EXPLORING THE ROLE OF PROSODIC AWARENESS AND EXECUTIVE FUNCTIONS IN WORD READING AND READING COMPREHENSION: A STUDY OF COGNITIVE FLEXIBILITY IN ADULT READERS

by

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ABSTRACT

The current study examined the phonological process of prosodic ability in a model of adult word reading and reading comprehension ability. All phonological tasks involve executive functions (EF) reflected in an individual's flexibility for manipulating different components of language. To account for the EF demands involved in phonological tasks of reading, EF was assessed using measures of inhibitory control and switching attention as both a control variable and predictor in each model of reading. Two research questions guided the study: 1) Do prosodic ability and EF make independent contributions to word reading, and reading comprehension ability when controlling for the other? 2) Do prosodic ability and EF make unique contributions to word reading, and reading comprehension ability when controlling for the other, in addition to controlling for vocabulary, fluid (nonverbal) intelligence, rapid automatized naming (RAN - Digits), and phonological short-term memory (PSTM)?

Participants were one hundred and three native-English speaking adults (18 to 55 years of age) recruited from Eastern Ontario. A total of 8 regression models were tested. The analyses revealed unique contributions of prosodic ability in adult word reading achievement, and EF in silent reading comprehension. Prosody's contribution to word reading above EF supports prosodic awareness as a phonological skill that can be used to explain individual differences in word reading, whereas EF's contribution to reading comprehension supports its' role in more complex reading tasks. Prosody and EF represent constructs that warrant future consideration in models of reading.

DEDICATION

To my mother Quen Quen and father Wing Kwong Chan

To my siblings Joyce, Josephine, Jonathan, and my Grandparents

Thank you for keeping me grounded and reminding me that

strength is in the eyes of the beholder.

题 献

自强不息。

谨将此文献给我的母亲 、父亲、 姐姐、妹妹、弟弟

以及外祖父母和祖父母.

衷心感谢我的家人，没有你们就不会有现在的我，你们是我最坚强的支柱.

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I stepped into the Faculty of Education full of questions about who I was, with the intention of being impactful in educational research. In closing this chapter, the questions have multiplied and the experiences have given me new perspective and purpose. To my future self, remember this moment. To every person that I have crossed paths with in this journey, thank you for the rich conversations and encouragement that has led me to reach this milestone in my life. Every bit counts. It was a challenge, and it has changed me.

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当我步入教育学院时，我满怀疑问我是谁，同时期待在教育界成为有影响力的人。在写完这章的时候，这些问题更多了，我经历的事情让我看待这些问题有了新的角度，也赋予了新的意义，但愿将来的我能记住这一刻。一路走来，感谢我遇到的每个人，感谢你们有趣的交谈和真心的鼓励，引领我走到生命中这个重要的驿站，一点一滴对我都非常重要。这段历程挑战了我，也改变了我。

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CHAPTER ONE

Introduction

Theoretical models in psychology have described a higher-order executive system that serves our decision making and problem solving behaviours (Diamond, 2013). Executive function (EF) refers to an individual's cognitive flexibility or capacity to "change perspectives or approaches to a problem, and flexibly adjust to new demands, rules or priorities" (Diamond, 2013, p. 137). EF is associated with frontal lobe development from birth into adolescence, reaching its peak in adulthood around the age of 25 years (Hunter, Edidin, & Hinkle, 2012). EF is typically assessed using tasks of inhibitory control, referring to control of automatic or prepotent responses, and switching attention, describing the shift between different mental sets of information (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). EF's involvement in reading development may vary depending on the nature of the reading task. For example, EF supports the goals of reading by coordinating our mental resources to selectively attend to relevant information and ignore distracting information, and by drawing connections between newly encoded information with content from our background knowledge.

In a society where literacy is regarded as an important skill to improve economic opportunities, reading researchers and educational practitioners recognize the importance of monitoring, assessing, and instructionally supporting young readers to set them up for reading success. In learning to read, mental attention is devoted to acquiring the basic skills for reading and EF skills are employed at different capacities dependent on the reading task. In English, this involves learning the alphabetic principle, matching sounds to letters, and decoding, which supports word recognition and vocabulary development

(Ehri, 1995). These foundational skills operate automatically in older readers, allowing mental resources to be spent on more complex reading tasks as we use reading to learn from print.

Adulthood represents a time period in the lifespan where cognitive processes are the most stable, adaptable, and flexible (Hunter et al., 2012). The level of cognitive activity operating in the adult executive system represents benchmark levels in executive functioning ability, as well as reading potential that young learners are working towards. It is necessary to consider how current models of reading development are represented when reading abilities have been mastered in adulthood. EF plays a role in text comprehension, as readers make inferences, gain meaning from texts, and update knowledge structures stored in our long-term memory as connections are made with new information (Kintsch, 1998). EF represents an underlying mechanism to support academic learning. Its role in literacy, however, is dependent on the reading outcomes measured and on the age group observed.

Accounting for individual differences in older readers including adults presents a few challenges. Phonological processing predicting early reading ability is traditionally assessed at the segmental level (e.g., phoneme blending, phoneme deletion) and loses predictive power when students are older and are better readers, commonly because participants perform at ceiling on these tasks (Lenchner, Gerber, & Routh, 1990; Torgesen & Mathes, 1998). This does not mean, however, that phonological processing is not involved in adult reading. One solution for assessing phonological skills in adults is to measure it at the suprasegmental level, which is typically more challenging. In English, suprasegmental features of language refer to phonological information provided at or above the word or segment (e.g., use of stress, tone, and intonation in multisyllabic words or across phrases).

A growing body of research has highlighted the importance of speech rhythm, or prosody in predicting early reading ability (Whalley & Hansen, 2006; Wood, Wade-Woolley, & Holliman, 2009). Prosodic awareness refers to a component of phonological awareness in spoken language represented by the manipulation of linguistic stress, tone, rhythm, and intonation (Wood & Terrell, 1998). Because English is a stress-timed language, prosody is measured through manipulating the strong and weak syllables applied at the individual word (e.g., REcord and reCORD) or at the phrase-level (e.g., WHOSE siblings are away this weekend? [Question]) More recent studies have successfully used prosodic measures involving the awareness and manipulation of multisyllabic English words to predict reading achievement in an adult population (Wade-Woolley, Austin, & Chan, 2012). Building on our understanding of phonological processes in reading, prosody represents a phonological component of language at the suprasegmental level that may be a better predictor of reading achievement ability in older readers compared to traditional assessments at the segmental level.

Purpose

The connection between phonological processing and reading has been examined extensively at the segmental level, while largely underrepresenting the parallel contribution of suprasegmental processes to support literacy acquisition (Holliman, Wood, & Sheehy, 2008; Wade-Woolley & Wood, 2006; Wood et al., 2009). All phonological processing tasks appear to involve an element of EF reflected in an individual's flexibility for manipulating different components of language. Necessarily, phonological processes not only measure a phonological skill but also measure EF demands embedded within them. What is unclear is the extent to which the phonological skill or EF component skill are involved in phonological tasks. This investigation will shed light on whether the profound relationship that has been found between phonological processing and reading ability truly represents only phonological abilities, or if phonological processing in reading is better explained when EF demands in the tasks are accounted for in individual differences when reading. EF is also heavily involved in text comprehension when assembling new information with background knowledge to develop a coherent situation model during reading. Given the involvement of EF in reading measures, the purpose of the current study was to determine whether prosodic awareness (a phonological task), and EF are related to word reading and reading comprehension processes in adults. Secondly, accounting for EF to explore the contribution of prosody allows us to answer the question of whether the phonological skill and EF capability are differentially important in reading achievement.

With general EF reaching optimal levels of functioning in adulthood (Hunter et al., 2012), there is reason to believe that the relationship between EF and reading achievement is strongest among adult readers. The basis for the present study was to examine the contribution of prosodic awareness as a phonological skill in adult reading achievement. Due to the engagement of EF skills across phonological tasks, EF was included both as a control measure and as a predictor of adult reading ability. Accounting for EF in our phonological measures is particularly important when administering phonological tasks, as EF skills are heavily involved in the completion of any task that involves flexibility of thinking. One of the benefits of investigating adult reading is that the basic requisite skills required to successfully use, transfer, and manipulate information across new and changing environments have been mastered. This provides the opportunity to make meaningful comparisons between the developmental nature and trajectory of reading across the lifespan.

