Oral reading fluency and prosody: A preliminary analysis of the Greek language

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Abstract. This article presents results from an initial investigation of Greek oral reading fluency and prosody. Although currently held perspectives consider reading the product of reading decoding and reading comprehension, there is enough evidence (both Greek and foreign) to suggest that other variables may affect reading, as well. Such variables include reading fluency and prosody. A small sample of 27 students from the 2nd and 5th grades of primary schools was examined using a variety of tests. All tests were computer-based. Data were collected and analyzed using Cognitive Workshop, a platform for presenting and recording of visually presented stimuli, and Praat, a specialized software for analyzing audio recordings and obtaining speech analysis measurements. Results suggested that differences in reading fluency might be attributed to automaticity acquired by students.

Keywords: Reading fluency, prosody, automaticity

Introduction

It is generally accepted that learning to read is an important prerequisite for all subsequent literacy development, since language, in its written form, constitutes the basic symbolic code for the transmission of knowledge. Reading refers to the process of gaining access to meaning from printed symbols and, as such, a preparative to extract meaning from visual symbols. Therefore, reading is the children's ability to learn and understand the code used by their culture for representing speech in the graphemic level (Ziegler & Goswami, 2006).

Over the last few decades numerous studies have dealt with the issue of reading and reading development in different orthographies (Aro & Wimmer, 2003; Katz & Frost, 1992; Seymour, Aro & Erskine, 2003; Wimmer & Goswami, 1994; Ziegler & Goswami, 2005). At odds with the growing bulk of research on reading process and reading development, the topic of reading fluency has been systematically neglected by researchers (Landerl & Wimmer, 2008). Recently though, a notable shift of attention towards reading fluency is evident in the literature. This may be attributed to a "…broader reconsideration of the role of oral reading in the development of skilled reading" (Kuhn, Schwanenflugel & Meisinger, 2010:230), and/or to the fact that recent studies identified reading fluency as been associated with comprehension skills (Denton et al., 2011; Patel & McNab, 2011; Rasinski et al., 2005; Schwanenflugel et al., 2006; for discussion). Protopapas, Parrila and Simos (2014) presented evidence that inefficient reading fluency skills are likely to be accompanied with deficient performance in comprehension tasks.

Reading is a multicomponent cognitive process that encompasses both low-level processes, such as word recognition and word decoding, and higher-level processes, such as comprehension (Wolf, Bally & Morris, 1986) and fluency (Norton & Wolf, 2012). In that sense, the term reading fluency may be conceptualized as fluent comprehension (emphasis added), as Norton and Wolf (2012) put it vividly. Reading fluency, in its broader sense, is the "… ability to read text quickly, accurately, with proper phrasing and expression, thereby reflecting the ability to simultaneously decode and comprehend" (Valencia et al., 2010, p. 271). It is therefore a multidimensional construct that incorporates three main features: accuracy, automaticity and prosody (Hudson et al., 2008; Kuhn, Schwanenflugel & Meisinger, 2010; Rasinski, Rikli & Johnston, 2009; Wise et al., 2010) and thus, integrates both lower-level and higher-level processes.

Accuracy in word recognition refers to the correct decoding of words. In written language, words constitute the most important linguistic units and consequently the dexterities of word decoding and recognition are of fundamental importance for reading performance. Initial studies in the field (Liberman et al., 1980; Shankweller & Liberman, 1972; Stanovich, 1980) did lead to the conclusion that reading difficulties may be attributed to children's inability to compose the constituent syllables of words. It became explicit that word recognition is feasible only when the written representations can be assigned to corresponding cognitive representations of phonological nature that stem from the orthographic structure of words, i.e. grapheme-phoneme representations (Grainger & Holcomb, 2009).

A basic problem that resulted from the relative studies was that not all orthographies reflect their phonology. Chomsky (1970) proposed that the lexical representations are "morphophonological", that is to say the words are registered as sequences of phonemes that are divided into their constituent morphemes. Consequently, in order to facilitate learning to read, the beginning readers should have a grasp of their language's phonology up to the point that the lexical representations match to the corresponding orthographic representations. The various orthographic systems, however, differ in the sense of the restrictions they pose to readers. In "shallow" orthographies grapheme-to-phoneme correspondence rules are straightforward (1:1 in most cases), whilst in "deep" orthographies a more explicit phonological awareness is required on behalf of the reader, since a phoneme may have multiple graphemic representations.

