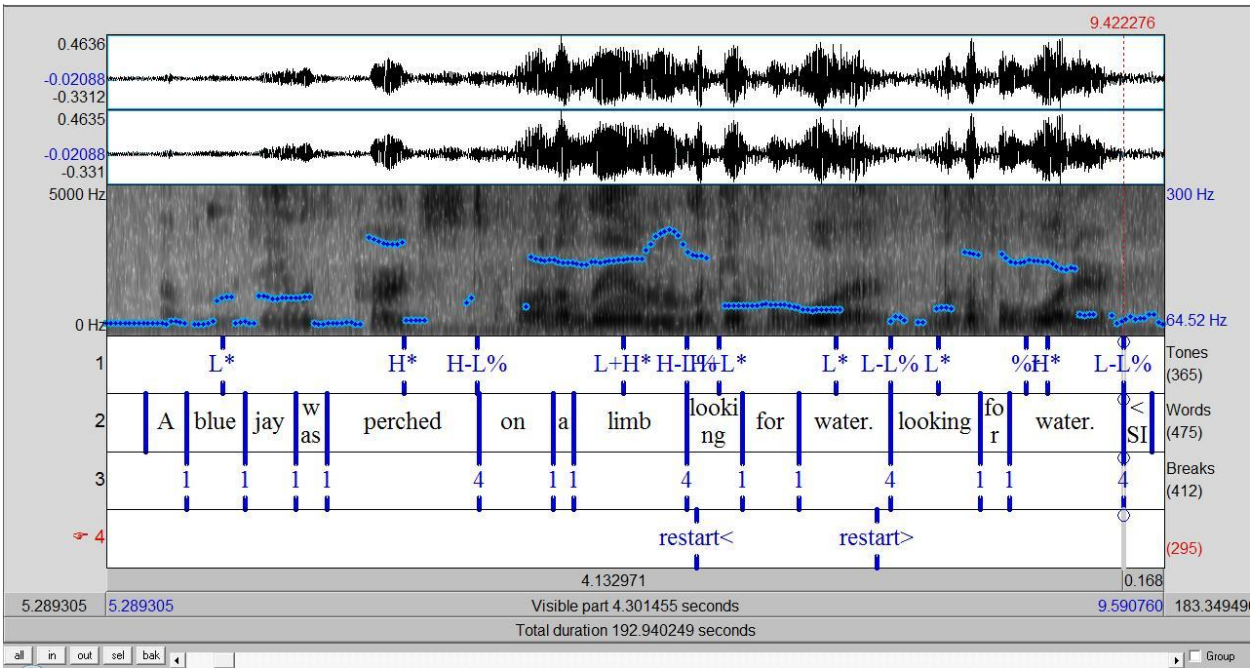

Fig. 2 – Example of ToBI transcription

Features Labeled and Analyzed

In order to analyze the read passages, general measures such as duration of readings, number of prosodic words produced in the readings, and reading rate (words per second) were recorded and compared. In addition, prosodic analysis consisted of recording total number of intonational phrases (IP) and intermediate phrases (iP), the average number of iPs per IP, the average number of words per iP and IP, the total number of pitch accents (PA), the average number of PAs per iP and IP, and the percentage of words containing PAs. Because of the different number of prosodic words uttered by each reader (despite the same amount of words in the text) due to disfluencies, these were discounted and the same amount of prosodic words was analyzed for each subject and for each prosodic analysis mentioned above.

Since variation in prosody seemed to correlate with disfluencies, a number of disfluencies was recorded and measured as the following: repairs or restarts in speech; hesitations, prolongations of a segment, or disfluent pauses (ungrammatical pauses); and filler words (eg. um, uh).

Unexpected placement or use of a certain pitch accent are treated as consequences of these disfluencies and therefore not included.

In addition to the above mentioned analyses, the production of boundaries at overt text punctuation marks was compared between the two groups of readers and the distribution of phrase-boundary tone type at punctuation sites was analyzed. The three stories totaled to twenty sentences which meant twenty (20) periods. Within those sentences were thirteen (13) commas. Two of those commas, it is important to note, we are expecting might act like periods, this is because they are after an independent clause, a construction that might trigger the production of L-L% boundary tone.

As a consequence of the results obtained in the first analysis, a second analysis examining the distribution of phrase-boundary tone types at the two different comma types: (1) commas separating dependent and independent clauses (eleven), and (2) commas separating independent clauses (two).

3. Results

In the following tables, good comprehenders are GC65 and GC77, while the poor comprehenders are PC63 and PC74. For two of the analyses that follow[4], because of the different numbers of prosodic words for each speaker and for a cleaner analysis, they were done for an equal amount of words. In addition, other analyses[5] were done both counting disfluencies and not counting them, which may potentially describe a reason why readers sound different (eg. "choppier" reading, more pitch accents). Also, the analyses that were done with equal numbers and no disfluencies (number of prosodic units and number of pitch accents) had the disfluencies discounted first and then the numbers were equaled and not the other way around.

3.2 Duration and Rate

Reading duration and rates were calculated to establish any other differences that might be present when comparing readers with different skills. Results showed that poor comprehend-

[4] Number of Prosodic Units, number of Pitch Accents,

[5] Number of Prosodic Units, number of Pitch Accents, Average number of iPs per IP, Average number of words per prosodic unit, Number of Pitch Accents, Average number of Pitch Accents per prosodic units, Percentage of words containing Pitch Accents

ders tended to take longer to read the three passages than the good comprehenders, as shown in Figure 3 below.