Two research questions guided the present study: 1) Do prosodic ability and EF make independent contributions to word reading, and reading comprehension ability when controlling for the other? 2) Do prosodic ability and EF make unique contributions to word reading, and reading comprehension ability when controlling for the other, in addition to controlling for Vocabulary, Fluid (Non-verbal) Intelligence, RAN (Digits), and PSTM?

Since the processes involved in phonological tasks recruit EF skills, I examined whether the variance in phonological skill (prosody) explaining adult reading ability is reduced or remains unchanged when EF is included as a control and predictor in a model of reading achievement. Should the contribution of prosody remain a significant predictor after accounting for EF, this would provide additional support to prosodic awareness as a predictor of adult reading achievement. However, if EF remains a significant predictor beyond prosodic awareness, this would support the role of EF as an important contributor to reading ability, one that deserves consideration in future models of reading ability.

CHAPTER TWO

Literature Review

Research in education has focused on factors that best represent and facilitate processes of learning to read with the ultimate goal of reading for understanding. The executive system in our frontal lobes is involved in all activities of our daily lives and operates at different capacities dependent on the complexity and goals of the tasks. Flexibility and control in cognition is strongly related to reading development and the reading process (Cartwright, 2009; 2012; Wagner & Sternberg, 1987). EF is particularly important for building a mental representation that includes re-organizing new and old information together into a coherent situation model for later retrieval. More flexible readers demonstrate greater awareness of their reading behaviour, and are more successful at monitoring and modifying behaviours based on the goals of the reading activity. Reading researchers have examined in-depth the underlying cognitive mechanisms important for reading success (e.g., phonological processing, naming speed). However, despite our best efforts, current models of reading cannot fully explain individual differences in reading abilities. In this direction, I explore the role that EF plays in phonological processing measures important for reading attainment, and examine EF as an important predictor of reading among adults.

Flexible Cognition in Phonological Measures

Phonological awareness (PA) is one of the strongest predictors of early reading achievement and involves the awareness and manipulation of sound units in oral language (Wagner & Torgesen, 1987). At the segmental level, PA is comprised of the understanding that spoken language is made up of the smallest sound units (phonemes).

Therefore, phonological processing tasks were designed to illustrate these skills in performance tasks that involved blending and segmenting speech sounds out loud (e.g., “What word does /c/…/a/…/t/ make?” “What does ‘silk’ sound like without the /l/ sound?”). Significant correlations between reading measures and tasks of this nature have been used to point to the involvement of phonology in reading. What is not frequently remarked upon, though, is the involvement of EF, which is essential in separating and re-arranging phonemes in oral language. In other words, these phonological tasks that are used to examine reading ability not only measure the phonological skills that they intended to measure, but also assessed the components of EF embedded within tasks.

The ability to manipulate speech sounds has been strongly implicated as a critical component in reading development (Stahl & Murray, 1994; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997). PA becomes less predictive of individual differences in reading ability among older readers, not because phonology ceases to be implicated in reading but because they tend to perform at ceiling on phoneme-level tasks (Lenchner et al., 1990; Torgesen & Mathes, 1998). The challenge for researchers is to identify phonological processing tasks that are sensitive to individual differences for older readers; one productive line of inquiry in this direction is prosodic awareness.

Prosodic Awareness

Much of the literature has focused on measuring phonological processing at the segmental level; yet, phonological measures can also be assessed at the suprasegmental level using tasks of prosodic awareness to predict reading (Holliman et al., 2008). Prosody refers to the speech rhythm in oral language represented by the manipulation of linguistic stress, tone, rhythm, and intonation (Wood & Terrell, 1998). This is particularly important in stress-timed languages like English when we have to apply the correct stress patterns in syllables at the word-level (e.g., REcord and reCORD) and among words within sentences that is critical to reading (e.g., WHO is coming today? [Question]). Prosody is also a pillar of oral reading fluency, along with reading with accuracy and appropriate pacing or speed. Reading prosodically involves reading with ease and accurate expression foundational to reading fluency, and closely related to reading comprehension (Kuhn, Schwanenflugel, & Meisinger, 2010).

Many of the findings on phonological awareness can also be applied to research in prosody. In recent studies, prosodic awareness has been used successfully to predict reading achievement in adults, suggesting its utility as a phonological measure of reading in older readers (Wade-Woolley et al., 2012, Wade-Woolley, Heggie, & Palm-Leis, 2013). Phonological processing measured at the suprasegmental level through prosodic awareness may be a better measure of phonological ability for older readers than segmental tasks. Wade-Woolley et al. (2012) devised an experimental task that asked participants to identify and manipulate the prosodic features in multisyllabic words. This measure was split into a two-part task administered separately across two sessions. In the first session, participants were asked to listen to a series of pre-recorded multisyllabic words and to identify the part of the word where they heard the primary stress/ strongest syllable (e.g., "Nepotism". The correct answer would be "NE"). The follow-up session played the same series of words and the participants were asked to identify the primary stress on their own and shift the main emphasis one syllable to the right to say the new word out loud (e.g., "nepotism" has the primary stress on the first syllable "**NE**potism", and with the main beat moved over one syllable to the right would shift the emphasis to the second syllable: “ne**PO**tism”).

Similar to PA, EF is a critical component in both parts of the prosodic tasks described above. The prosodic shift component relies strongly on cognitive resources to parse out syllables in a multisyllabic word to identify the one containing the primary stress (or main beat of the word). In addition, shifting the main beat over for articulation is a complex process. It involves both stress identification and manipulation to reduce the sound of the primary stress and amplifying the syllable to the right when repeating each multisyllabic word out loud.

In linguistics, the awareness of prosodic features in oral language has been described as a metaphonological process involving the production and manipulation of components of speech (e.g., rhyme, syllable awareness, alliteration; Hester & Hodson, 2009). The description of prosody as a metaphonological construct fails to recognize the EF demands built into the performance tasks. The current study will examine prosody as phonological process predicting adult reading achievement, and explore the nature of the relationship when controlling for EF.

Executive Functions

Executive functions incorporate one’s overall ability to adapt flexibly to change, through monitoring, maintenance, and applying appropriate modifications across situational contexts (Luria, 1973). Theoretical accounts that have incorporated a cognitive supervisory system include Baddeley and Hitch’s (1974) multi-component working memory model. The model describes a central executive for higher-order thinking and problem solving that coordinates between two temporary stores encoding auditory and visual-spatial information. The executive system involves a number of interconnected but separable processes. Two EF processes modeled in Miyake et al. (2000) were assessed in the current study: inhibitory control and switching attention. Inhibitory control refers to the ability to suppress an automatic or prepotent response to focus on relevant information and ignore irrelevant or distracting information, and switching attention refers to the ability to shift attention accordingly between two or more mental sets of information based on a set of rules.

An influential article by Miyake et al. (2000) examined the processes of EF in adult college students (n=137). The purpose of the study was to examine experimental tasks described in previous literature reported to measure separate executive functions. The study focused on three constructs well accepted in the literature: inhibitory control, switching (mental set-shifting), and updating (includes monitoring of information). In examining a group of cognitively healthy adult participants, Miyake et al. (2000) administered multiple measures of each EF skill to assess the unity or diversity of the tasks. They examined how the participants performed on the EF measures and whether the measures of each EF component validly measured the construct. It would be concluded that EF represents a unitary domain if strong relationships found between EF measures were not dissociable. Alternatively, if certain EF processes were found to be more related than others, or if EF processes were found to be dissociable and separate diverse processes, it would suggest that each EF skill can be assessed distinctly. In the results, Miyake et al. (2000) reported moderate correlations (0.42 to 0.63) across all measures. Using confirmatory factor analysis, a report of three factor loadings was presented across the nine measures. In addition, through structural equation modeling, the results provided empirical evidence to support typical EF processes as related but separable; a distinction that suggests executive skills may differentially impact individual differences across domains in human cognition.