Studies that focused on presumable differences in reading acquisition across various orthographic systems (Frith, Wimmer & Landerl, 1998; Goswami, Porpodas & Wheelwright, 1997; Spencer & Hanley, 2003; Wimmer & Goswami, 1994) have also led to similar conclusions. Perhaps the most ambitious cross-language reading comparison to date has been the COST Action A8 (1995-1999). The results indicated that reading performance in orthographically consistent languages (Greek, Finnish, German, Italian, Spanish) exhibited ceiling effects in both word and nonword reading by the middle of primary 1, whilst recoding accuracy in deep orthographies seemed to fall behind (Seymour et al., 2003). Landerl and Wimmer (2008) stated that in transparent orthographic systems young readers achieve word decoding accuracy close to ceiling only after a short period of reading instruction. This is consistent with research findings in the Greek Language (Georgiou, Parrila, & Papadopoulos, 2008a; Georgiou et al., 2012; Goswami, Porpodas & Wheelwright, 1997; Manolitsis et al., 2009; Protopapas & Skaloumbakas, 2008; Sarris & Porpodas, 2005; 2008). The Greek orthography is relatively transparent, even though it includes digraphs and context-dependent graphemes (Protopapas & Vlahou, 2009). Despite the fact that the Greek language is classified as "shallow", it displays a remarkable asymmetry between reading and spelling (Porpodas, 2006). The most obvious complexities between phonology and spelling concern cases in which, different letters or letter strings represent a single phoneme. The phoneme /i/ for example may be assigned to multiple graphemes (e.g. *ι*, *η*, *υ*, *οι*, *ει*, and *υι* in rare cases). Nevertheless, these inconsistencies are rule-learned and as such the pronunciation of most words is predictable from print (Porpodas, 2001).

Thus, in transparent languages, the most appropriate assessment for obtaining a reliable, valid and easy-to-use measurement of decoding performance is word decoding speed

(Landerl & Wimmer, 2008). Hence, only at the very early stages of learning to read in a shallow orthography, accuracy in word decoding is highly correlated to comprehension (Protopapas et al., 2007), whereas reliance on fluency-related skills, such as RAN (Rapid Automated Naming) measures, become more evident later on (Norton & Wolf, 2012). In fact, RAN measures are significant predictors of reading fluency (Georgiou, Parrila & Liao, 2008b).

So far, a number of different terms have been used to illustrate the composite nature of the reading process. Norton and Wolf (2012) provide an excellent contour on the subject. They use the term reading circuit to portray its complex construct, where phonology, orthography, visual and motor processes, as well as semantics are involved. In fact, they suggest that RAN tasks actually enable researchers to get an insight into this cognitive system. When all these separate but codependent components operate evenly with both accuracy and speed, then the notion of automaticity emerges (Norton & Wolf, 2012). This vital apex in reading development is easily discernible on account of significant reduction of reaction time scores on decoding (Sarris & Porpodas, 2005; 2008).

That being the case, automaticity in word decoding is a second crucial component of fluent reading that incorporates three distinct factors: speed, autonomy and resource use, which develop concomitantly with one another (see Schwanenflugel et al., 2006 for discussion). The use of efficient word recognition strategies exploit or/and systematize grapheme-to-phoneme mappings that are repeated to texts, and as a consequence, they are recognized as partial visual cues (Tunmer & Chapman, 2002). It is argued that effortless decoding of words preserves valuable cognitive resources that can be directed to tackle higher-level processes, applied for example to text comprehension (Kuhn & Stahl, 2003; Norton & Wolf, 2012; Rasinski, Rikli & Johnston, 2009; Tunmer & Chapman, 2002). The rationale behind this perspective stems from the acknowledgement that reading comprises two distinct but interrelated cognitive processes, decoding and comprehension. As numerous research articles have documented so far, difficulties in word recognition entail weaker performance on measures of reading comrehension (Adlof, Catts & Little, 2006; Torgesen & Hudson, 2006). According to LaBerge and Samuels' (1974) influential paper, struggling readers, who spend effort and cognitive attention in order to decipher the low-level decoding task of reading, face pronounced difficulties in comprehending the text (see also Samuels & Flor, 1997).

According to Kuhn and Stahl (2003), the developmental shift from the arduous and time consuming sequential decoding of grapheme arrays to an elaborated, automatically decoding of whole orthographic patterns occurs when readers acquire a certain amount of expertise on deciphering familiar sets of letters. Familiarity is assumed to depend on extensive exposure to print, explicit instruction and practice (Karemaker, Pitchford & O'Malley, 2010; Norton & Wolf, 2012; Snow, Burns & Griffin, 1998; Stanovich & Cunningham, 2001). At this stage of reading acquisition (see developmental models of reading acquisition) it is evident that novice readers begin to utilize syllable-sized or morpheme-sized segments in reading (Sarris & Porpodas, 2005; 2008). So, forging the link between phonological and orthographic representations facilitates the development of automatic recognition of words (Carlisle & Stone, 2005). This is in step with automaticity theory, according to which continuous practice enables readers to spend less cognitive effort on word recognition (Moats, 2001; Samuels, 2012; Schwanenflugel et al., 2006). It is worth mentioning at this point that automaticity skills in decoding visual stimuli are often used as a general indicator of reading performance (Sabatini, 2002), whilst the lack of systematic reading practice may result to the "Matthew Effect" phenomenon (Archer, Gleason & Vachon, 2003).

