



Speech rhythm sensitivity in pre-readers: What role does it have in reading acquisition?

Dr Andrew J. Holliman

Acknowledgements

I am very grateful to the Nuffield Foundation for their generous support of this project. I would like to thank Claire Pillinger and Helen Cunnane, my excellent research assistants who collected data at Time 1 (Reception Year) and Time 2 (Year 1) respectively. I would like to express my appreciation to members of the advisory group (Clare Wood, along with the teachers, parents, and children from participating schools) for their invaluable feedback at different stages of the project and finally to those teachers, parents, and reading researchers whose comments have shaped the final version of this report (Natalie Clelland, Claire Newson, Jennifer Reeves, Sarah Critten, and Julia Carroll).

The research project was funded by a grant from the Nuffield Foundation, an endowed charitable trust that aims to improve social well-being in the widest sense. It funds research and innovation in education and social policy and also works to build capacity in education, science and social science research. The Nuffield Foundation has funded the project reported, but the views expressed are those of the author and not necessarily those of the Foundation. More information is available at www.nuffieldfoundation.org.



Summary

This study aimed to develop a test of speech rhythm sensitivity in four- to five-year-olds and to examine how performance in this test is linked to performance at word reading and spelling one year later. We found a significant, indirect link between these skills and recommend that interventions designed to enhance speech rhythm sensitivity are incorporated into early reading instruction methods, as well as wider use of speech rhythm sensitivity assessment to enable earlier identification of reading difficulties.

According to national statistics reported by the Department of Education (March, 2015), too many children in England are not reaching high standards in literacy. Moreover, standards of literacy in England are also below those of many competing nations. To address this, research has begun to focus on precursor skills that may support the development of reading and spelling abilities in young children. One such skill that is beginning to receive a great deal of research attention in relation to reading acquisition is that of speech rhythm (or prosodic) sensitivity.

Speech rhythm refers to the overarching acoustic patterns of the speech stream such as intonation, loudness, and tempo. A growing literature has shown that children with reading difficulties have problems processing the rhythm of speech. This skill develops well before formal literacy instruction; therefore, it is possible that assessments of speech rhythm may provide an early indication of potential reading difficulties in young children. Information from such assessments may also be used to inform the content of reading intervention programmes and assist in the prevention of later literacy difficulties.

In the study reported here, there were two principal aims:

- to produce and validate an assessment of speech rhythm sensitivity that could be successfully administered to a sample of four- to five-year-old pre-readers in Reception Year (the UK equivalent of Kindergarten in the US), and;
- to examine the mechanisms by which speech rhythm sensitivity and other emergent literacy skills in four- to five-year-old pre-readers might interact to influence word reading and spelling one year later.

In the first phase of data collection, four- to five-year-old English-speaking children in Reception Year ($N = 101$) from three Primary Schools in the West Midlands, UK who were identified as 'pre-readers' completed a new test of speech rhythm sensitivity and were also assessed for their vocabulary knowledge, phonological awareness, and morphological awareness. In the second phase of data collection, one year later, 93 of these children (now in Year 1) were re-contacted and assessed for their word reading and spelling.

We found that children's performance on the new test of speech rhythm sensitivity – which yielded sound psychometric properties (i.e., reliability and validity) – was significantly related to their vocabulary knowledge, phonological awareness, and morphological awareness concurrently, and to their word reading and spelling one year later. A series of multiple regression and mediation analyses also revealed that pre-readers' sensitivity to speech rhythm indirectly predicts word reading and spelling abilities primarily through an influence on phonological awareness and (to a lesser extent) vocabulary and morphological awareness.

There are three key outcomes/implications of this research:

- A new measure of speech rhythm sensitivity was produced and validated using a sample of four- to five-year-old pre-readers in Reception Year (the UK equivalent of Kindergarten in the US);
- Interventions designed to enhance speech rhythm sensitivity might be incorporated into early reading instruction methods (curricula) to support the development of other emergent literacy skills

such as phonological awareness which, in turn, supports the development of word reading and spelling;

- Assessment of speech rhythm sensitivity might allow earlier identification of young children at risk of later reading difficulties as it is measurable well before other emergent literacy skills (e.g., phonological awareness) and before formal literacy instruction commences.