Cognitive Control in the Developmental Lifespan

Davidson, Amso, Anderson, and Diamond (2006) conducted one of the first studies that compared the performance on EF measures in a large sample (n=314) that included a developmental age group (between 4 to 13 years of age) and young adults. EF skills were examined to illustrate whether age-related differences exist on EF tasks, and explored the differential role of EF across two developmental age ranges. Using computerized technology, Davidson et al. (2006) created a battery of measures that examined EF skills of working memory, inhibitory control, and task-switching (between rules) that manipulated the amount of information needed to be stored in memory for the task, as well as variation in inhibitory conditions demands (low, medium, and high). The study included four measures (Pictures, Arrows, Dots, Abstract shapes) that required the participant to respond following a first set of rules and then switch to a different rule when prompted. The purpose of the study was to evaluate how each age group performed on the EF tasks in terms of reaction time, accuracy, and percentage of anticipated responses. They predicted that level of difficulty would impact performance on EF measures. For instance, lower levels of difficulty (i.e., tasks involving low memory load/ low inhibitory control) would result in better EF performance and increased levels of difficulty (i.e., tasks involve both a high memory load/ high inhibitory control) would produce lower EF performance. They compared the performance on EF measures across the developmental age groups to examine the progression and development of each EF skill into young adulthood, under conditions that varied in memory load and level of inhibitory response.

In general, Davidson and colleagues (2006) found that young adolescents demonstrated a steady growth on inhibitory control, and their performance on inhibitory tasks during low memory load conditions when the rules were unchanged was similar to adult performance. Switching between rules and conditions had the slowest developmental progression with smaller age-related differences between age groups, likely due to the process involving much more cognitive effort. Moreover, the results of the study suggest that cognitive processes develop at different rates, and that cognitive processes are differentially implicated in learning outcomes, with more complexity in the cognitive system during adulthood. This has implications for better understanding the types and levels of cognitive processing influencing academic domains. This is particularly important in adulthood, a period where individuals are faced with challenges and greater demands that require responding flexibly towards a goal under changing conditions (e.g., postsecondary studies, search for a career or plans for the future).

EF and Academic Achievement

A cross-sectional study by Best, Miller, and Naglieri (2011) examined the executive skill of planning using three subtests of the Cognitive Assessment System (CAS) to report the relationship between EF and academic scholarship. Originating from the PASS theory (Planning, Attention, Selective, and Successive; see Das, Naglieri, & Kirby, 1994) of cognitive function, CAS comprises a system of subtests that assess each EF function. Best et al. (2011) recruited a sample (n=2036) of younger (5 to 7 years) and older students (8 to 17 years) to study the relationship between age, EF planning task performance, and reading and math achievement measured on the Woodcock-Johnson Test of Achievement-Revised. For the age-group comparisons, Best et al. (2011) found that the executive skill of planning showed the steepest slope in the younger age group indicating a rapid change in planning skill during this period. EF planning was related to reading and math ability up to the age of 15, and then continued to develop moderately into the older age range. These findings further support the role of EF as a general executive system operating both concurrently and differentially across academic achievement domains.

The EF planning tasks used in Best et al. (2011) were designed to evaluate processes from the conception of a plan, to plan execution, and monitoring the effectiveness by examining accuracy in task completion. For instance, students were to follow a set of instructions that included underlying numbers that matched in a series of rows, fill in empty boxes based on a planned code scheme (e.g., OX for A and XX for B) and a planned connections task that began with connecting numbers and letters in sequential order separately and then alternating between connecting numbers-letters (e.g., 1-A, 2-B, 3-C). This planned connections task is synonymous with the switching attention tasks described in Miyake et al. (2000) suggesting that there is a general similarity in the types of measures and operations used to assess EF functions. However, differences in the types of measures used across studies still exist and are a result of how EF sub-processes are operationalized and defined across various theoretical models.

Though the developmental account suggested in Best et al. (2011) examining cross-sectional age-group comparisons for the EF skill of planning cannot be generalized to the remaining EF domains, the results provide additional evidence to support the association between EF and academic achievement. In an earlier study, St Clair-Thompson and Gathercole (2006) also explored the connection between executive skills and overall scholastic achievement in one group of 11 to 12 year olds (n=51). They examined multiple EF measures including working memory, inhibitory control, updating of representations, and shifting attention in separate academic subjects of English, math, and science. They found that working memory predicted subject-specific performance for English and mathematics and was not predictive of science. In comparison, inhibitory control significantly explained additional variance above and beyond working memory across all three subjects of English, math and science. Taking these findings together, it appears that EF skills develop rapidly during the young adolescent period marked by the steeper slope illustrated in the age-group comparisons, which is then followed by a moderate progression where participant performance on EF tasks increases with age.

EF and Reading Comprehension

The connection between EF skills and academic achievement suggests that the association between EF and specific academic domains such as reading can also be examined. Recent work explored whether EF plays a distinct role in reading comprehension deficits when investigating a group that included normal readers, readers with attentional difficulties in behavioural regulation, and readers with specific reading deficits. This important study conducted by Sesma, Mahone, Levine, Eason, and Cutting (2009) investigated the executive skills of working memory and planning in students between the ages of 9-15 (n=60) who were classified as struggling decoders with deficits in word reading accuracy and good comprehension (n=16), fluent readers with good decoding skills and poor comprehension (n=10), two groups (n=16) comprised of students who were previously diagnosed with attention deficit/ hyperactivity disorder (ADHD) and children with a current ADHD diagnosis (n=14), and normal readers (n=30). Word reading deficits (WRD) were classified as scores below the 25^{th} percentile scores on a single standardized word recognition measure, and reading comprehension deficits (RCD) were classified as scores below the 25^{th} percentile on two out of three standardized measures of reading comprehension. Their study tested whether EF contributed differently to word reading and reading comprehension in a heterogeneous group of readers.

Sesma et al. (2009) used the Tower of London task to assess the EF skill of planning. It required examinees to begin at an initial state and reach a goal state by moving coloured discs one at a time using the fewest moves possible. The total number of moves was recorded and additional moves taken beyond the most efficient solution (described as the ‘excessive moves’) were suggested to be an indication of weak planning ability. The working memory task involved following a set of rules that required the temporary storage and manipulation of information. For verbal working memory, children were presented with tasks that tested arithmetic calculation without any aids and digit span backwards, where the examinees listened to a series of numbers sequentially and asked to repeat the series of numbers in reverse order.

Sesma et al. (2009) hypothesized that both executive skills would contribute to reading comprehension above and beyond the control measures of attention, vocabulary, fluency, and decoding, but would not contribute to word reading ability. With reading comprehension reflecting a more complex reading process compared to word reading, EF was expected to be more strongly associated with reading comprehension as a higher involvement of EF skills is needed to make meaning of the text, to consolidate information, make inferences, and relate new information with background knowledge to gain a global understanding of the text being read. The results reported that word reading was correlated with all control measures and working memory and not related to the EF skill of planning; whereas reading comprehension was strongly correlated to all measures. Using multiple regression analyses, Sesma et al. (2009) confirmed their hypothesis and presented a model that explained 63% of student performance on reading comprehension with executive skills of planning and working memory each explaining an additional 4% of the variance in the model. For word reading, the same regression model explained 69% of the variance with decoding as the strongest predictor. Sesma et al. (2009) only used tasks containing real words. For adolescents, the lists and passages administered contained many sight words, which may explain the lower EF and word reading relationship, as EF would not be recruited to the extent that complex comprehension processes would. Moreover, Sesma et al. (2009) found EF to be an important predictor of reading comprehension of students diagnosed with RCD, and not WRD beyond working memory measures.

Similar findings to further support EF as a predictor of literacy acquisition have been found in studies that assessed other literacy skills that reflect abilities in the classroom including written expression and oral reading tasks (Altemeier, Abbott, & Berninger, 2008; Locascio, Mahone, Eason, & Cutting, 2010). Cutting, Materek, Cole, Levine, and Mahone (2009) examined the contributions of reading fluency, oral language, and EF to specific reading comprehension deficits (RCD) in a population of 9 to 15 year olds (n=56). The study included two measures of word fluency: Test of Word

Reading Efficiency (TOWRE), an isolated phonemic measure of decoding efficiency, and Gray Oral Reading Test – 4 (GORT-4), the contextual fluency subtest that had students read passages out loud that became increasingly difficult in content and vocabulary. Executive functions (working memory, planning) were administered with oral language measures, which included receptive vocabulary, receptive and expressive grammar, sentence combination, grammatical comprehension, interpreting ambiguous sentences and inference generation. Cutting et al. (2009) reported that children with general reading disability (deficits in word decoding plus comprehension) had lower performance on the contextual word fluency condition measured through the oral reading of passages, and found that lower executive function was related to poor reading comprehension performance. The observation of lower EF performance to reading comprehension may be more salient among students with reading difficulties, so it would be critical to examine the differential contributions that EF has in typical word reading development and reading comprehension.