Finally, a third feature of reading fluency is prosody, which pertains parsing the text into syntactically and semantically appropriate units (Rasinski, 2004). While early reading attempts are limited to sounding out phoneme sequences that convey meaning, skilled reading aloud requires an increasing awareness of prosody (Patel & McNab, 2011). Defining prosody is a rather challenging task since it consists of a combination of features, but is widely accepted that "… prosody is a linguistic term to describe the rhythmic and tonal aspects of speech: the "music" of oral language" (Torgesen & Hudson, 2006, p. 4). Proficient readers are expected to read with expression, modulate pitch and place proper emphasis on salient words (Patel & McNab, 2011). It is considered to be a linguistic term that accounts for the rhythmic and tonal aspects of speech (Hudson, Lane & Pullen, 2005). Researches have described several prosodic features that involve, amongst others, duration (Benjamin et al., 2013; Duong, Mostow & Sitaram, 2011; Hudson, Lane & Pullen, 2005), pitch fluctuation (intonation) and pausing (Miller & Schwanenflugel, 2008; Torgesen & Hudson, 2006).

Prosody is also closely related to comprehension (Kuhn & Stahl, 2003; Patel & McNab, 2011). Diffluent and slow reading, as well as laborious decoding processes, are key variables for predicting comprehension difficulties (Archer, Gleason & Vachon, 2003). Likewise, readers who fail on appropriate phrasing, exhibit substantial differences in reading rate and intonation contours, ignore punctuation pauses or make stress assignment errors, are unlikely that they will completely comprehend the text (Rasinski, 2004; Rasinski, Rikli & Johnston, 2009; Schwanenflugel et al., 2004).

These three elements of reading fluency can easily be assessed using simple measurements. Word decoding ability is typically evaluated by calculating the percentage of words that are accurately decoded on grade-level material (Rasinski, 2004). In transparent orthographies however, the most appropriate measure on word decoding performance is reaction time scores (Landerl & Wimmer, 2008). Automaticity in word decoding, on the other hand, is estimated in terms of reading rate (Rasinski, 2004). Words read correctly in one minute (WPM) is widely used as a proxy for automaticity and it's calculated as the ratio of the number of word read accurately over the total reading time (in seconds) required to read the words (Valencia et al., 2010). It should be noted at this point though that word decoding rate fails to incorporate the prosodic element of fluency, which is the key link to comprehension (Rasinski, Rikli & Johnston, 2009). Hence, it may be that studies on reading fluency should include data on prosody. Prosody is most commonly assessed with qualitative rubrics or rating scales (Benjamin et al., 2013; Fountas & Pinnell, 2006; Rasinski, Rikli & Johnston, 2009; Zutell & Rasinski, 1991), that usually score expression and pitch, pace, phrasing etc. Despite the fact that these fluency scales are practical and research-convenient measures, they "… are not direct measurements of the prosodic aspects of reading" (Schwanenflugel et al., 2004, p. 3). Contemporary trends in fluency research may require the use of advanced technologies, which extend beyond the scope of paper-and-pencil tests. For example, proper fluency research necessitates the implementation of spectrographic analysis, where prosodic features are assessed using three (3) distinct criteria: (1) the number of pauses (Schwanenflugel et al., 2004), (2) pause duration (Balogh et al., 2012), and (3) pitch (Cohen, Lee Hong & Guevara, 2010; Sitaram & Mostow, 2012).

The present study presents a preliminary assessment of reading automaticity (i.e. reading rate) and prosodic reading in the Greek language using a sample of 2nd and 5th primary school grade students. The study's main goals are twofold: (a) to investigate reading rates for 2nd and 5th primary school grades in an effort to establish average reading rates per grade level, and (b) to identify predictor variables on both reading rate and prosody. Within this perspective, automaticity in reading was assessed by calculating the number of words read correctly per minute (CWpM) on both age-appropriate and control texts. Prosodic analysis was carried out using a combination of standard qualitative rubrics and computerized assessment. For the computerized assessment, speech analysis software was utilized and involved measures such as pitch variation, pause duration and phonation time, since all have been identified as associating factors with reading prosody (Schwanenflugel et al., 2006; see also Clay & Imlach, 1971; Lieberman, 1996). An interesting link between pitch and prosodic reading has been made by Casper & Leonard (2006, p.24). According to their view, pitch sigma (the SD of pitch) "…reflects frequency variability for a reasonably large time segment or passage". Phonation time (or articulation time) has been found to predict reading fluency (Horii, 1983; Cucchiarini, Strik & Boves, 2000) and refers to the proportion of the time producing audible speech in relation to the total time spent (Kormos & Dénes, 2004). Protopapas (in press) argues that phonation time is more strongly related to fluency than pause measures. Thus, we used pitch ratio (pitch SD/reading time), phonation time ratio (phonation time/total reading time) and the total number of voice breaks during reading. Pseudoword decoding performance was also included as an indicator of participants' general ability to decipher unknown words. Finally, we used a RAN task (rapid naming of digits) since performance on RAN tasks has been associated with reading fluency and reading automaticity.