Background

Policy details

A recent report by the Department for Education (March, 2015) on 'Reading: the next steps' regards reading as "one of life's profound joys" (p. 5) and states "nothing is more important in education than ensuring that every child can read well" (p. 7). This is supported by converging evidence linking literacy levels to academic achievement, employment and economic prospects, and social outcomes. However, the report highlights that too many children in England are not reaching high standards in literacy. It also reports that standards of literacy in England are behind those of many competing nations. It follows that raising standards of literacy in schools is a top priority for the new government.

To improve standards within England and against international benchmarks a robust programme of systematic synthetic phonics has been introduced along with a statutory phonics screening check. Since its introduction in 2012 standards have improved year on year. However, despite this 26% of children in Year 1 – approximately one in every four – did not meet the expected standard of phonic decoding in 2014. At the same time, National Curriculum Assessments at the end of Key Stage 1 revealed that 10% of children did not reach the expected level 2 in reading and 14% did not reach the expected level 2 in writing. These statistics indicate that current reading instruction methods, and intervention methods, fail to meet the needs of all learners in English schools.

The Department for Education's statutory framework for the Early Years Foundation Stage (March, 2014, effective from September, 2014) currently stipulates that educational programmes (in relation to literacy) must involve activities and experiences that encourage children to link sounds and letters (phonics) and begin to read and write, and also ignite their interest in literacy. The use of phonic knowledge is singled out as the necessary tool for decoding regular words. Notwithstanding the strong evidence linking phonic knowledge to reading and spelling, this is somewhat at odds with the statistics reported above which demonstrate that even with systematic synthetic phonics instruction, refined over three years, many children are failing to meet government-set standards in phonics (the phonics screening check) and in reading and writing (National Curriculum Assessments). Subsequently, a recent literature has begun to focus on other precursor skills that may also support the development of reading and spelling abilities in young children.

Precursors of reading acquisition: a focus on phonology

Research over the past few decades has shown that an important determiner of successful reading acquisition is 'segmental' phonological awareness; that is, the ability to identify and manipulate sound units at the level of the syllable, rhyme, and phoneme (see Melby-Lervag, Lyster, & Hulme, 2012). Children with difficulties processing phonological information are thought to have underspecified (i.e., weaker, fuzzier, noisier) phonological representations of words (e.g., Snowling, 2000); this, in turn, makes the process of acquiring phonics (the matching of letters with speech sounds) substantially more difficult. While a converging literature has shown that segmental phonological awareness is a reliable predictor of later reading ability it is unable to account for all the variation in reading skill. Moreover, some (e.g., Chiappe, Stringer, Siegel, & Stanovich, 2002) have theorized that phonological deficits, when found, might be secondary to another underlying cause which occurs earlier on in child development. One potentially important precursor skill that is beginning to receive a great deal of research attention in relation to reading acquisition and the development of phonological awareness is that of speech rhythm sensitivity.

Speech rhythm is bound up with 'suprasegmental' phonology and refers to the overarching acoustic patterns of the speech stream such as intonation, loudness, and tempo. This skill develops in early infancy as part of a progressive attunement to one's first language (Jusczyk, 1999). A series of recent studies have shown that speech rhythm sensitivity is implicated in successful reading acquisition (e.g., Goswami et al., 2009; Holliman, Critten et al., 2014; Holliman, Williams et al., 2014; Leong et al., 2011), and in ways that are linked to, but also independent of, segmental phonological awareness (e.g., Clin et al., 2009; Holliman et al., 2012; McBride-Chang, Lam et al., 2008; Whalley & Hansen, 2006; Wood, 2006). This represents a key theoretical development, as suprasegmental phonology is neglected in current models of reading acquisition (Wood et al., 2009; Zhang & McBride-Chang, 2010).