EF measures have been combined interchangeably (e.g., assessing a number of different sub-processes) in these studies to further support the executive system as a general construct containing separable but interrelated EF skills (Diamond, 2013; Miyake et al., 2000). There is evidence to suggest that EF is recruited differentially depending on the reading ability being investigated. In Sesma et al. (2009), no significant effect of EF was found for word reading, whereas EF was predictive of reading comprehension. The strongest predictor of word reading was decoding, which reflects the awareness of letter-sound relationships and correct application of this knowledge to new or unfamiliar words. Basic word reading processes including decoding are sufficiently developed by about

Grade 3, so the nonsignificant relationship found between EF and word reading in the adolescent age group is not surprising. However, recent work by Foy and Mann (2013) found that inhibitory control predicted reading performance of words and nonwords in young readers, which suggests that EF processes may be more important in younger readers when decoding is being mastered.

There is a need to examine readers outside of the adolescent age group since the executive system in the adolescent age range is still undergoing change (Hunter et al., 2012). EF reaches its peak levels in adulthood (around 25 years of age) and represents a time in our lifespan where processing capabilities demonstrate the most stability. Exploring the connections between EF and reading in adults would permit meaningful comparisons across different age groups, and establish the significance of EF as a predictor to be included in the assessment and remediation of reading.

As mentioned earlier, traditional phoneme awareness measures that examine awareness and manipulation at the segmental level are less sensitive to individual differences among older readers. Phonological processing examined at the suprasegmental level through tasks of prosodic awareness is a better measure of phonological abilities in older readers as it involves manipulating components of language of speech rhythm in multisyllabic words (e.g., linguistic stress, tone, rhythm, and intonation; see Wood & Terrell, 1998). Prosody has been shown to be predictive of early reading ability above phonological awareness (Holliman et al., 2008), and is also sensitive to individual differences in phonological ability in older readers (including adults) eliminating the problem of ceiling effects (Wade-Woolley, 2012; 2013). Dennis, Allington, and Solic (2012) suggested that prosody is an essential component for comprehension to occur, where the correct use and awareness of suprasegmental features and cues in language such as intonation and pitch is needed for reading success. At the level of connected-text, the connection between prosody and EF related to reading comprehension is still unclear. It is possible that tasks of phonological awareness that involve the manipulation of language units not only measure the phonological skill, but also measure the EF processes required in task performance. Tasks of prosodic awareness are more challenging and may impose greater EF demands than traditional phoneme awareness tasks. Therefore, a closer examination of the degree of involvement in both constructs in relation to reading ability is required. Since the inclusion of EF as a control variable has been missing in the analyses of phonological processing in reading performance, accounting for EF when examining phonological processes in models of reading ability would provide evidence regarding the strength and direction of this relationship.

The Current Study

In the current study, I aim to determine how prosodic ability and EF are implicated in word reading and reading comprehension. Specifically, I test a model that allows these two constructs to predict both types of reading outcomes (see Figure 1). Two research questions guided the present study: 1) Do prosodic ability and EF make independent contributions to word reading, and reading comprehension ability when controlling for the other? 2) Do prosodic ability and EF make unique contributions to word reading, and reading comprehension ability when controlling for the other, in addition to controlling for Vocabulary, Fluid (Non-verbal) Intelligence, RAN (Digits), and PSTM (see Figure 2).

Based on the review of the literature review, the executive system and its functions are important in coordinating attentional resources during mental operations of reading. The role of EF has been largely overlooked in phonological processing. This has important implications for our understanding of the predictors of reading. If phonological processing continues to explain variance in reading performance after EF is accounted for, then it would suggest that the measure is more accurately measuring the phonological skill. On the other hand, if phonological processing does not explain additional variance in reading when EF is controlled for, or if a relationship goes from significant to nonsignificant, then it would suggest that executive functioning is the underlying mechanism being measured in phonological tasks indicating the need to control for EF in models of reading development.

The current study examines the independent contributions of phonological processing, measured by prosodic awareness, and executive functioning, measured by inhibitory control and switching, to adult word reading and reading comprehension. Assessing the cognitive underpinnings underlying reading abilities among adults improves our understanding of the executive operations and levels of cognitive processing needed to function ably in a highly literate society.

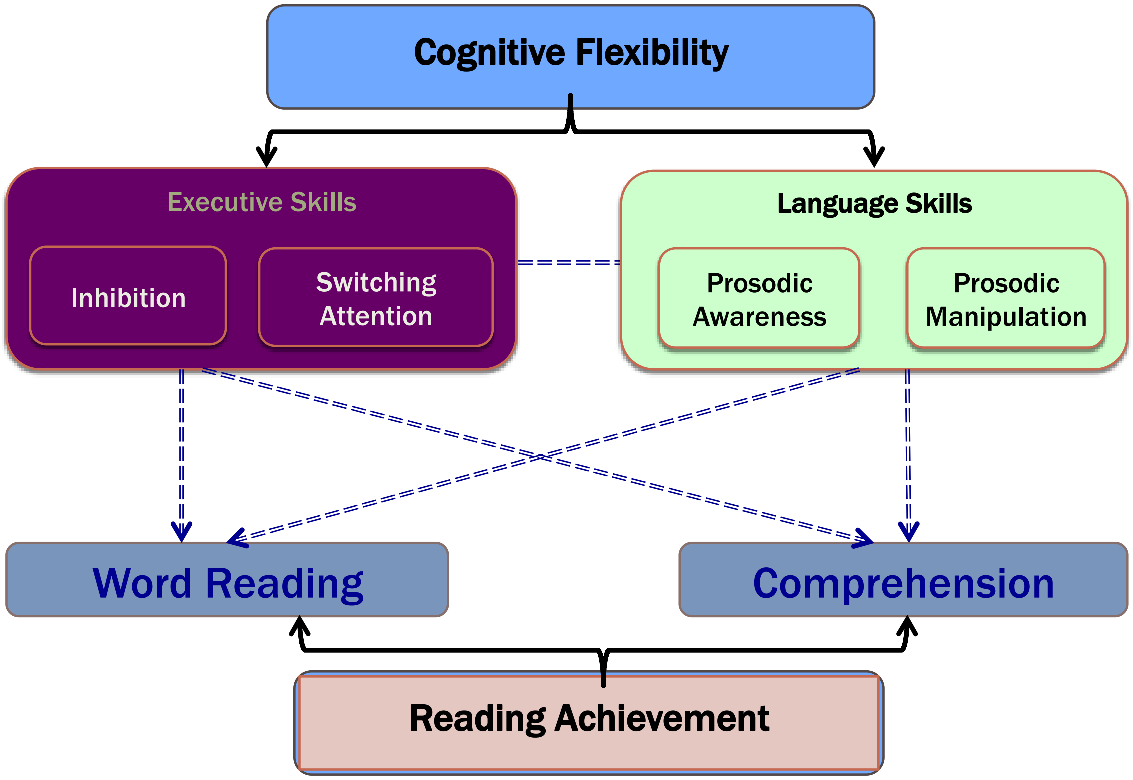

Figure 1. Proposed research model investigating individual contributions of prosodic ability and executive skills in word reading, and reading comprehension in adults.