Method

Participants

Twenty-seven students attending 2nd and 5th grade of primary school participated in the study. They were randomly selected from two primary schools within the area of Patras and were assessed in March 2013. Of the students, 13 (5 boys and 8 girls) attended 2nd grade and 14 students (8 boys and 6 girls) attended 5th grade. Their mean age was 102.25 months (SD = 4.01) and 138.78 months (SD = 3.33), respectively. They were all native Greek speakers. None of them had visual or hearing difficulties or any other special educational needs.

Materials

The linguistic material used in this study was drawn from the visual vocabulary of the 2nd and 5th Grades of primary school. Students had already been introduced to the words through their respective reading textbooks. As much as possible, word items covered the most frequent syllabic patterns (Consonant-Vowel-Consonant) and all cases of deviation from the 1:1 phoneme-grapheme correspondence rules occurring in the Greek language (i.e. vowel diphthongs, double consonants and so on). Pseudowords were constructed by placing words in an orthogonal matrix (i.e, a nxn matrix, where *n* is the number of letters for each word) and selecting the letters from the main diagonal of the matrix to form the pseudowords.

Twenty middle-frequency words (frequency = 0.32%, range = 0.06%) and twenty pseudowords were used in the study. Word items consisted of two and three-syllable content and function words. The words ranged in length from four to seven letters. Pseudowords were constructed from the word battery and shared the same length, syllabic structure and stress patterns of the words. Stimuli were presented one at a time on the computer screen preceded by a fixation point (i.e. *) for 1000 milliseconds. Word and pseudoword items disappeared as soon as the participant had completed the vocal response. No feedback was provided. There was a 1000 milliseconds interval before presentation of the next sequence (fixation point, stimulus, etc.). Item lists were presented in a different random order in 48pt Arial font size. Testing sessions did not exceed 15 minutes each.

RAN tasks

Colour naming: A 4x4 colour matrix was used and participants had to state as quickly as possible the name of the colours (red, yellow, blue, green). Each row of the matrix consisted of four colours in a random order.

Digit naming: A 4x4 number matrix was used and participants had to state as quickly as possible the name of the numbers (the selected numbers consisted of two syllables). Each row of the matrix consisted of four numbers in a random sequence.

Stimuli for both colour and digit naming tasks were presented on the computer screen for 30 seconds preceded by a fixation point (i.e. *) for 1000 milliseconds. Participants had to produce the names of the colours and the digits as quickly and accurately as possible. The total count of correct naming efforts was scored for each participant.

Text reading

Reading fluency was assessed with an age-appropriate text-reading paradigm adopted from the reading textbooks used in Grades 2 and 5 and a control text passage taken from the web. All texts were short and simple. For Grade 2, the text (a narrative) consisted of 75 words and 163 syllables and for Grade 5 the narrative text consisted of 79 words and 162 syllables. As the control text, a passage about summer vacations on an island was used that consisted of 74 words and 176 syllables. Both errors and reading times were recorded. Text passages were presented on a computer screen, proceeded by a fixation point (i.e. *) for 1000 milliseconds. Text item disappeared as soon as the participant had completed reading. No feedback was provided.

Fluency measures

Fluency rubric: Reading fluency was assessed using the qualitative fluency rubric of Fountas and Pinnell (2009) titled “Six Dimensions Fluency Rubric”. The rubric consists of five main dimensions that rate reading (i.e. rate, phrasing, intonation, pausing, and stress) and a sixth dimension (i.e. integration) that assesses the integration of the first five dimensions. A score, ranging from one to four, is assigned to each dimension. Three different evaluators were used to score all recordings in order to control for possible variation in scoring. The evaluators were experienced primary school teachers, but were not connected or related to the investigation presented here. A total average score was calculated for all factors and evaluators (total prosody score).

Apparatus and procedure

Students were tested individually in a quiet room within the school setting and were asked to read aloud, as quickly and as accurately as possible, all visually presented items (words, pseudowords, RAN items and text readings). All items were presented randomly. Prior to each testing session, participants completed a practice trial for all experimental procedures to ensure familiarity.

Oral responses were recorded via a microphone connected to the computer, within the Cognitive Workshop (v.1.1) experimental control shell. The digitized oral reading recordings were analyzed using Praat v.5.3.59 (Boersma & Weenink, 2011). Praat software (shown in Figure 1) allowed for obtaining basic measurements of pitch, speech duration, pause duration, phonation time etc.