Wood et al. (2009) reviewed the available evidence and proposed a model that aims to explain the nature of the relationship between speech rhythm sensitivity and early literacy development via three possible contributory pathways. In the first pathway, it was suggested that children are born with a periodicity bias (Cutler & Mehler, 1993) which allows them to ‘tune in’ to the rhythmic properties of speech in their environment. This allows them to bootstrap their way into spoken word recognition, which facilitates the development of vocabulary and in turn, phonological awareness (Walley, 1993). In the second pathway, it was argued in accordance with Chiat (1983) and Kitzen (2001) that speech rhythm sensitivity (to linguistic stress in particular) may facilitate the identification of phonemes in words (which are easier in stressed rather than unstressed syllables). It may also promote the identification of onset-rime boundaries given that the peak of loudness in a syllable corresponds to vowel location (Scott, 1998), which may support decoding skill via analogical reasoning (Goswami, 2003; Goswami et al., 2002). In the third pathway, it was argued that the relationship between speech rhythm sensitivity and literacy may be explained via its link with morphological awareness in decoding multisyllabic words, which requires the additional skill of stress assignment (i.e., knowing to pronounce the word ‘together’ as toGEther, rather than TOgether, for example).

In spite of some notable exceptions (e.g., Holliman, Critten et al., 2014) few have fully examined the pathways of relationships proposed by Wood et al. (2009). Furthermore, no study to date has investigated whether (and how) speech rhythm sensitivity in pre-readers can predict later reading acquisition; this is an important omission because such a study would indicate whether there is a systematic (causal) effect of speech rhythm sensitivity on reading acquisition. This focus on pre-reading skills is important because it rules out the possible reverse relationship in which scores on speech rhythm sensitivity depend upon reading skill. However, at least one challenge of such a study is that there are few (if any) validated assessments of speech rhythm sensitivity that are suitable for children of this age.

In this study, a new assessment of speech rhythm sensitivity was developed and its relationship with measures of vocabulary, phonological awareness, and morphological awareness (concurrently) and word reading and spelling (one year later) was explored.

There were two principal aims:

- to produce and validate an assessment of speech rhythm sensitivity that could be successfully administered to a sample of four- to five-year-old pre-readers in Reception Year (the UK equivalent of Kindergarten in the US), and;
- to examine the mechanisms by which speech rhythm sensitivity and other emergent literacy skills in four- to five-year-old pre-readers might interact to influence word reading and spelling one year later.

Method

Sample

All participating children in this study were recruited from three primary schools in the West Midlands, UK. These schools were comparable in terms of locality, proportion of males to females, and percentage of pupils with additional education requirements. At Time 1, 101 four- to five-year-old English-speaking children (37 females) in Reception Year were available to take part: it was established that these children were ‘pre-readers’ in that they were unable to read a single word on a validated UK word reading test. Of these children, 93 (33 females) were available to take part at Time 2, one year later, by which time they were aged five- to six-years-old in Year 1.

Measures

The assessment battery was carefully chosen to ensure that a) appropriate constructs – based on research evidence and theory – were targeted, and b) the constructs were measured using tests that have demonstrated psychometric properties (i.e., reliability and validity) and have been standardized on UK and/or other English speaking population; thus, can be considered sound assessments of the constructs they purport to measure. The test battery covered the following skills (full details are provided in the Appendix 1):

- Speech rhythm sensitivity (perception of intonation, loudness and tempo)
 - Compound nouns
 - Word stress
 - Intonation
 - Phrase stress
- Vocabulary knowledge (knowledge of word meanings)
- Phonological awareness (the ability to identify and manipulate the sounds in words)
 - Rhyme awareness
 - Phoneme isolation
- Morphological awareness (knowledge of word structure and significance)
- Word reading
- Spelling

In Reception Year, children completed a new test of speech rhythm sensitivity (see Appendix 2) comprising four sub-tests designed to assess the full range of rhythmic features such as intonation, loudness and tempo, and were also assessed for their vocabulary knowledge, phonological awareness and morphological awareness. In Year 1, children were re-contacted and assessed for their word reading and spelling.

Findings

Measurement of speech rhythm sensitivity

It was first important to demonstrate that the new assessment of speech rhythm sensitivity – which was inspired by other available measures in the literature and designed in consultation with parents, teachers, and researchers – was suitable for the four- to five-year-old pre-readers in Reception Year. Results revealed that the measure was: not prohibitively difficult; able to detect individual differences in speech rhythm sensitivity; and sound in terms of psychometric properties given that all four sub-tests loaded strongly onto a single internally and externally consistent higher-order factor of speech rhythm sensitivity. Since there was no cause for concern regarding the new measure of speech rhythm sensitivity, its interaction with other emergent literacy skills and its influence on word reading and spelling was then examined using i) bivariate (zero-order) correlation analyses, ii) multiple regression analyses, and iii) mediation analyses following the criteria proposed by Baron and Kenny (1986).