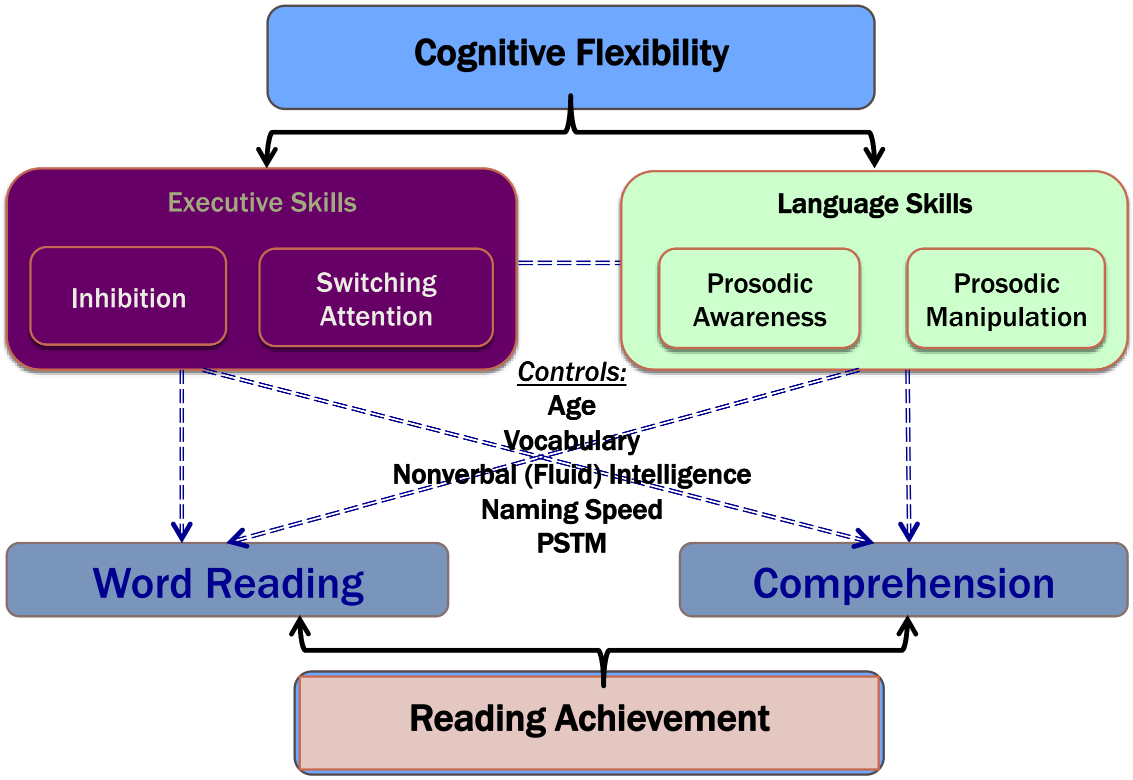

Figure 2. Research model investigating individual contributions of prosodic ability and executive skills in word reading, and reading comprehension in adults controlling for age, vocabulary, fluid intelligence, speed of lexical access, and PSTM.

CHAPTER THREE

Method

This study was part of a larger project that examined the cognitive and linguistic processes contributing to adult reading achievement (Wade-Woolley et al., 2013). The aim of the current study was to inform existing reading development models by exploring reading attainment in an adult population. In particular, the current study assessed the individual contributions of prosodic ability skills (awareness, manipulation) and executive functioning (inhibition, switching attention), both of which involve flexibility of cognition, as predictors of reading ability. Ethics approval to conduct statistical analyses using archival data was approved by the General Research Ethics Board at Queen's University, Kingston, Canada in May 2013.

The extant dataset comprised of data for both word-level reading ability (Word ID, Word Attack, TOWRE Words, TOWRE NonWords), and connected-text reading comprehension ability (Gray Oral Reading Test - Comprehension, Nelson-Denny Comprehension). Participants were also assessed on a number of cognitive predictors including receptive vocabulary (PPVT), non-verbal fluid intelligence (WASI-Matrix), naming speed (RAN Digits), and phonological short-term memory (PSTM). Only tasks related to the outcome measures of the present study were included in the data analysis. See Table 1 for an outline of the measures administered for the two testing sessions. The control measures and measures of interest included in the current data analysis are described in detail below.

Table 1

Tasks Administered in Session 1 and 2 Grouped by Construct

Session 1 (Battery A)	**Session 2 (Battery B)**
Control Variables	*Control Variables*
Fluid (Non-Verbal) Intelligence	Vocabulary (Receptive)
	RAN (Digits)
	PSTM
Word Reading	*Word Reading*
Word ID	Word Attack
TOWRE Words	TOWRE Non-Words
Reading Comprehension	*Reading Comprehension*
GORT-4 (Oral Reading Task)	Nelson-Denny (Silent Reading Task)
Prosodic Ability - Awareness	*Prosodic Ability - Manipulation*
Stress ID (word)	Stress Move – Manipulation (word)
Prosodic Disambiguation (phrase)	
Executive Function	
Inhibition and Inhibition/Switching (verbal) *Colour Stroop*	
Switching Attention (Set-Shift) (non-verbal visual-motor) *Trail Making Test*	

Participants

The original study included 103 native-English Adult speakers (*M* = 27.64 years, *SD* = 7.85 years) from Eastern Ontario, Canada. The age of participants ranged from 18.58 years to 54.58 years of age with a total of 11 male and 92 female participants. Each participated in two, one-to-one sessions of approximately one hour each with trained research assistants to examine the cognitive and linguistic processes that contribute to adult English reading achievement. The criterion of participation included self-report of English as their first language, no current/ former history of cognitive impairment, or language difficulties that would make it difficult to participate in reading tasks. Although socioeconomic status was not reported and therefore could not be assessed, the majority of recruitment occurred at Queen's University and the Kingston community among a population of individuals who were enrolled in, or had completed post-secondary level education, including those who were pursuing post-graduate education at the University.

The tasks administered in sessions A and B is listed in Table 1. The majority of the test measures used to assess each construct are standardized tests that yield standard scores and percentiles. For the current analyses, the raw scores for each task were used. In Chapter 4: Results, I provide a description of the current sample by examining the standard scores to compare it with the norming sample.

Instruments

Control Measures

Verbal Intelligence

The Peabody Picture Vocabulary Test (PPVT-III) assessed participants' verbal intelligence through receptive (listening) vocabulary (Dunn & Dunn, 1997). It contains normative data for 2 years of age to 90 years. In this measure, the participant must correctly match a target picture to a vocabulary word spoken by the experimenter. There were a total of four illustrations presented with each vocabulary word, which included the target picture among three distractors. There were a total of 17 sets of 12 words each that increased in level of difficulty. The participant received one point for each correct response for a total score out of 204 items. The task always began with two practice items before starting at the appropriate entry point dependent on the age of the participant, and a basal was reached when one or no errors are made in the first set. The task concluded when the participant had eight or more errors within a set of 12 items, or when all items were completed. The PPVT-III has demonstrated strong split-half and test-retest reliability scores falling within the range of .90 and .99. Studies that have compared PPVT-III to other measures of listening comprehension, oral expression, vocabulary, and general verbal ability have reported strong evidence for its validity.

Nonverbal Intelligence

The Matrix Reasoning subtest of the Wechsler Abbreviated Scale of Intelligence (WASI - Matrix) assessed participants’ non-verbal fluid intelligence (Wechsler, 1999), and has normative data for individuals aged 6 to 89 years. In this task, a picture of an incomplete illustration or abstract puzzle containing a missing piece was presented to the participant and they were instructed choose the segment piece that best completed the picture by considering a series of options displayed at the bottom of the page. The measure began with two practice items at the start, before proceeding to the appropriate age entry point. Participants received one point for each correct answer for a possible total of 35. A basal was reached when participants correctly answered the first two items from the entry point. The task was terminated when a ceiling level was reached with any combination of four or more incorrect answers achieved within any set of five items, or when all plates in the booklet were attempted. The WASI has reported strong reliability scores with Cronbach's α ranging between .84 and .96 for then entire system, and internal consistency of .88 to .96 and test-retest reliability of .77 for the WASI – Matrix subtest, along with good evidence supporting its content validity.

Processing Speed

Digits naming. Rapid Automatized Naming (RAN - Digits) subtest of the Comprehensive Test of Phonological Processing (CTOPP) was a timed measure of participants' lexical retrieval fluency. RAN is measure of speed of lexical access and predictive of reading acquisition and fluency (Wagner, Torgesen, & Rashotte, 1999). This measure contains normative data for age 5 up to 24 years. It involved the presentation of a page with individual numbers (ranged from 0 to 9) printed in rows. The participant was instructed to name the digits out loud across each row, one after another, as quickly and as accurately as possible. The experimenter began timing when the first number was called and discontinued once the page was finished. Form A and B were presented one at a time and a total score was derived by adding the response time for both Forms. The CTOPP has strong reliability scores with Cronbach's α internal consistency exceeding .80, test-retest reliability ranging between .70 and .92 for the entire system, .78 to .97 for individual subtests, and .78 to .95 for composite scores. In addition, there is strong evidence for its validity including criterion-related validity to other reading measures and construct validity through confirmatory factor analyses (Wagner et al., 1999).