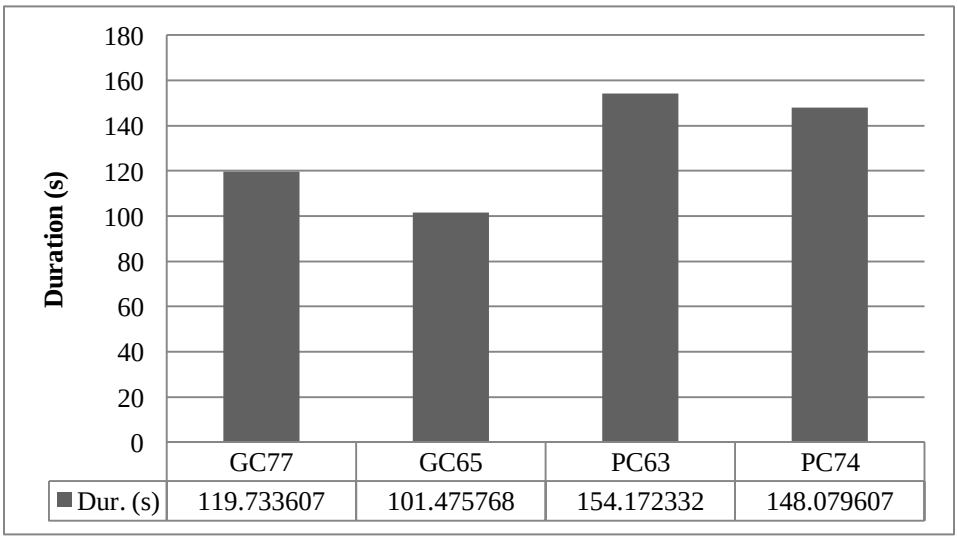

Fig. 3 – Graph of passage durations per reader in seconds

As expected, the reading rates (words per second) corresponded with the passage reading durations where poor comprehenders read slower than good comprehenders (Table 1). The number of prosodic words produced was different, mostly due to disfluencies such as repeated phrases, where poor comprehenders uttered more words than the good comprehenders. This was the same trend per story too.

	GC77	**GC65**	**PC63**	**PC74**
#Words (total)	367	368	413	388
#Words per story - s1, s2, s3	*107, 108, 152*	*106, 114, 148*	*113, 132, 168*	*112, 111, 165*
Wps - Rate	3.07	3.63	2.68	2.62

Table 1 – Total number of Words, *Words per story*, Reading Rate

3.3 Phrasing

Number of Prosodic Units

The total numbers of IPs and iPs were recorded in order to examine the correlation between reading skill and how readers read: ultimately how they divide their speech prosodically. The same trend is followed in both results including and not including disfluencies. However, the amount of IPs and iPs when not counting disfluencies in the good comprehenders' prosody was significantly less than in poor comprehenders. In both analyses, we can see that the differences

between numbers within each group did not vary widely as much as they did between different groups. Figures 4-5 show the results.