Bivariate (zero-order) correlation analyses

Bivariate correlations (Pearson) between the key variables in this study are presented in Table 1.

Table 1. Correlation matrix between speech rhythm sensitivity, vocabulary, phonological awareness, morphological awareness (using raw scores), word reading and spelling (using ability scores)

Variable	1	2	3	4	5
1: T1: Speech Rhythm Sensitivity					
2: T1: Vocabulary	.384***				
3: T1: Phonological Awareness ¹	.367***	.266**			
4: T1: Morphological Awareness	.313**	.345***	.320**		
5: T2: Word Reading	.259*	.294**	.449***	.282**	
6: T2: Spelling	.222*	.266*	.452***	.232*	.893***

* $p < .05$; ** $p < .01$; *** $p < .001$

It can be seen from the bivariate correlations that speech rhythm sensitivity was significantly correlated with all measures in this study. It is also noteworthy that all other variables were correlated significantly with each other.

Multiple regression analyses

In order to examine whether speech rhythm sensitivity is able to make a significant contribution to word reading and spelling independently of its association with vocabulary, phonological awareness, and morphological awareness a series of standard multiple regression analyses were used (Table 2).

Table 2. Standard multiple regression analysis predicting word reading and spelling from speech rhythm sensitivity (SRS), vocabulary, phonological awareness (PA) and morphological awareness (MA)

Predictor	T2 Word Reading			ΔR^2	T2 Spelling			ΔR^2
	<i>B</i>	<i>SE B</i>	β		<i>B</i>	<i>SE B</i>	β	
T1 SRS	.023	.343	.007	.004	-.057	.273	-.023	.000
T1 Vocabulary	.627	.413	.161	.020	.463	.328	.151	.018
T1 PA	8.020	2.320	.366**	.105**	6.907	1.844	.400***	.126***
T1 MA	.732	.706	.107	.009	.314	.561	.059	.003

Note. Tabled values are presented in non-standardized regression coefficients (*B*) with standard errors (*SE*), standardized regression coefficients (β) in the final model and changes in R^2 (ΔR^2), and each line represents individual contributions are controlling for all other variables.

* $p < .05$; ** $p < .01$; *** $p < .001$

It can be seen from Table 2 that the only variable measured at Time 1 that was able to make a significant independent contribution to word reading and spelling one year later was phonological awareness: this explained 10.5% and 12.6% of the variance respectively. Once all other variables – vocabulary, phonological awareness, and morphological awareness – had been accounted for, speech rhythm sensitivity was unable to account for unique variance in word reading or spelling. This may indicate that the observed relationship between speech rhythm sensitivity and word reading and spelling is partially or completely mediated by some of the other variables in this study.

Mediation analyses

Due to the significant associations found between speech rhythm sensitivity and the other variables in this study, further analyses were undertaken to assess whether vocabulary, phonological awareness, and morphological awareness mediate the relationship between speech rhythm sensitivity and word reading,

¹ A composite measure of phonological awareness was constructed by adding together z-scores for rhyme awareness and phoneme isolation – this was to produce a single estimate of phonological measure that would include a range of phonological skills.

and between speech rhythm sensitivity and spelling. Mediation was assessed following the criteria proposed by Baron and Kenny (1986). To meet the criteria there must be i) a significant relationship between predictor and criterion, ii) between predictor and mediator, and iii) between mediator and criterion while controlling for the predictor. Then, to assess for partial or complete mediation, iv) the relationship between the predictor and the criterion should reduce or disappear (respectively) after controlling for the mediator. Sobel's test (<http://quantpsy.org/sobel/sobel.htm>) was also used to see whether the indirect effect of the predictor (speech rhythm sensitivity) on the criterion (word reading or spelling) through the mediator (vocabulary, phonological, or morphological awareness) is statistically significant²; thus, whether there is a statistically significant reduction in the effect of the predictor on the criterion, after including the mediator in the model (the mediation effect).