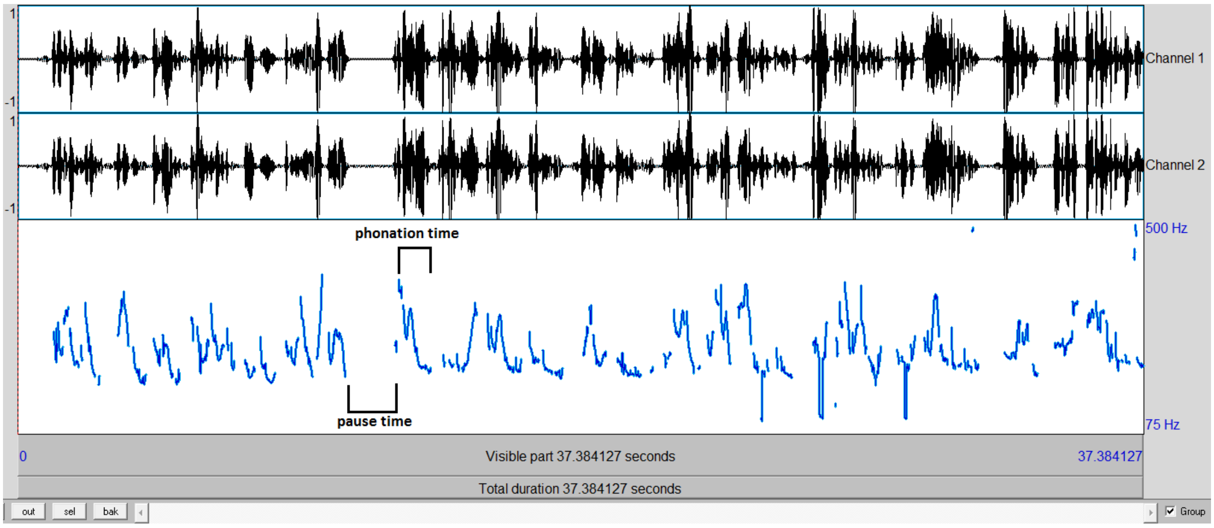

Figure 1. Sample waveform and pitch contours of oral text reading computed in Praat

Results

Means, standard deviations and an independent t-test analysis between groups for the decoding and RAN measures were determined for each grade level and are reported in Table 1. Fifth graders were significantly faster than second graders on word decoding reaction time ($p = .01$). Inspection of the two groups indicates that the mean reaction time score for Grade 2 students (836.54 milliseconds) was significantly higher than the score (720.36 milliseconds) for Grade 5 students. Second and fifth graders did not differ significantly either on pseudoword decoding reaction time scores ($p = .51$) or on word decoding accuracy ($p = .33$). This is in step with research findings (Sarris & Porpodas, 2008) suggesting that second graders experience a developmental shift from relying on the alphabetic strategy to utilizing bigger orthographic segments.

Significant differences between groups were found for both RAN digit and colour tasks ($p = .003$ and $p = .002$, respectively). Fifth graders outperformed their second grade peers in reading rate assessment on both types of text. The mean CWpM score for Grade 5 students (93.87 words for the control text and 121.1 words for the narrative text) was significantly higher than the score (66.62 words for the control text and 93.66 words for the narrative text) for Grade 2 students. The eta squared (η^2) effect size index was .27 and .21 respectively.

Table 2 displays the Pearson's correlations between all the measures. The analysis was run to measure the relationship between CWpM scores (control text) and the three predictor variables (i.e. RAN digits and pseudoword decoding performance).

A multiple regression was employed to determine the best linear fit of RAN digits, pseudoword reading speed and accuracy for predicting CWpM scores. The means, standard deviations, and correlations are presented in Table 2. RAN-digits ($r = .70$, $n = 27$, $p < .001$), pseudoword decoding speed ($r = -.61$, $n = 27$, $p < .001$) and pseudoword decoding accuracy ($r = .64$, $n = 27$, $p < .001$) were all significantly correlated with CWpM scores. This combination of variables significantly predicted CWpM scores ($F(3,23) = 15$, $p < .001$), with all four variables significantly contributing to the prediction. The beta weights, presented in Table 3, suggest that RAN scores contribute most to predicting CWpM scores, and that pseudoword decoding speed and accuracy also contribute to this prediction. The adjusted R squared value was .62, indicating that 62% of the variance in CWpM scores was explained by the model.