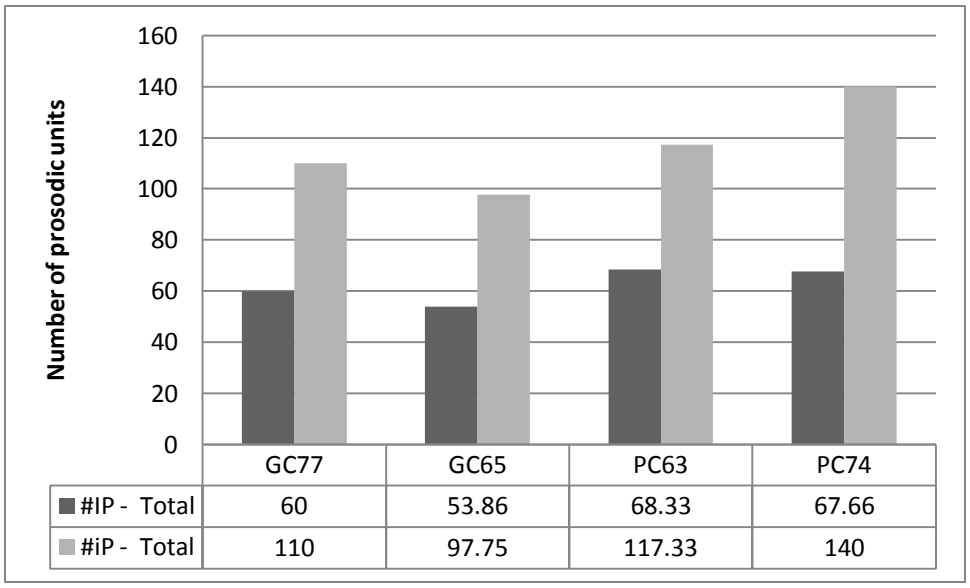

Fig. 4 – Number of Prosodic Units w/Disfluencies

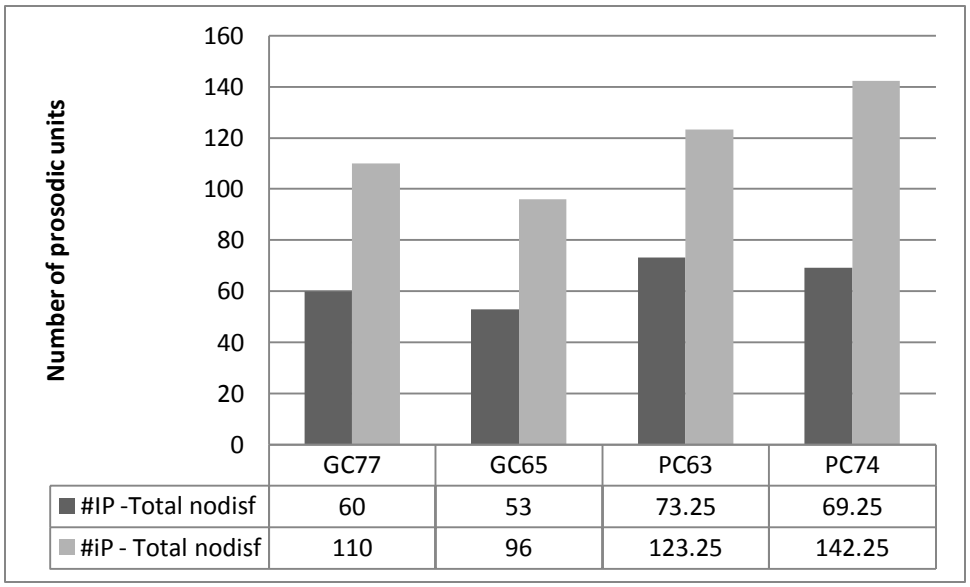

Fig. 5 – Number of Prosodic Units w/out Disfluencies

Average number of Intermediate phrases per Intonational phrases

In addition to the total number of prosodic units, average iP per IP (#iP/IP) were measured. As seen in Figure 6-7, the numbers in the separate analyses with and without disfluencies did not vary significantly. Both GC77 and GC65 have nearly identical averages in both analyses, but PC74 and PC63 both varied more, one having a more average iPs per IP than the good comprehenders and one having less.

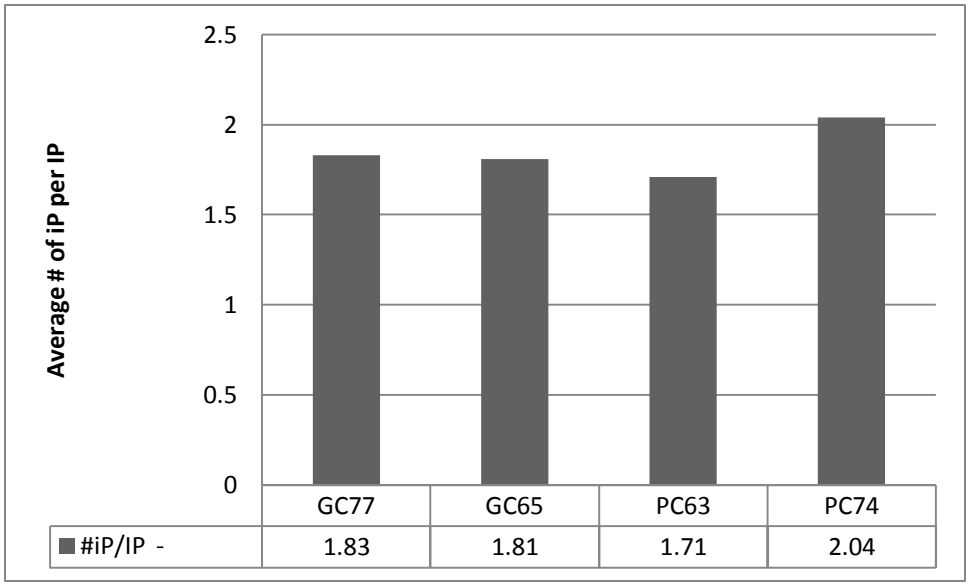

Fig. 6 – Average Number of intermediate Phrases per Intonational Phrase w/Disfluencies

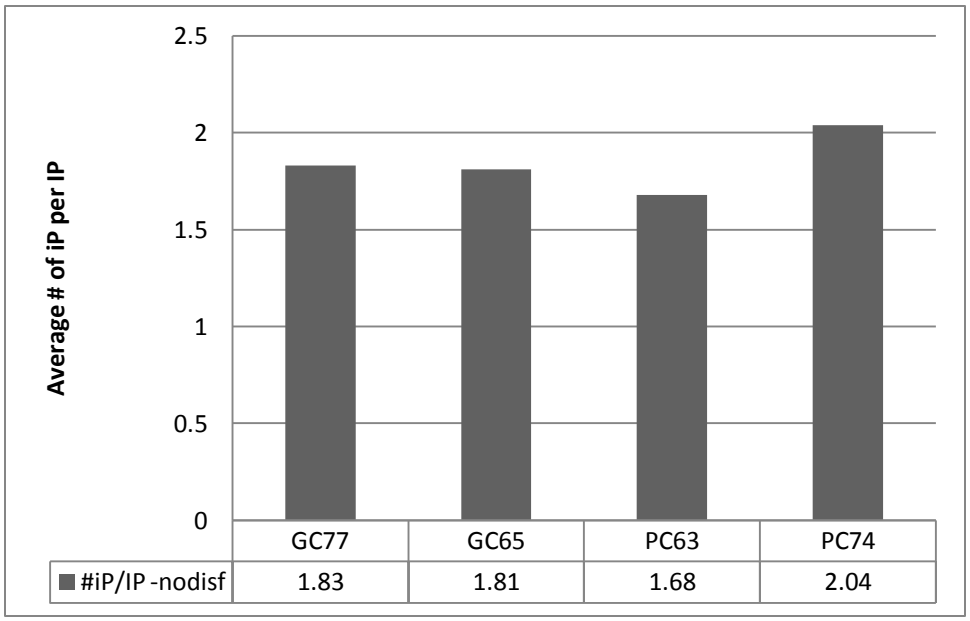

Fig. 7 – Average Number of intermediate Phrases per Intonational Phrase w/out Disfluencies

Average Number of Words per Prosodic Unit

Figures 8-9 show the average number of words uttered per unit. Differences between the analyses with and without disfluencies did not vary significantly and followed the same trend. Good comprehenders had on average higher words per IP and words per iP than did the poor comprehenders.