In predicting **word reading**, speech rhythm sensitivity, when entered without any control variables, was a significant predictor, $Beta = 0.259$, $t(89) = 2.531$, $p = .013$; however, when it was entered simultaneously with vocabulary, phonological awareness, or morphological awareness this relationship became non-significant. This indicates that vocabulary, phonological awareness, and morphological awareness mediate the link between speech rhythm sensitivity and word reading. Results from Sobel's test revealed a significant indirect (mediation) effect of speech rhythm sensitivity on word reading through phonological awareness ($z = 2.82$, $p = .005$), but not through vocabulary ($z = 1.81$, $p = .071$) or morphological awareness ($z = 1.76$, $p = .079$). The same pattern of results was observed in predicting **spelling**: speech rhythm sensitivity, when entered without any control variables, was a significant predictor, $Beta = 0.222$, $t(89) = 2.145$, $p = .035$; however, when it was entered simultaneously with vocabulary, phonological awareness, or morphological awareness this relationship became non-significant. This indicates that vocabulary, phonological awareness, and morphological awareness mediate the link between speech rhythm sensitivity and spelling. Results from Sobel's test revealed a significant indirect (mediation) effect of speech rhythm sensitivity on spelling through phonological awareness ($z = 2.89$, $p = .004$), but not through vocabulary ($z = 1.69$, $p = .091$) or morphological awareness ($z = 1.48$, $p = .140$).

Conclusions

A number of paradigms have been developed to assess children's sensitivity to speech rhythm, but these can often be criticised for placing heavy demands on verbal short-term memory and for yielding poor levels of internal and external reliability. There is a paucity of available measures that are suitable for young children in the earliest stage of reading development. This research demonstrates that speech rhythm sensitivity can be reliably measured in four- to five-year-old pre-readers in Reception Year (the UK equivalent of Kindergarten in the US) using a validated assessment tool. This development is of great value to researchers and educators alike who may wish to examine young children's sensitivity to speech rhythm.

Bivariate (zero-order) correlation analyses revealed that four- to -five-year-old children's sensitivity to speech rhythm was significantly related to their vocabulary knowledge, phonological awareness, and morphological awareness concurrently, and to their word reading and spelling one year later. This is consistent with a growing literature (most of which is concurrent in nature and using older children) which demonstrates associations between these skills. However, a series of standard multiple regression analyses revealed that four- to -five-year-old children's sensitivity to speech rhythm is unable to make a significant contribution to word reading and spelling one year later independently of its association with vocabulary knowledge, phonological awareness, and morphological awareness. Indeed, of the measures taken from pre-readers in Reception Year, the best predictor of Year 1 word reading and spelling attainment was phonological awareness, and this was perhaps unsurprising given the wealth of research in this area.

However from the mediation analyses, and Sobel's test in particular, it was found that four- to -five-year-old children's sensitivity to speech rhythm did have a significant indirect (mediation) effect on word reading and spelling one year later through phonological awareness. Thus, the influence of speech rhythm sensitivity on word reading and spelling one year later is not direct; it influences later word reading and spelling

² The reported *p*-values for Sobel's test are drawn from the unit normal distribution under the assumption of a two-tailed *z*-test of the hypothesis that the mediated effect equals zero in the population.

attainment via phonological awareness (and vocabulary and morphological awareness to a lesser extent). This finding is in line with recent evidence and models of reading (e.g., Holliman, Critten et al., 2014; Wood et al., 2009), which indicate that speech rhythm sensitivity might support early word reading and spelling indirectly via its influence on other emergent literacy skills such as phonological awareness which, in turn, supports the development of word reading and spelling. Since reading and spelling were assessed in Year 1, when children are at the earliest stages of learning to read, children did not complete multisyllabic word reading tasks or sentence reading, in which suprasegmental awareness might be expected to be particularly important beyond the role of segmental phonological awareness. It would be useful to reassess these children's literacy in Key Stage 2.