Phonological Short-Term Memory (PSTM)

Pseudoword Repetition. Nonword Repetition is a task of phonological short-term memory, another subtest of the CTOPP (Wagner et al., 1999). This standardized measure contains normative data for age 5 up to 24 years. A pre-recorded speaker on an audio file from the administration manual instructed the participant to repeat out loud a made-up word spoken by the speaker immediately after each test item was heard. The participant was encouraged to pronounce the made-up word as correctly and accurately as they heard it. They were told that the non-words would become increasingly longer containing more syllables (e.g., Item 6: *nigong*, Item 14: *burloogugendaplo*). The task was digitally recorded from the beginning of the task for subsequent scoring. Three practice items were administered to provide feedback and the sound of a “beep” signaled the start of each non-word. There were a total of 18 non-words that increased in both length and difficulty. Scoring procedures followed that prescribed in the technical manual (Wagner et al., 1999), with attention paid to correct pronunciation of stressed and unstressed syllables for each test item. Participants received one point for each correct response for a total score out of 18. A ceiling was reached when three consecutive incorrect pronunciations were made. Reliability coefficients and evidence of the CTOPP validity is reported above in the description of processing speed.

Reading Measures

Word Reading Ability

Word reading. The Word Identification (Word ID) subtest from the Woodcock Reading Mastery Tests – Revised (WRMT-R; Woodcock, 1987) is a task of isolated word reading ability, and accurate application of phonological knowledge sound units of written text into spoken language. This measure contains normative data for Kindergarten up to 75 years. Participants were instructed to read out loud individual words presented on a page as correctly as possible, and were marked for accurate pronunciation of phonological units and syllable stress. The task began with two practice items to allow opportunity for feedback and clarification of instructions, and began at the proper starting point for the age group until a basal was reached where the first six consecutive items were read correctly. If a basal was not reached, the experimenter returned to the previous set until a basal was reached. Participants were informed that words increased in level of difficulty with progression of the task, and were encouraged to sound out unfamiliar words as best as possible. Participants received one point for each correct response for a total score out of 106. The participant continued until a ceiling was reached with six or more incorrect answers within a set, or when all test items were attempted. The Word ID of the WRMT-R system has strong split-half reliability scores at .98. There is good evidence to support its validity including content validity, concurrent validity, and convergent validity of the scale, with strong correlations with other measures of reading performance.

Word reading speed. The Test of Word Reading Efficiency (TOWRE) Words (TOWRE-W; Torgesen, Wagner, & Rashotte, 1999) evaluated participants' ability to read out loud up to 104 items of isolated words that increased in difficulty within a given time limit of 45 seconds. This measure contains normative data for ages 6 to 24 years. Participants were presented with a page containing columns of words and were instructed to read the list of words as quickly and accurately as possible. The experimenter digitally recorded this task from the beginning and marked for accuracy in pronunciation.

Participants received one point for each correctly pronounced response and the score reflected the number of correctly pronounced words in 45 seconds. The TOWRE is a reliable measure with test-retest reliability within the .82 to .97 range for the entire system, and strong evidence to support it as a measure of sight word efficiency, and phonemic decoding.

Word Decoding

Pseudoword Reading. Word Attack (Word Att) is a standardized subtest from the Woodcock Reading Mastery Tests – Revised (Woodcock, 1987), a task of decoding ability of unfamiliar words. Administration of this subtest mirrored that of the Word ID subtest in that it involved the accurate application of phonological knowledge to written text into spoken language of individual made-up pseudowords. The task began with two practice items, before the administration of all 45 test items. Participants were encouraged to sound out unfamiliar words as best as possible and received one point for each correct response for a total score out of 45. The participant continued until a ceiling was reached with six or more consecutive incorrect items, or when all test items had been attempted. The Word Att of the WRMT-R system has strong split-half reliability scores at .93.

Pseudoword reading speed. The Test of Word Reading Efficiency (TOWRE) NonWords (Torgesen et al., 1999) mirrored the administration described in TOWRE-W, and evaluates phonemic decoding of unfamiliar pseudowords. Participants read out loud up to 63 items with increasing difficulty within a 45 second time limit. The pseudowords ranged from single syllable sound units to three or four syllable sound combinations. The experimenter digitally recorded this task from the beginning and marked for accuracy in pronunciation. The participant was stopped at 45 seconds. Participants received one point for each correct response and the score reflected the number of correct pseudowords read in 45 seconds. Reliability coefficients and evidence of TOWRE system validity is reported above in the description for TOWRE-W.

Reading Comprehension Ability

For the current study, two measures of reading comprehension were used, the Gray Oral Reading Test-Fourth Edition and the Nelson-Denny Reading Test. The first reading measure was an oral reading assessment and the second a silent reading assessment, both of which have been considered reliable and valid measures of comprehension ability. The two reading measures are described below.

Oral Reading Comprehension. The Gray Oral Reading Test-Fourth Edition (GORT-4) is an effective measure of oral reading ability (Wiederholt & Bryant, 2001). This measure has normative data for students ranging from 6 to 18 years. There were a total of 14 stories that each participant was asked to read aloud. The participant had to pay attention to the details within each passage to create a situation model to answer comprehension questions. For each passage, the experimenter recorded the time it took the participant to read each passage from beginning to end, marked deviations from print (e.g., incorrectly pronounced words or repetitions), and the number of correctly answered comprehension questions (out of 5) regarding each passage.

Individual scores of oral reading ability used in the analyses are described:

GORT Accuracy: Participants ability to decode words in the passages, and deviations from print are considered errors (e.g., repetitions, incorrect pronunciation, etc.)

GORT Comprehension: Participants answered five comprehension questions for each passage which measured their understanding of the content of each passage.

There were a total of 14 passages for this task. However, for participants in the adult age range, the appropriate entry level was Story 9. Participants began by reading Story 9 and were not allowed to reference back to the passage to answer the multiple-choice comprehension questions. Each story was timed and scored during administration to ensure a basal score was established (i.e., a score of 5 out of 5 on comprehension questions). The further along in this task, the more difficult were the stories (i.e., more difficult content words, more complex sentence structure). Participants continued reading out loud and answering comprehension questions until a ceiling was reached (i.e., 2 out of 5 comprehension questions correct) or until all stories were administered. The GORT-4 has high internal consistency reliability scores with Cronbach's α reported at .90, and test-retest reliability ranging from .78 to .95. Extensive studies on its validity have concluded that it is a valid measure of reading comprehension ability.

Silent Reading Comprehension. The Comprehension subtest of the Nelson-Denny (N-D) Reading Test was first published in 1929 (Nelson & Denny, 1929; as cited in Brown, Fishco, & Hanna, 1993), and measured comprehension in silent reading. It instructs participants to read up to 7 passages and answer multiple-choice questions about each passage on their own. Participants record answers on an individual response sheet.

N-D Reading Comprehension (N-D Comp): Different from the oral response involved in the GORT-Comp, when completing the N-D Comprehension (N-D Comp) task, the participant was provided up to twenty minutes to read the passages silently and answer as many of the 38 multiple-choice questions as possible on their own which were made up of both factual and inferential questions. In addition, participants were allowed to take their own approach to completing the task in the allotted time, and were allowed to refer to the passage at any time to verify and inform their answers. Answers were scored correct or incorrect with no penalty given for incorrect answers to derive a score out of 38. The task was discontinued when the participants completed all questions or when 20 minutes elapsed. The N-D Reading Test has reported test-retest reliability of .77, internal reliability of .96 and alternate form reliability of .90 for individuals Grade 9 level and above, however this only presents partial evidence for its reliability and validity as the content in the passages may not reflect that of more updated measures of reading ability (Kentucky Literacy, 2011).

Prosodic Awareness and Manipulation

Word-Level Stress Task - Identification (Stress ID). As described earlier, Stress ID is an authentic, experimenter-derived task of prosodic stress recognition at the word level used in a previous study among adult participants (Wade-Woolley et al., 2012). It comprises of two sessions, Stress ID and Stress Manipulation, administered in this order respectively. In the first session, participants were presented with twenty pre-recorded English multisyllabic words of four or five syllables in length. In this task, participants were briefed on the nature of words being made up of stronger and weaker syllables, and how a strong syllable in a word can be viewed as having the main beat or strongest emphasis in the word. For example, test items had the primary stress on the first or second syllable (e.g., NEpotism, inEVitable), and six filler/ distractor items had primary stress on the third or fourth syllable (e.g., alphaBEtical, melaTOnin) for a total of 28 words. During the testing phase, participants were instructed to listen to each word and indicate the one syllable that was the “main beat, emphasis, or primary stress” for each word. Two practice items were administered to address any questions and provide feedback. Participant responses were recorded by the test administrator and scored as correct (“1”) or incorrect (“0”) to derive a total out of the 20 test items, and filler items were not scored. Cronbach’s α in the current study was .81.