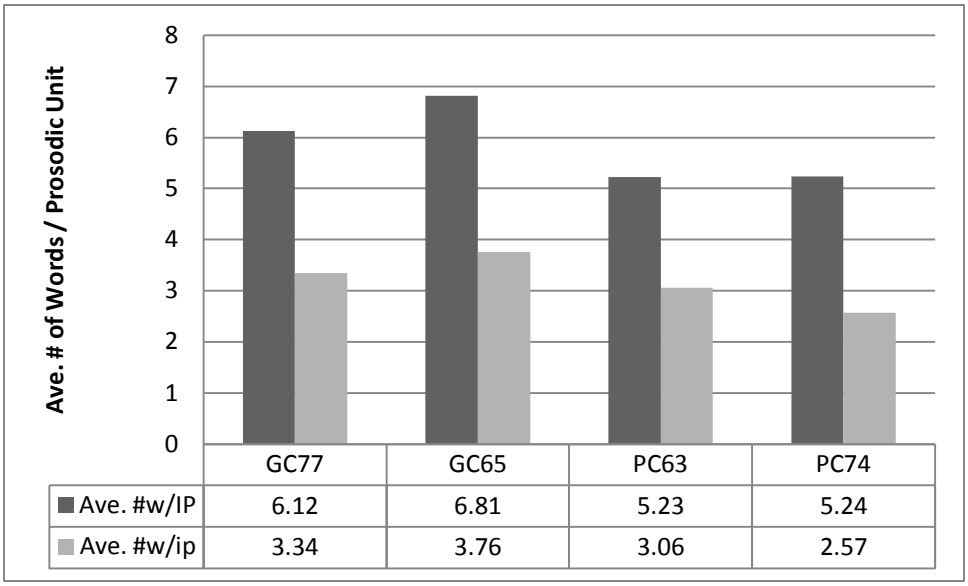

Fig. 8 – Average Number of Words per Prosodic Unit w/Disfluencies

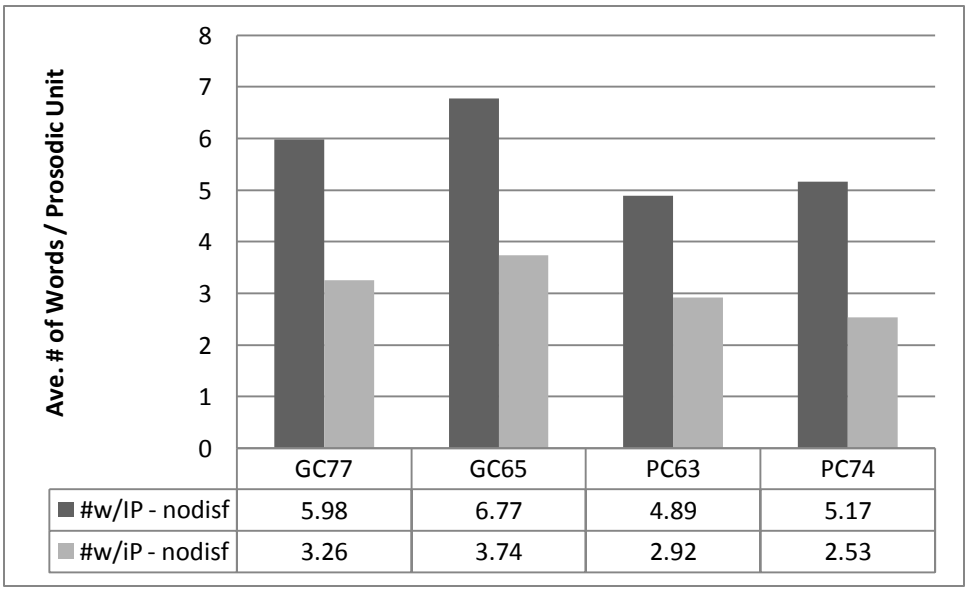

Fig. 9 – Average Number of Words per Prosodic Unit w/out Disfluencies

3.4 Prominence

Prominence is yet another aspect of prosody we examined. The total number of PAs was counted and to look at average distribution, the average number of PAs per prosodic unit, and then the percentage of words with PAs were recorded, all as possible quantifiers of reading comprehension

Number of Pitch Accents per Reader

Figures 10-11 displays how poor comprehenders show more instances of prominence in their prosody than do the good comprehenders, however the differences do not seem to be so great except for PC74 who has a higher and greater difference in number of pitch accents. If we compare the percentage of words with pitch accents across the readers, Tables 2-3 show that regardless of whether you count disfluencies or not, the variation does not seem to be too distinct for each group. All the readers seem to place prominence in almost half to a little over half of their words.