Implications for policy and practice

This research has policy implications and implications for the statutory framework for the early years foundation stage (EYFS) in particular. As noted previously, national figures reported by the Department for Education in 2014 demonstrate that that 26% of children in Year 1 did not meet the expected standard of phonic decoding. Moreover, National Curriculum Assessments at the end of Key Stage 1 also revealed that 10% of children did not reach the expected level 2 in reading and 14% did not reach the expected level 2 in writing. Most previous research has focused on the acquisition of phonics and the importance of phonological awareness in this development – a somewhat justified endeavour based on the data reported here. However, the findings may also indicate that segmental phonological skills are influenced by suprasegmental phonological skills (such as speech rhythm sensitivity) which begin to develop earlier on in child development.

In sum, this research adds to other recent studies (e.g., Holliman, Critten et al., 2014) which indicate that sensitivity to speech rhythm might support the development of phonological awareness which, in turn, supports the development of word reading and spelling. Subsequently, interventions designed to enhance sensitivity to speech rhythm might be incorporated into early reading instruction methods (curricula) to support the development of word reading and spelling via the development of other emergent literacy skills such as phonological awareness. Additionally, given that sensitivity to speech rhythm begins well before formal literacy instruction and before other emergent literacy skills (e.g., phonological awareness), teaching methods promoting awareness of speech rhythm could be particularly useful in the pre-school years and with children at risk of literacy difficulties. We have a parallel line of research directly investigating this issue (Harrison et al., submitted).

Finally, we have created a set of sensitive, valid and reliable measures of speech rhythm sensitivity for use with children as young as four years, before children have measurable levels of phonological awareness. These measures could be very useful in identification of young children at risk of later reading difficulties.

References

- Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173-1182.
- Chiappe, P., Stringer, R., Siegel, L. S., & Stanovich, K. E. (2002). Why the timing deficit hypothesis does not explain reading disability in adults. *Reading and Writing*, *15*, 73-107.
- Chiat, S. (1983). Why Mikey's right and my key's wrong: The significance of stress and word boundaries in a child's output system. *Cognition*, *14*, 275-300.
- Clin, E., Wade-Woolley, L., & Heggie, L. (2009). Prosodic sensitivity and morphological awareness in children's reading. *Journal of Experimental Child Psychology*, *104*, 197-213.
- Cutler, A., & Mehler, J. (1993). The periodicity bias. *Journal of Phonetics*, *21*, 103-108.

Department for Education (2014). Statutory framework for the early years foundation stage: Setting the standards for learning, development and care for children from birth to five (available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/335504/EYFS_framework_from_1_September_2014_with_clarification_note.pdf).

Department for Education (2015). Reading: the next steps: Supporting higher standards in schools (available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/409409/Reading_the_next_steps.pdf).

Dodd, B., Crosbie, S., McIntosh, B., Teitzel, T., & Ozanne, A. (2000). *Preschool and Primary Inventory of Phonological Awareness*. London, UK: The Psychological Corporation.

Dunn, L. M., Dunn, D. M., Styles, B., & Sewell, J. (2009). *British Picture Vocabulary Scales III*. Windsor: NFER-Nelson.

Elliott, C. D., & Smith, P. (2011). *British ability scales III*. London: GL Assessment.

Goswami, U. (2003). How to beat dyslexia. *The Psychologist*, 16, 462-465.

Goswami, U., Gerson, D., & Astruc, L. (2010). Amplitude envelope perception, phonology and prosodic sensitivity in children with developmental dyslexia. *Reading and Writing*, 23, 995-1019.

Goswami, U., Thomson, J., Richardson, U., Stainthorp, R., Hughes, D, Rosen, S., et al. (2002). Amplitude envelope onsets and developmental dyslexia: A new hypothesis. *Proceedings of the National Academy of Sciences*, 99, 10911-10916.

Harrison, E., Wood, C., Holliman, A., & Vousden, J. (submitted). The immediate and longer term effectiveness of a speech rhythm-based reading intervention in beginning readers.

Holliman, A. J., Critten, S., Lawrence, T., Harrison, E. C. J., Wood, C., & Hughes, D. J. (2014). Modeling the relationship between prosodic sensitivity and early literacy. *Reading Research Quarterly*, 49, 469-482.