Table 1. Comparison of Grades 2 and 5 on word and pseudoword decoding speed and accuracy, RAN-colours, RAN-digits and CWpM (*n* = 27)

Variables	Mean	SD	t	df	p	η^2
Word decoding speed			2.78	25	.01	.22
Grade 2	836.54	107.97				
Grade 5	720.36	108.94				
Word decoding accuracy			-.99	25	.33	.04
Grade 2	98.46	4.27				
Grade 5	99.64	1.34				
Pseudoword decoding speed			2.05	25	.051	.14
Grade 2	1473.38	529.1				
Grade 5	1160	212.78				
Pseudoword decoding accuracy			-4.73	25	.000	.15
Grade 2	69.23	17.78				
Grade 5	93.93	7.89				
Colour naming			-3.54	25	.002	.47
Grade 2	32.23	7.4				
Grade 5	45.14	10.97				
Digit naming			-3.25	25	.003	.29
Grade 2	58.77	10.75				
Grade 5	74.79	14.43				
CWpM –control			-3.21	25	.004	.27
Grade 2	66.62	22.47				
Grade 5	93.87	21.62				
CWpM –narrative			-2.63	25	.014	.21
Grade 2	93.66	31.2				
Grade 5	121.1	22.71				

Table 2. Mean, SD's and Correlations for CWpM (control text) and predictor variables

Variable	Mean	SD	1	2	3
CWpM-control	80.75	25.67	.70**	-.61**	.64**
Predictor variables					
1.RAN-digits	67.07	14.97		-.45*	.58**
2.Pseudoword decoding speed	1310.89	421.08			-.34
3.Pseudoword decoding accuracy	82.04	18.31			

Note. * < .05, ** < .01, N = 27

Table 3. Multiple Regression Analysis: Summary for RAN, pseudoword reading speed and accuracy predicting CWpM-control

	Unstandardized Coefficients		Standardized Coefficients		95% CI for B
	B	SE	B	t	
(Constant)	31.068	24.531		1.27	(-19.68 / 81.81)
RAN-digits	.618	.271	.360	2.28*	(.057 / 1.18)
Pseudoword decoding speed	-.021	.008	-.346	-2.54*	(-.038 / -.004)
Pseudoword decoding accuracy	.438	.211	.312	2.08*	(.022 / .873)

Note. * < .05, N = 27

Table 4. Mean, SD's and intercorrelations for CWpM (narrative text) and predictor variables

Variable	Mean	SD	1	2	3
CWpM-narrative	107.89	30.04	.68**	-.65*	.63**
Predictor variables					
1.RAN-digits	67.07	14.97		-.45*	.58**
2.Pseudoword decoding speed	1310.89	421.08			-.34
3.Pseudoword decoding accuracy	82.04	18.31			

Note. * < .05, ** < .01, N = 27

Table 4 displays basic descriptive statistics and Pearson correlation coefficients between all the measures. The analysis was run to measure the relationship between CWpM scores (narrative text) and the three predictor variables (i.e. RAN digits and pseudoword decoding performance). A multiple regression was employed to determine the best linear fit of RAN digits, pseudoword reading speed and accuracy for predicting CWpM scores. The means, standard deviations, and intercorrelations are presented in Table 4. RAN-digits ($r = .68$, $n = 27$, $p < .001$), pseudoword decoding speed ($r = -.65$, $n = 27$, $p < .001$) and pseudoword decoding accuracy ($r = .63$, $n = 27$, $p < .001$) were all significantly correlated with CWpM scores. This combination of variables significantly predicted CWpM scores ($F(3,23) = 15.72$, $p < .001$), with all four variables significantly contributing to the prediction. The beta weights, presented in Table 5, suggest that RAN scores also contributed to predicting CWpM scores, however, pseudoword decoding speed and accuracy may be better predictors of CWpM scores. The adjusted R squared value was .63, indicating that 63% of the variance in CWpM scores was explained by the model.

Table 5. Multiple Regression Analysis: Summary for RAN, pseudoword reading speed and accuracy predicting CWpM-narrative

	Unstandardized Coefficients		Standardized Coefficients		95% CI for B
	B	SE	B	t	
(Constant)	60.434	28.263		2.138*	(-1.968 / 118.9)
RAN-digits	.629	.313	.313	2.012*	(-.018 / 1.275)
Pseudoword decoding speed	-.029	.010	-.400	-2.984**	(-.048 / -.009)
Pseudoword decoding accuracy	.521	.243	.317	2.146*	(.019 / 1.023)

Note. * < .05, ** < .01, N = 27

Table 6. Comparison of Grades 2 and 5 on prosody, voice breaks, phonation time ratio and pitch ratio

Variables	Mean	SD	t	df	p	η^2
TOTAL PROSODY-control			-4.99	25	.000	.48
Grade 2	1.85	.60				
Grade 5	2.97	.56				
TOTAL PROSODY-narrative			-3.76	25	.001	.36
Grade 2	2.56	.87				
Grade 5	3.58	.50				
Voice breaks-control			3.80	25	.001	.36
Grade 2	141.38	21.39				
Grade 5	116.21	12.06				
Voice breaks-narrative			2.82	25	.009	.23
Grade 2	115.38	17.89				
Grade 5	96.29	17.24				
Phonation time ratio-control			-1.88	25	.07	.12
Grade 2	.53	.09				
Grade 5	.59	.08				
Phonation time ratio-narrative			-.64	25	.53	.02
Grade 2	.62	.09				
Grade 5	.64	.08				
Pitch ratio-control			-2,65	25	.014	.21
Grade 2	.59	.27				
Grade 5	.93	.37				
Pitch ratio-narrative			-3,65	25	.001	.36
Grade 2	.72	.28				
Grade 5	1.33	.54				