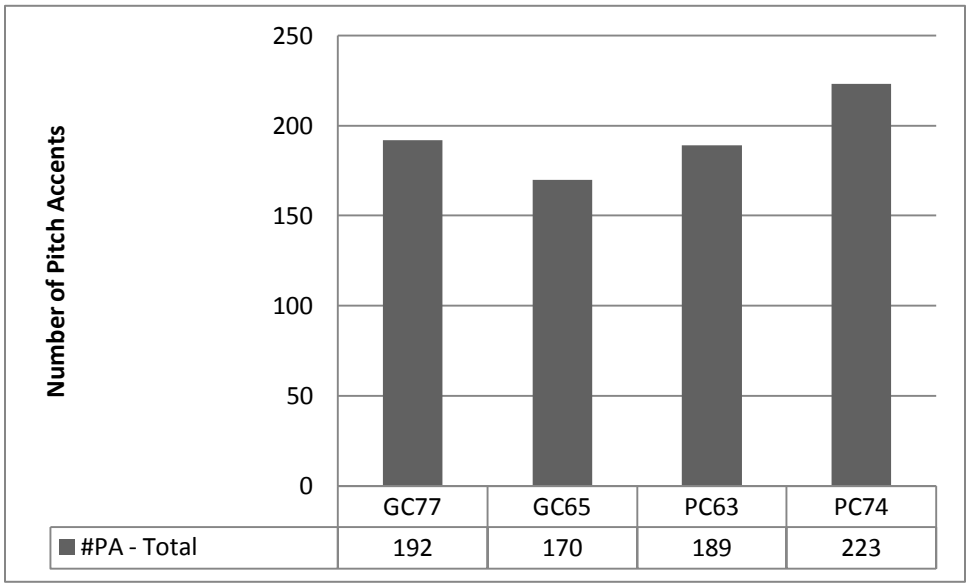

Fig. 10 – Number of Pitch Accents w/Disfluencies

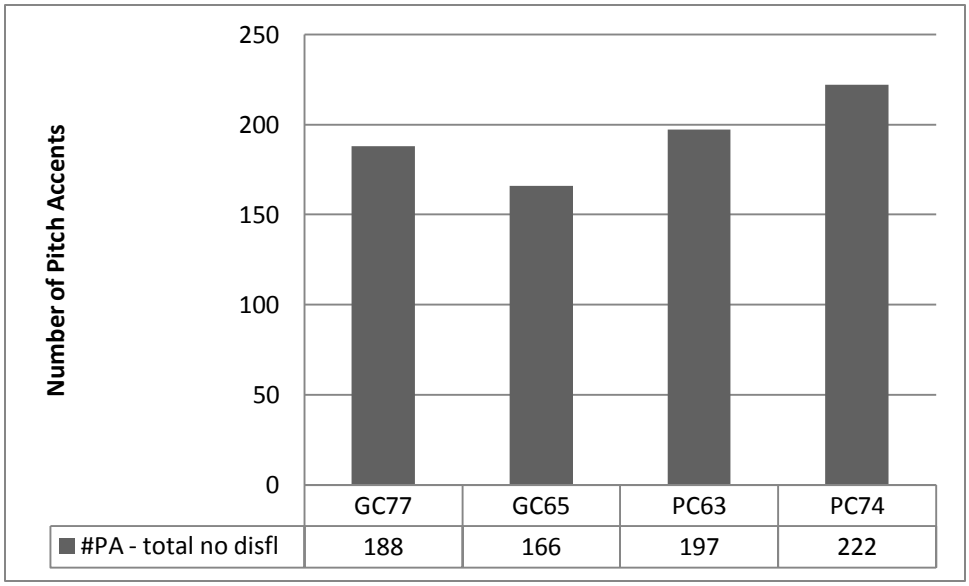

Fig. 11 – Number of Pitch Accents w/out Disfluencies

	GC77	GC65	PC63	PC74
%words w/PAs - nodislf	52.37%	46.24%	54.97%	61.88%

Table 2 – Percent of Total Words with Pitch Accents w/out Disfluencies

	GC77	GC65	PC63	PC74
% words w/PA	52.32%	46.20%	52.78%	61.60%

Table 3 – Percent of Total Words with Pitch Accents w/Disfluencies

Average Number of Pitch Accents per Prosodic Unit

The average distribution of pitch accents across prosodic units was taken and shown below in Figures 12-13. The distribution among both groups did not vary much between analyses. The distribution of pitch accents mirrored the previous results in that the differences in number were does not seem very significant. The poor comprehenders, however, vary more in PAs per IP where PC63 had less PAs per unit than the good comprehenders and PC74 had more per unit.