Holliman, A. J., Williams, G. J., Mundy, I. R., Wood, C., Hart, L., & Waldron, S. (2014). Beginning to disentangle the prosody-literacy relationship: A multi-component measure of prosodic sensitivity. *Reading and Writing: An Interdisciplinary Journal*, 27, 255-266.

Holliman, A. J., Wood, C., & Sheehy, K. (2012). A cross-sectional study of prosodic sensitivity and reading difficulties. *Journal of Research in Reading*, 35, 32-48.

Jusczyk, P. W. (1999). How infants begin to extract words from speech. *Trends in Cognitive Sciences*, 3, 323-328.

Kitzen, K. (2001). *Prosodic sensitivity, morphological ability, and reading ability in young adults with and without childhood histories of reading difficulty*. Unpublished doctoral dissertation, University of Columbia–New York.

Leong, V., Hämäläinen, J., Soltész, F., & Goswami, U. (2011). Rise time perception and detection of syllable stress in adults with developmental dyslexia. *Journal of Memory and Language*, 64, 59-73.

McBride-Chang, C., Lam, F., Lam, C., Doo, S., Wong, S. W. L., & Chow, Y. Y. Y. (2008). Word recognition and cognitive profiles of Chinese pre-school children at risk for dyslexia through language delay or familial history of dyslexia. *Journal of Child Psychology and Psychiatry*, 49, 211-218.

Melby-Lervåg, M., Lyster, S. A. H., & Hulme, C. (2012). Phonological skills and their role in learning to read: A meta-analytic review. *Psychological Bulletin*, 138, 322-352.

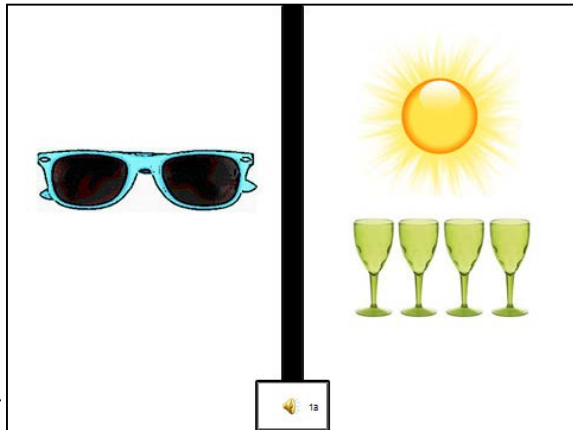
- Newcomer, P., & Hammill, D. (2008). *Test of Oral Language Development: Primary – Fourth Edition*. Austin, TX: Pro-Ed.
- Scott, S. K. (1998). The point of P-centres. *Psychological Research/Psychologische Forschung*, 61, 4-11.
- Snowling, M. J. (2000). *Dyslexia* (2nd ed.). Massachusetts, USA: Blackwell publishers.
- Walley, A.C. (1993). The role of vocabulary development in children's spoken word recognition and segmentation ability. *Developmental Review*, 13, 286-350.
- Whalley, K., & Hansen, J. (2006). The role of prosodic sensitivity in children's reading development. *Journal of Research in Reading*, 29, 288-303.
- Wood, C. (2006). Metrical stress sensitivity in young children and its relationship to phonological awareness and reading. *Journal of Research in Reading*, 29, 270-287.
- Wood, C., Wade-Woolley, L., & Holliman, A. J. (2009). Phonological awareness: Beyond phonemes. In C. Wood & V. Connelly (Eds.), *Contemporary perspectives on reading and spelling* (pp. 7-23). London: Routledge.
- Zhang, J., & McBride-Chang, C. (2010). Auditory sensitivity, speech perception, development and impairment. *Educational Psychology Review*, 22, 323-338.