Word-Level Stress Task - Manipulation (Stress Move/ Shift). The second session is built upon the Stress ID; however, it may also be administered on its own. In the second session, participants were reminded a list of words that they had heard in the first session, and they had identified the location of the primary stress. They were instructed that they would listen to the same list of items, however this time they were to pronounce the word out loud the way it would sound if the main emphasis or beat in the word was moved over one syllable to the right. For example, the word ‘**NE**potism’ (main beat on the first syllable) became ‘ne**PO**tism’ (main beat moved to second syllable – one syllable to the right) and ‘in**EV**itable’ became ‘inev**I**table’. All responses were audio recorded and scored independently by two trained coders for a score out of 20. Stress Manipulation (Stress Move) was administered after Stress ID as it required the ability to identify and manipulate the strongest syllable for each word. Participants were marked for correctness based on their pronunciation of the “new” word when the main emphasis was moved over “one syllable to the right”. Cronbach’s α in the current study was .84.

Phrase-Level Stress Task – Awareness (Prosodic Disambiguation). The phrase-level stress task is an authentic measure designed by Wade-Woolley et al. (2013) to measure the ability to accurately interpret meaning from an “ambiguous” sentence. An ambiguous sentence is one that can generate two meanings containing the same syntactical structure. This ambiguity is marked by differences in prosodic stress placements at the phrasal level. For example, the test item “Break the cup on the rock” can be articulated as either, “[Break] [the cup on the rock]” (Extracted Meaning: Go break the cup that is sitting on the rock, using a hammer) or “[Break the cup] [on the rock]” (Extracted Meaning: Break the cup that you have in your hand by banging it on that giant rock). A more detailed description of the task design is described in Palm-Leis (2013).

For this task, participants listened to pre-recorded audio files of 22 ambiguous sentences. Each sentence was presented with two illustrations. Participants were instructed to choose the illustration that best matched the meaning of the sentence they heard. Participants were given two practice items prior to the administration of the 22 items. At the start of the task, participants were reminded to listen carefully to each sentence before choosing the illustration that best matched the meaning of the sentence they heard. Each correct answer was assigned one point and scored out of 22. Cronbach’s α in the current study was .30.

Executive Functions

Delis-Kaplan Executive Function System (D-KEFS)

The D-KEFS is a standardized measure of executive functioning ability normed for age 8 to 89 years (Delis, Kaplan, & Kramer, 2001). The present study examined two theoretically sound executive functions, inhibition and switching attention (Miyake et al., 2000). The current study included a *verbal* inhibition and switching ability task, in addition to a *non-verbal* visual-motor switching task. Details of the subtests used are described below. D-KEFS has been extensively used in neuropsychology as an assessment tool to identify cognitive impairments related to higher-level executive ability including verbal fluency, problem-solving, planning, flexibility of thinking, inhibition, abstract thinking, and other tasks designed to isolate skills that impact activities of daily living. Moreover, D-KEFS has been used as an assessment tool for clinical practitioners and also includes normative data for clinical populations. Since many of the tasks have been adapted or designed as an extension of previously sound measures that examine the same construct, it has demonstrated moderately good internal consistency (Swanson, 2005), strong construct validity and content validity (Pearson Assessment, 2006).

Inhibition/ Switching Attention - ***Verbal*****.** The Color-Word Interference Test of the (D-KEFS), an extended version of the classic Stroop task (Stroop, 1935) was a timed verbal response task of inhibition that examined the individuals ability to control automatic, prepotent responding. It consisted of 4 conditions administered in the following order: 1. Color Naming, 2. Word Reading, 3. Inhibition, and 4. Inhibition/ Switching. As the participant moves on from one condition to the next, each condition would build on the previous condition, which also increased in level of difficulty to ensure that participants' ability to complete the preceding conditions are considered and accounted for when deriving a score for inhibition and switching attention. A stimulus booklet containing a page for each condition administered and timed individually. Each condition and instruction for each condition is described below.

Condition 1 – Colour Naming**:** Participants were presented with a series of colour blocks along 5 rows with 10 colour blocks displayed on each line. Participants were asked to name the colours across each row as quickly and accurately as possible.

Condition 2 – Word Reading**:** Participants were presented with rows of colour words (e.g., red green blue) displayed along 5 rows with 10 colour words displayed on each line. Participants were asked to read the colour words across each row as quickly and accurately as possible.

***Condition 3 – Inhibition*:** Participants were presented with rows of colour word names that are printed in colours incongruent to the colour names (e.g., the word ‘red’ was printed in the colour blue). Participants were asked to name the ink colour of the word and to not read the colour word name.

***Condition 4 – Inhibition/ Switching*:** Participants were presented with rows of colour word names that are printed in colours incongruent to the colour names where select items have a box around them. Participants were instructed to name the colour of the ink [same as Condition 3] with the exception of the words displayed inside a black box, to which they are instructed to read the word and not the ink colour.

Each participant was given two practice trials for each condition before the presentation of test items, and timed within a limit between 90 seconds and 180 seconds. Condition 4, Inhibition/ Switching, was included in D-KEFS revision to measure verbal interference effects and cognitive flexibility concurrently.

Switching Attention (Set-Shifting) – *Nonverbal, Visual-Motor*. The Trail Making Test (TMT) in D-KEFS was adapted from the original Trail Making Test (Brown & Partington, 1942; Partington & Leiter, 1949), designed as a speeded measure of visuo-motor sequencing, divided attention, and task switching. It consisted of 4 conditions administered in the following order: 1. Visual Cancellation, 2. Number Sequencing, 3. Letter Sequencing, and 4. Number and Letter Sequencing (Switching between two mental sets). Four of the five task conditions were administered because the fifth condition, motor speed, was recommended for individuals’ who demonstrated severe deficits in timed sequences. In addition, a measure of processing speed (i.e., Rapid Automatized Naming - Digits) was included in the battery of measures. Similar to the description for the Colour-Word Interference task, each condition is administered in sequential order as it built on the previous task to ensure that participants ability to complete the preceding conditions are accounted when deriving a score for switching attention. Though only a switching attention score was derived, the process of inhibition is implied as the ability to inhibit response and switch between two mental sets (alphabet and numbers) involves both cognitive processes. A stimulus booklet containing a page for each condition was presented and administered and timed individually. Each condition and instruction to the participant are described below.

Condition 1 – Visual Cancellation: Presented with an 11 x 17 cm sheet with an array of numbers and letters displayed in circles. Participant marked all the 3's on the page of numbers and letters).

Connect the Dots Sequencing (Condition 2 to 4)

Condition 2 – Number Sequencing: Presented with a second 11 x 17 cm sheet with array of numbers and letters displayed in circles. Participants were asked to connect the circles in numerical order, starting at "1" in order up to "16".

Condition 3 – Letter Sequencing: Presented with a third 11 x 17 cm sheet with an array of numbers and letters displayed in circles. Participants were instructed to connect the letters in alphabetical order starting at "A" in order up to "P".

Condition 4 – Number-Letter Sequencing: Presented with a fourth 11 x 17 cm sheet containing 32 circles (16 circles with numbers 1 to 16, 16 circles with letters A to P). Participants were instructed to connect each circle in numerical and alphabetical order switching between connecting numbers and letters (i.e., 1, A, 2, B, 3, C, 4, D, etc.).

This nonverbal timed task measures cognitive flexibility in problem solving, primarily assessed in the Number-Letter Switching condition that instructs the individual to switch between connecting numbers and letters (i.e., 1, A, 2, B, 3, C, 4, D, etc.) in numerical (i.e., 1 through 16) and alphabetical order (i.e., A through P). The remaining conditions help with derivation of a true score of individuals' cognitive flexibility for shifting attention between, and attending to two sets of information (Delis et al., 2001). Each participant was given an untimed practice trial for each condition before the presentation of the timed, test condition (on an 11x17 page that is unfolded). They were given a maximum time limit of 150 seconds (Condition 1, 2, 3) to 240 seconds (Condition 4). The time of completion for each condition was recorded as the raw score.