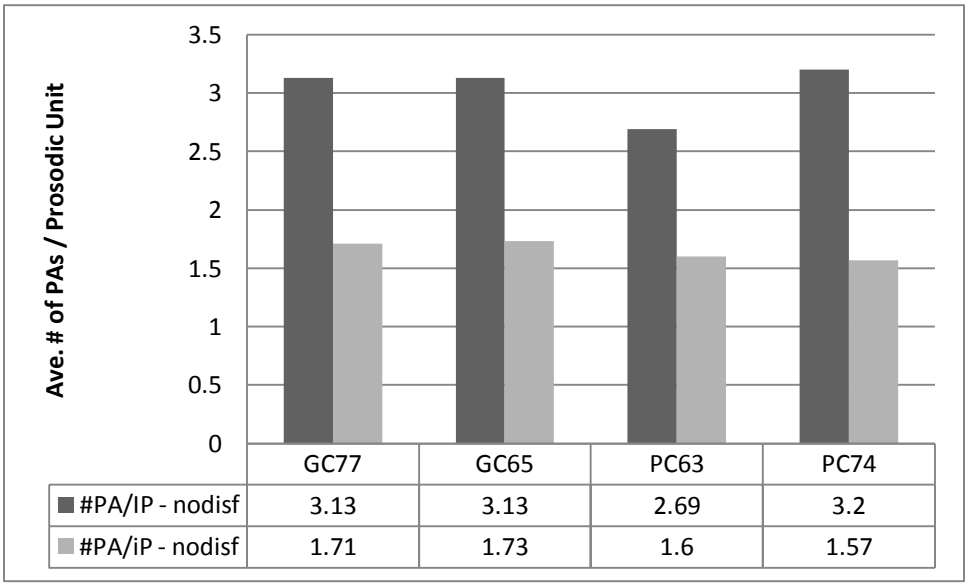

Fig. 12 – Average Number of Pitch Accents per Prosodic Unit w/out Disfluencies

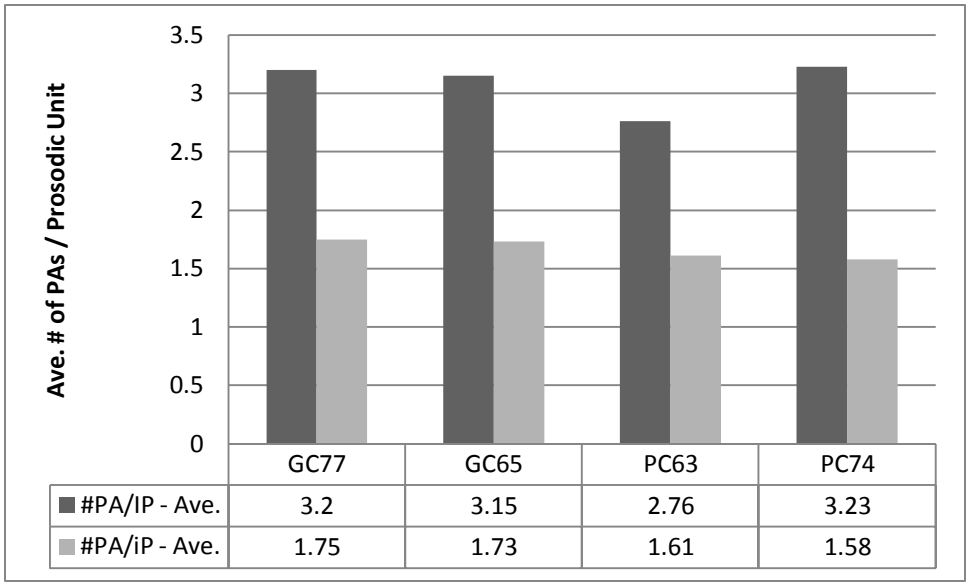

Fig. 13 – Average Number of Pitch Accents per Prosodic Unit w/Disfluencies

3.5 Disfluencies

In addition to prosodic differences, disfluencies were examined to find any distinctive variations between the two groups of comprehenders. The disfluencies observed were the following: repairs or restarts; hesitations, prolongations of a segment, or disfluent pauses (ungrammatical pauses); and filler words (eg. um, uh). The results, displayed below in Table 4, were as expected, where poor comprehenders had more than double the disfluencies than the

good comprehenders. The range of the amount of disfluencies between poor comprehenders was almost negligible while the good comprehenders had larger range. The percents displayed describe the percent of disfluencies of that kind per reader.

	GC77	GC65	PC63	PC74
#Disfl - Total	29	10	64	67
#repair/restart	4	3	22	14
%repair/restart	13.79%	30%	34.38%	20.9%
#hesit/prolong	24	5	42	52
%hesit/prolong	82.75%	50%	65.62%	77.61%
#fillers	1	2	0	1
%fillers	3.45%	20%	0%	1.5%

Table 4 – Number of Disfluencies, Number and Percentages of Types of Disfluencies

When examining the different types of disfluencies, the most common disfluency that occurred across all readers was the hesitations and prolongations. The second most common was the repair or restart, and the least common between all the readers was the use of fillers. No considerable or conclusive differences in type of disfluency distribution were found between groups, leaving us with the seemingly significant difference of total disfluency numbers between groups.

Pausal Intrusions

Although included in the disfluency count, the number of ungrammatical pauses was also calculated (Table 5) in order to verify this as a quantifier of reading skill. The pauses that were counted in this analysis were the ones that occurred in ungrammatical phrases (refer to sentence 1a and 1b for example), although this might be somewhat subjective. The results were not necessarily as expected as it was one of the good comprehenders, GC77, who produced more of these pausal intrusions. GC65 on the other hand only had one. Both PC63 and PC74 were similar in their production of ungrammatical pauses.

	GC77	GC65	PC63	PC74
# ungrammatical pauses	16	1	15	12

Table 5 – Number of Pausal Intrusions

3.6 Phrase-Final Intonation Contour

Distribution of Boundary Tones at Punctuation Sites

The results for each subject can be seen in Tables 6-9. All readers ended their sentences at periods with the tone type L-L%: the standard sentence final declination found in English declarative sentences. A distinctive difference between the two groups is that more than half of the poor comprehenders' phrase-boundary tones at commas were of the L-L% type, unlike in the good comprehenders' data where they had most of their tones distributed into other types.

GC65		
	At comma (,)	**At period (.)**
L-L%	15%	100%
L-H%	23%	
L-!H%		
H-L%	62%	
!H-L%		

Table 6 – GC65 Distribution of Boundary Tones

GC77		
	At comma (,)	**At period (.)**
L-L%	31%	100%
L-H%	23%	
L-!H%	31%	
H-L%	7.5%	
!H-L%	7.5%	

Table 7 – GC77 Distribution of Boundary Tones

PC63		
	At comma (,)	**At period (.)**
L-L%	63%	100%
L-H%		
L-!H%		
H-L%		
!H-L%	31%	

Table 8 – PC63 Distribution of Boundary Tones

PC74		
	At comma (,)	**At period (.)**
L-L%	69%	100%
L-H%	7.75%	
L-!H%	7.75%	
H-L%	7.75%	
!H-L%	7.75%	

Table 9 – PC74 Distribution of Boundary Tones

Boundary Tone Type at Comma Sites

The second analysis stems from the previous one further examining the distribution of boundary tones in the different comma locations. Two types of commas were identified earlier, the comma between independent clauses and the comma between a dependent and independent clause. The results are displayed in Tables 10-13, which show the types of phrase-boundary tones produced by that reader and the distribution of each type into the two categories for commas. Percentage of tone type used in each comma category is shown, and N/A means reader didn't produce that specific tone type.