Means, standard deviations and an independent t-test analysis between groups for the prosodic measures of the analysis (i.e. total number of voice breaks, phonation time ratio and pitch Standard Deviation ratio) for each grade level and are shown in Table 6. Fifth graders were significantly different from second graders on all prosodic measures. Statistically significant differences were found on prosody evaluation for both the control and the narrative text ($p = .000$ and $p = .001$ respectively).

Significant differences between groups were found for total number of voice breaks ($p = .001$ and $p = .009$, for control and narrative texts respectively). Fifth graders performed equally well as their second grade peers did in phonation time ratio (PtR) on both types of text. The mean PtR scores for Grade 5 students (.59 for the control text and .64 for the narrative text) were not significantly higher than the score (.53 for the control text and .62 words for the narrative text) for Grade 2 students. These results are summarily presented in Table 6 above.

The next table (Table 7) displays Pearson correlation coefficients between all the measures. The analysis was run to measure the relationship between prosodic evaluation average scores (control text) and the three predictor variables (i.e. phonation time ratio, voice breaks and pitch SD ratio).

A multiple regression was conducted to determine the best linear combination of voice breaks, phonation time ratio and pitch ratio for predicting prosody assessment scores. The means, standard deviations, and correlations are presented in Table 7. Voice breaks ($r = -.83$, n = 27, p < .001), phonation time ratio (r = .72, n = 27, p < .001) and pitch ratio (r = .78, n = 27, p < .001) were all significantly correlated with prosody assessment scores. This combination of variables significantly predicted prosody (F(3,23) = 35.62, p < .001), with all four variables significantly contributing to the prediction. The beta weights, presented in Table 8, suggest that voice breaks contribute most to predicting prosody assessment scores, and that pitch ratio and phonation time ratio also contribute to this prediction. The adjusted R squared value was .80, indicating that 80% of the variance in prosody assessment scores was explained by the model, a rather large effect.

A multiple regression was conducted to determine the best linear combination of voice breaks, phonation time ratio and pitch ratio for predicting prosody assessment scores. The means, standard deviations, and correlations are presented in Table 9.

Table 7. Mean, SD's and correlations for prosody assessment (control text) and predictor variables

Variable	Mean	SD	1	2	3
Prosody-control	2.43	.81	-.83**	.72**	.78**
Predictor variables					
1.Voice breaks	128.33	21.17		-.60**	-.67**
2.Phonation time ratio	.56	.09			.53**
3.Pitch ratio	.76	.37			

Note. * < .05, ** < .01, N = 27

Table 8. Multiple Regression Analysis: Summary for voice breaks, phonation time ratio and pitch ratio predicting prosody - control text

	Unstandardized Coefficients		Standardized Coefficients		95% CI for B
	B	*SE*	*β*	*t*	
(Constant)	2.577	1.062		2.427*	(.380 / 4.773)
Voice breaks	-.016	.005	-.432	-3.371**	(-.027/ -.006)
Phonation time ratio	2.450	1.015	.272	2.413*	(.350/ 4.549)
Pitch ratio	.768	.267	.348	2.876**	(.216 / 1.320)

Note. * < .05, ** < .01, N = 27

Table 9. Mean, SD's and intercorrelations for prosody assessment (narrative text) and predictor variables

Variable	Mean	SD	1	2	3
Prosody-narrative	3.09	.86	-.70**	.67**	.71**
Predictor variables					
1.Voice breaks	105.48	19.77		-.51**	-.25
2.Phonation time ratio	.56	.09			.37
3.Pitch ratio	1.03	.53			

Note. * < .05, ** < .01, N = 27

Table 10. Multiple Regression Analysis: Summary for voice breaks, phonation time ratio and pitch ratio predicting prosody - narrative text

	Unstandardized Coefficients		Standardized Coefficients		95% CI for B
	B	*SE*	*β*	*t*	
(Constant)	2.757	.905		3.047**	(.885 / 4.628)
Voice breaks	-.020	.004	-.452	-4.716**	(-.028/ -.011)
Phonation time ratio	2.488	.993	.250	2.506*	(.434/ 4.542)
Pitch ratio	.828	.146	.505	5.676**	(.527 / 1.130)

Note. * < .05, ** < .01, N = 27

Voice breaks ($r = -.70$, $n = 27$, $p < .001$), phonation time ratio ($r = .67$, $n = 27$, $p < .001$) and pitch ratio ($r = .71$, $n = 27$, $p < .001$) were all significantly correlated with prosody assessment scores. This combination of variables significantly predicted prosody ($F(3,23) = 41.29$, $p < .001$), with all four variables significantly contributing to the prediction. The beta weights, presented in Table 10, suggest that pitch ratio contributes most to predicting prosody assessment scores, and that voice breaks and phonation time ratio also contribute to this prediction. The adjusted R squared value was .82, indicating that 82% of the variance in prosody assessment scores was explained by the model.