Appendix 1: Test Battery

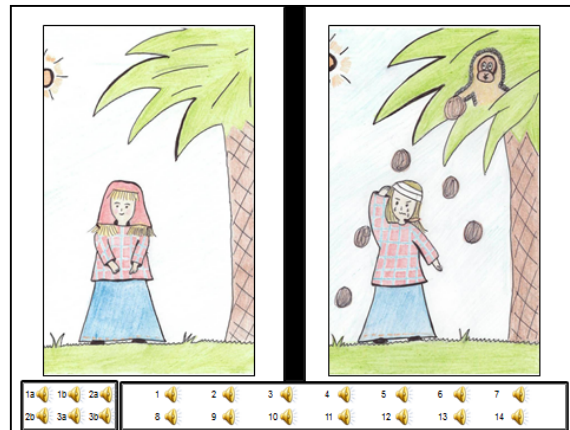
Target	Test
Speech rhythm sensitivity	New task: Brenda's Animal Park – see Appendix 2
Vocabulary knowledge	British Picture Vocabulary Scales III (Dunn, Dunn, Styles, & Sewell, 2009)
Phonological awareness	Rhyme Awareness and Phoneme Isolation subtest of the Primary Inventory of Phonological Awareness – four subtests (Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2000)
Morphological awareness	Morphology Completion subtest of TLD: Primary (Newcomer & Hammill, 2008)
Word Reading	British Ability Scales III Word Reading subtest (Elliot & Smith, 2011)
Spelling	British Ability Scales III Spelling subtest (Elliot & Smith, 2011)

Appendix 2: Brenda's Animal Park (Speech Rhythm Sensitivity)

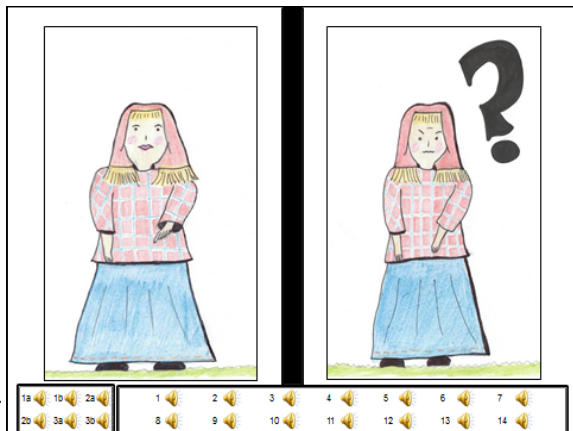
Introduction to the task: During the task, children are introduced to the main character, Brenda, who works at/in? an animal park. Brenda encounters four different kinds of problems on the animal park, which can be thought of as four subtests measuring slightly different aspects of speech rhythm sensitivity, although multiple components are usually present in each, as follows:



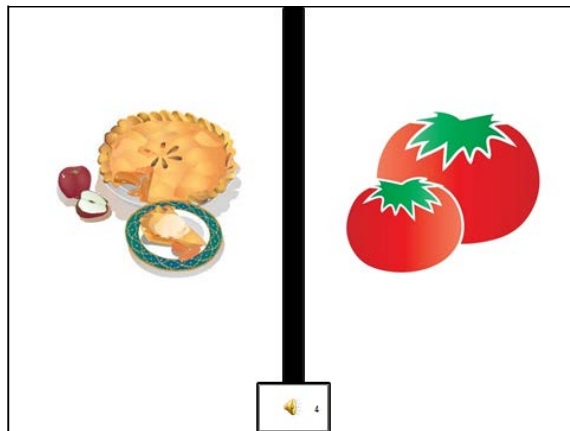
Compound Nouns: Children had to decide whether a pre-recorded utterance took the form of a compound noun (e.g., 'sunglasses') or a noun phrase (e.g., 'sun...glasses')



Word Stress: Children had to decide whether a pre-recorded word was correctly stressed (e.g., 'CROcodile') or incorrectly stressed *depicted by a coconut falling on Brenda's head* (e.g., 'croCOdile')



Intonation: Children had to decide whether a pre-recorded utterance sounded like a question (e.g., 'the farmer gets up early') or a statement (e.g., 'the farmer gets up early') implied by a rise or fall in intonation



Phrase Stress: Children had to decide which of two pre-recorded utterances (e.g., 'apple pie' [strong-weak-strong] and 'tomatoes' [weak-strong-weak]) matched the 'Ba-Ba' phrase (e.g., BA-ba-BA)

Additional information: The task was administered on a laptop using a Microsoft PowerPoint Presentation with audio files (see some examples above). For each subtest there were six practice trials where corrective feedback was provided and 14 test trials. The task was administered in the order presented above to maintain a coherent story that would be understandable to children of this age. A total score out of 56 was obtained.