GC65					
Location of commas	L-L%	L-H%	L-!H%	H-L%	!H-L%
B/w independent clau.	2(100%)	0%	N/A	0%	N/A
B/w dependent & independent clau.	0%	3(100%)		8(100%)	

Table 10 – GC65 Boundary Tone Type at Comma Sites

GC77					
Location of commas	L-L%	L-H%	L-!H%	H-L%	!H-L%
B/w independent clau.	2(50%)	0%	0%	0%	0%
B/w dependent & independent clau.	2(50%)	3(100%)	4(100%)	1(100%)	1(100%)

Table 11 – GC77 Boundary Tone Type at Comma Sites

PC63					
Location of commas	L-L%	L-H%	L-!H%	H-L%	!H-L%
B/w independent clau.	2(22%)	N/A	N/A	N/A	0%
B/w dependent & independent clau.	7(78%)				4(100%)

Table 12 – PC63 Boundary Tone Type at Comma Sites

PC74					
Location of commas	L-L%	L-H%	L-!H%	H-L%	!H-L%
B/w independent clau.	2(22%)	0%	0%	0%	0%
B/w dependent & independent clau.	7(78%)	1(100%)	1(100%)	1(100%)	1(100%)

Table 13 – PC74 Boundary Tone Type at Comma Sites

The above Tables 10-13 show that poor comprehenders' L-L% were mostly found between dependent and independent clauses as opposed to the good comprehenders who only or mostly had it between independent clauses. All the readers had the two expected L-L% instances in the commas between independent clauses.

4. General Discussion

The objective for this study was to find quantifiable prosodic differences between oral readers with poor comprehension and readers with good comprehension. In studies examining the determining factors of reading comprehension in oral reading, word decoding and reading rate were found to be directly related to reading comprehension. In the present paper all four subjects were matched for word decoding skills. Variation in their speed was found, where poor comprehenders read at a slower rate than the good comprehenders. Kuhn et al. (2010) mention Hudson and colleagues (2009) comment that slower reading is sometimes necessary for "a construction of meaning", but also stating that excessively slower reading can hamper comprehension, and that skilled readers vary their reading rate upon the difficulty and complexity of the text. From this, we can take that it is possible to correlate reading comprehension with reading rate, and the data in the present paper does support this. However, because we know that fast reading is not the same as fluent reading, we looked into prosody.

We set out to examine the role of prosody in reading comprehension. Prosodic boundaries, pitch accents, and punctuation and boundary tones were examined. Although we did do multiple analyses per examined feature, the trends between analyses were the same and there were no great differences between results[6]. This shows that disfluencies aren't the only thing contributing to the way a person sounds when they read aloud.

Good comprehenders' and poor comprehenders' division of read speech into prosodic units was compared. The total number of IPs and iPs in each group's individuals distinguished the good comprehenders from the poor ones: the good comprehenders divided their speech into less IPs and iPs than did the poor comprehenders. The average number of iPs per IP did not seem to be a significant difference between groups. Each reader did almost two iPs to a little more than two iPs per IP. However, although it seemed unusual that one poor comprehender, PC74 had a higher average number of iPs per IP than the good comprehenders and PC63 had a lower average, this can be explained by looking at the total amount of IPs in each one. PC63 had more IPs than PC74 but she also had less iPs, which could explain the average #iP/IP. What this is telling us is that total number of prosodic units might be a better indicator of reading skill than the actual distribution of iPs.

[6] Because of this, the results will be discussed without further mention of the two different analyses.

Next, pitch accents were analyzed (see Figures 10-13 and Tables 2-3). In comparing the total amount of PAs per reader, poor comprehenders produced slightly more pitch accented prosodic words throughout than the good comprehender. However, the difference does not seem to be so large between readers of the different groups. The only reader who stands out is PC74 with the greatest amount of pitch accented words. This difference in might be due to an individual difference in reading or speech. Nevertheless, more information on this and all other readers will be needed, in addition to a larger sample of subjects, to examine whether or not a larger variation in prominence production exists between groups of different skill levels.

It has been shown that overt prosodic cues tend to help with prosodic reading (Steinhauer & Friederici, 2001). One last prosodic feature examined was the phrase-boundary tone at punctuation locations. Although we should be wary of calling certain boundary tones "incorrect" for certain overt prosodic boundaries in text, we can talk about those expected at certain junctures such as the L-L% tone at the end of declarative sentences in English. However, it seems, as the data in this paper show, that commas tend to elicit more varied productions in boundary tones, rather than just having a default tone. The results in the Tables 6-13 above show that the poor comprehenders tended to mark most of their commas with the declarative default tone: L-L% and the good comprehenders' tones at those same punctuation marks varied more. Periods and commas separating two dependent clauses, on the other hand, unanimously ended in L-L% tones for all the readers. The L-L% usually suggests a "wrap-up" of an idea, creating a form of disconnect with the next phrase. All other phrase-boundary tones suggest that the next phrase over might be needed to complete the idea, hence the endings include rising tones like L-H%, L-!H% and !H-H% or slighter falling tones like H-L%, !H-L% or H-!H%. All these tones seem to occur mostly for all readers in commas between dependent and independent clauses.

Contrasting productions of boundary tones at the eleven commas with expected tone variance were observed between good and poor comprehenders. Like mentioned earlier, poor readers would end most of their commas with the L-L% tone where variance between H and L tones was expected, between dependent and independent clauses. This distinction seems to be the suggested correlation between prosody at punctuation sites and reading comprehension. But why does this distinction exist and how is it significant? Hirotani et al. (2006) mentions that punctuation, such as commas, may serve as the only signal for the interpretation of a particular

structure; its use being strategic when processing sentences. If a punctuation mark does not elicit the "right" boundary tone, the reader might have trouble parsing the sentence and therefore comprehending it. If poor readers are using L-L% tones in places of punctuation where other tones are expected then they might be "wrapping-up" their sentences too soon and parsing is only partially accomplished. This also lends evidence to the importance of prosody in reading comprehension.