Conclusions

This paper presented preliminary results on a variety of oral reading rate and reading prosody measures employing 2nd and 5th grade primary school students. Results indicated that differences among groups in reading rate may be attributed to children's development of automaticity skills. As readers became proficient with the whole-word reading strategy on decoding, reaction time scores decreased and accuracy scores increased. In other words, as students become more competent with letter-sound correspondences, they move beyond processing individual letters (i.e. letter-by-letter decoding strategy) to a more elaborated whole-word orthographic processing strategy. Thus, they start utilizing larger grain size orthographic units, or group of letters (Ziegler & Goswami, 2006). When whole-word reading strategies are established, familiar words are identified quickly and effortlessly (Castles & Nation, 2006).

Results revealed that performance on all RAN measures was significantly higher for fifth graders compared to their second grade peers. Similar outcomes were obtained for the decoding speed measures. As young readers develop their automaticity skills, word recognition time scores decrease. In step with previous research, analysis on RAN scores pinpointed a close relation with reading fluency (Norton & Wolf, 2012). The exact nature of how performance on rapid automated naming tasks and reading fluency are correlated is still a rather baffling issue for researchers. Nevertheless, RAN tasks could still be considered as universal predictors of reading fluency (Georgiou et al., 2008b).

A key aim of this paper was to search for a link between the qualitative assessment of reading prosody using rubrics compared to a computerized analysis of speech. In this study we adopt the "Six Dimensions Fluency Rubric" qualitative fluency rubric of Fountas and Pinnell (2009). Three independent evaluators provided with an average score to control for subjectivity. Oral reading prosody scores were regressed for total number of voice breaks, phonation time ratio and pitch ratio scores on two different types of texts. These measurements were extracted by using the Praat voice analysis software. The multiple regression analysis revealed that all three variables had statistically significant and independent contribution to reading prosody performance for both the control and narrative text.

Despite a general consensus on the definition of reading fluency as a multidimensional construct that encompasses accuracy, speed and prosody, a notable divergence between researchers on assessment practices/techniques is evident. LaBerge and Samuels (1974) for example, held the view that reading fluency can be assessed using reading accuracy and reading rate, whilst others argued that prosodic features are of importance and therefore should not be neglected (Rasinski, Rikli & Johnston, 2009). The focus on reading rate performance stems from the fact that it is assumed to serve as a general indicator of reading fluency (Morris et al., 2013). So, it is important for both reading instruction as well as for reading intervention programs to have an accurate measure of reading range for each grade level. Without valid reading scale scores, it is difficult for anyone, who works with struggling readers, to properly assess the student's reading difficulty and, therefore provide an effective intervention program for the particular student. Yet, proficiency in oral reading presupposes a balance in pitch, emphasis on salient words and so on (Patel & McNab, 2011). Besides that, recent research offered some evidence that slow and laborious reading rate negatively affects performance on comprehension tasks (Archer, Gleason & Vachon, 2003). This makes sense if one considers that non-fluent reading (where significant variation in reading rate is present, and stress assignment or intonation errors are noted) is unlikely to lead to complete text comprehension (Rasinski, 2004; Schwanenflugel et al., 2004; Rasinski, Rikli & Johnston, 2009).

As mentioned earlier in this report, the prosodic features of oral reading are commonly assessed with qualitative rubrics (Zutell & Rasinski, 1991; Fountas & Pinnell, 2006; Rasinski, Rikli & Johnston, 2009; Benjamin et al., 2013). Schwanenflugel and her collaborators (2004) though acknowledging the practicality of such measurements, usually do not interpolate the independent contribution of reading rate and reading accuracy. The current trend involves the spectrographic analysis of prosodic features in oral reading (Schwanenflugel et al., 2004; Cohen, Lee Hong & Guevara, 2010; Balogh et al., 2012; Sitaram, & Mostow, 2012).

Limitations

This is a preliminary investigation employing a combination of "classic" techniques and more advanced ones requiring expert software. A notable limitation of the present report is the small sample size involved. One should take into consideration that the number of participants is often dependent on the total amount of time required for each individual assessment session. If, for example, a classroom-wide assessment were possible, then the number of available participants should have been higher. A second limitation, which should also be considered and be the scope of future investigations is the exclusion of learning disabled students in reading. The inclusion of such a subsample would have provided a better perspective into the workings of reading in Greek. Future research should look into this matter.

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