Poor planning might also be a reason for this distinction. Rayner (1998) shows that less skilled readers are slower readers, have a smaller perceptual span and make shorter saccades. This might be another reason for the production of these unexpected L-L% tones at commas. The lack of "looking ahead" (shorter saccades, smaller perceptual span) might be hindering the syntactic parsing of a phrase and therefore the reader is reverting to the "default" L-L% tone of the declarative sentence. Though the latter may seem simplistic, it is a preface to further research on prosody and reading comprehension where planning should probably be taken into account as a correlation with reading skill.

While some prosodic differences seem to distinguish these readers, disfluencies seem to be a more straightforward correlation. One thing to note is that the varying number of prosodic words in this paper is directly related to the number of disfluencies. Hence, the more prosodic words, the more disfluencies. Data showed that errors in reading distinguished groups. The good comprehenders' disfluency count was 10 and 29. Disfluencies in poor comprehenders were 63 and 67, over double of the disfluencies. No considerable differences between groups were found in the type of these disfluencies, with hesitations and prolongations being the most common between all of the readers. Pausal intrusions were also calculated as part of the disfluency measure, but the results were inconclusive (see Table 5): although the poor comprehenders' productions of ungrammatical pauses were similar, so was one of the good comprehenders'. This could either lead us to more examination of individual differences in reading or that pausal intrusion might not be a reliable quantifier for reading skill. However, taking all the data into account, we can preliminarily conclude that more disfluencies may indicate lower reading comprehension skill.

In adults matched with word decoding skills, reading comprehension skills seemed to be predicted by the number of features rather than the overall distribution of prosodic features (eg.

#ip/IP, % type of disfluency, etc) . However, a notable attribute, such as type of phrase-boundary tones at certain punctuations, seem to be a big difference between groups and could help be a sign of reading skill. The present paper's hypotheses overall was right in terms of distinguishing differences between groups. In sum, a preliminary model for quantifying reading skills should include a combination of reading duration and rates, number of prosodic units, number of disfluencies, number of words per prosodic units, and an examination of their phrase-boundary tones at punctuation locations. An example of a poor comprehender (using this paper's data as reference) compared to a good comprehender could be described as one with slower reading rates, at about 1word/s less than a good comprehender; over double the amount of disfluencies than that of a good comprehender, and L-L% tones at most commas.

5. Conclusion

The implications of this study reach out to a better understanding in diagnosing reading comprehension skill through quantifying of prosody. This analysis does not serve as a general conclusion, as further study of individual differences between groups of the same skill must be done in order to have an established quantitative scale of prosody that describes reading skill. However, what this study does tell us is that differences in prosody are quantifiable and are able to distinguish good comprehenders from poor comprehenders even when individual variation exists, possibly attributable to many causes such as degree of practice in reading, interest, confidence, memory, and even reading strategies such as creating an image of what is being read as you read. It is evident that there are many factors contributing to reading skill, and reading skill possibly contributing to those factors. However, the skill and lack-there-of seems to manifest themselves in the way people read, regardless of directionality.

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Appendix I – Word decoding (Word Attack) and Reading Comprehension (Passage Comprehension) Data for Each Reader

FILE	AGE	GENDER	Years of school	WORD ATTACK			PASSAGE COMPREHENSION		
				RAW	STANDARD	Grade equiv	RAW	STANDARD	Grade equiv.
PC63	21.17	F	11	29	96	12.9	32	83	5.8
PC74	17.99	M	11	29	98	12.9	33	86	6.7
GC77	22.77	M	15	29	97	12.9	41	107	19
GC65	22.22	F	17	30	101	15.4	39	101	13

Appendix II – Texts that were read

(1) A blue jay was perched on a limb looking for water. Having just flown a great distance, she was very thirsty. At that moment she happened to spot a water jar on the ground, so she flew down and tried to get a drink from the jar. But there was so little water in the jar that she was unable to drink. Just as she felt that she would surely die of thirst, an idea struck her. The jay gathered a pile of stones and began dropping them in the jar. Little by little the water rose and at last the jay could drink her fill.

(2) The era of the cowboy came to an end as a result of changes in the cattle business. When cows roamed the vast ranges of the Southwest, the herd could not be rounded up without skilled riders on horseback. But with the invention of barbed wire, great stretches of ranchland were fenced into smaller ranches. Then the roundup was no longer a major event and cowboys became less important. The long trail drives to the north, in which the cowboy's skill at herding cattle was essential, also became a thing of the past. With the coming of the railroad, cattle could be shipped directly to market.

(3) Mark was delighted to obtain his deputy sheriff's badge, but now he nervously pondered the difficult undertaking ahead. As his first assignment, he had been appointed to escort a prisoner to the authorities in Preston, the county seat and site of the impending trial. The cunning prisoner had previously eluded the law and let state troopers in hot pursuit before finally surrendering. Experienced officers had cautioned Mark that this was a treacherous and possibly violent criminal who would stop at nothing. According to reliable testimony and other evidence, he was guilty of several ruthless attacks for which his victims could offer no clear motive. But when the prisoner was delivered to Mark's vehicle, the young deputy was struck by his sympathetic appearance and courteous manner. It seemed utterly incredible to Mark that physical form and conduct could so perfectly conceal the true nature of a human being.

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