Data Analyses

The current study used archival data to examine flexible components of language and cognitive abilities. More specifically, I investigated the contribution of prosodic ability and executive functioning as two flexible components to adult reading achievement through a combination of correlational and regression analyses. For the present study, the effect size of a correlational coefficient will be described as a low effect size when r is around .1, moderate when r is around .3, moderately high when r is around .5, and high when r is around .7 or greater (Cohen, 1992; Field, 2009). In using the effect size, the probability that the effect is likely to be represented in the population can be estimated. Multiple regression analyses was used to explore each construct independently when controlling for the other in word reading ability and reading comprehension. The results of the first regression analyses informed the inclusion of each construct in subsequent regression analyses to examine a model for word reading ability, and reading comprehension, after controlling for important predictors such as vocabulary, fluid (non-verbal) intelligence, RAN, and phonological STM.

CHAPTER FOUR

Results

Cognitive Flexibility in Adult Reading Achievement

Adult reading achievement presents a unique opportunity to capture the cognitive and mental capabilities within a population that demonstrate optimal levels of cognitive abilities (Hunter et al., 2012). In other words, the cognitive system is operating most efficiently and effectively during early adulthood, and likely associated with reading achievement. The purpose of the current study was to extend our understanding of reading achievement in adult readers by illustrating the linguistic and cognitive functions needed to participate successfully in daily activities and in becoming engaged citizens in a literacy dominant society. During the early stages of reading, individuals build the foundations for learning to read (i.e., mapping speech sounds onto print) and once these skills have reached automaticity, mental resources are allocated to reading connected-text and comprehension in order to form deeper representations of a particular concept through making connections using the material to background knowledge. When mastering a skill or area of study, an overarching theme and outcome is the ability to transfer and transform the knowledge acquired to new situational contexts. In essence, the level of cognitive flexibility specific to linguistic and executive functioning components may be a more reliable and valid measure operating within a general cognitive system that predicts achievement abilities in the adult age range. Identifying the processes involved in an adult reading achievement model will allow us to gain perspective on the trajectory and span of reading development, and inform the direction of developmental research on reading and the cognitive processes that underlay reading ability once it is achieved in adulthood.

The current study examined the role of prosodic ability and executive functioning ability on adult reading achievement by examining word reading ability and reading comprehension independently. Two research questions formed the basis for the present study: 1) Do prosodic ability and EF make independent contributions to word reading, and reading comprehension ability when controlling for the other? 2) Do prosodic ability and EF make unique contributions to word reading, and reading comprehension ability when controlling for the other, in addition to controlling for Vocabulary, Fluid (Non-verbal) Intelligence, RAN (Digits), and PSTM? For the current study, correlational analyses was used to create composite scores, and hierarchical linear multiple regression analyses was used to test models of reading in adults. The archival data had been scored using the administration manuals for standard scores and percentiles, and according to the answer key for experimenter-designed tasks. For the current study, raw scores for each measure were used in the analyses. Data was analyzed using Statistical Package for the Social Sciences (SPSS®) Version 21. This chapter begins with details about the data analysis procedures and descriptive statistics, prior to the reporting of results.

Data Analysis Procedure

Transformation of Outlier Scores. Preliminary analysis involved exploration of extreme scores using descriptive statistics, histograms of distributions, stem and leaf plots, and tests of normality using Kolmogorov-Smirnov Statistic. For the current study, a criterion for extreme scores was treated as any data point 3 or more Standard Deviations (SD) above or below the mean. The Winsorisation technique was applied to transform scores by replacing the data point with the next highest or lowest value plus or minus one, respectively. This method was used to ensure that no extreme score was pulling the distribution positively or negatively in one direction, and to achieve closer representation of normal distributions across measures, and yet the extreme scores maintained their rank relative to other scores. Values from the following measures were winsorized: Non-Verbal intelligence, RAN, Word ID, TOWRE Words, TOWRE NonWords, GORT Accuracy, GORT Comprehension, Prosodic Disambiguation, C-W Inhibition, Inhibition/ Switching, TMT-Number Letter Switching. All further analyses were performed using the transformed variables.

Multicollinearity: Managing strongly correlated variables. To address the potential influence of multicollinearity, where standard errors are inflated as a result of strong correlational coefficients between variables, I decided to create a composite score for variables through the composition of z-scores to reduce standard error. There is theoretical support and empirical evidence that demonstrates the strong interrelations thay may be found between the independent measures of prosodic ability and executive function tasks (Miyake et al., 2000; Wade-Woolley et al., 2013). This may be due to the nature of both tasks where each cognitive process is examined through measures that build on the previous task. For instance, *Condition 4* Inhibition/ Switching involves the same rules as *Condition 3* Inhibition with the addition of one rule. Each task also derived a stand-alone separate score and can be interpreted on its own. Moreover, the strong correlation between each sub-skill is theoretically supported and consistent with previous findings. The standardized word reading and reading comprehension measures provided in the extant data have demonstrated good reliability and validity, suggesting that the measures have been used with success to measure the construct it sought out to measure and across situational contexts. For the present study, due to the strength of the relationships among variables, composite scores were created for word reading, prosodic ability, and executive functioning to manage multicollinearity.

Descriptive Statistics

Control Measures. Descriptive statistics for age and the four control measures are presented in Table 2. Age and Gender were not included as predictors in regression analyses, as gender did not correlate with any reading outcome, and age (in months) only correlated with Word ID, $r = .26$, $p < .01$ (see Appendix A).

Table 2

Descriptive Statistics for Age and Control Variables

Variables	*N*	*M*	*SD*	*Min*	*Max*
Demographic					
Age (in months)	103	331.72	94.19	223	655
Control Measures					
Vocabulary (Receptive)	100	184.96	7.78	167	202
Nonverbal Intelligence	102	28.02	3.64	16	34
RAN (Digits) [a]	100	22.29	4.10	15	39
Phonological STM	100	12.97	2.52	6	18

Note. All variable measures reflect the number of items responded correctly. [a] Measure reflects the number of seconds taken to complete the task, with lower scores reflecting better performance.

Cognitive flexibility. Descriptive statistics for the three prosodic ability measures and the four executive functioning measures are presented in Table 3.

Table 3

Descriptive Statistics for Prosodic Ability, and Executive Functioning Measures

Variables	*N*	*M*	*SD*	*Min*	*Max*
Prosody					
Stress Identification	103	15.58	3.69	7	20
Stress Manipulation	99	14.23	4.63	1	20
Phrase Disambiguation	83	13.81	2.55	9	22
Executive Functions					
Colour-Word Interference					
Inhibition [a]	103	45.19	10.28	26	80
Inhibition/ Switching [a]	103	53.54	16.05	36	103
Switching - Inhibition [a]	103	8.35	13.89	-17	58
Trail Making Test					
Number-Letter Switch [a]	102	59.50	20.50	28	132

Note. All measures reflect the number of items responded correctly. [a] Measures reflect the time taken to complete the task, with lower scores reflecting better performance. Switching – Inhibition: difference score between the Inhibition and Inhibition/Switching.

Prosodic Ability. Three measures of prosodic ability included a stress awareness, stress manipulation, and phrase disambiguation discrimination task. Table 4 presents intercorrelations between the prosodic measures. All measures were significantly correlated, and a composite score reflecting prosodic ability was used in further analyses.

Table 4

Intercorrelations between Prosodic Measures

Variables	1	2	3
1. Stress ID	–	.25*	.75**
2. Phrase ID		–	.31**
3. Stress Move			–

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

Executive Functions. Three measures of executive functions: inhibition, switching, and number-letter switching were significantly intercorrelated (see Table 5).

Table 5

Intercorrelations between Executive Functioning Measures

Variables	1	2	3
1. Inhibition	–	.52**	.30**
2. Inhibition/Switching		–	.32**
3. N-L Switching			–

Note. ** $p < .01$

Initially, a difference score between inhibition and inhibition/ switching was derived by subtracting subtask *Condition 3* Inhibition from *Condition 4* Inhibition/ Switching, with the difference between the scores reflecting true switching attention ability. However, Inhibition *minus* Switching only correlated with Gender, TOWRE Words and *Condition 4* Inhibition/ Switching, and so was not used in further analyses (see Appendix A).

Reading Measures. Descriptive statistics for all reading tasks using raw scores are presented in Table 6, and with standard scores presented in Table 7.

Table 6

Descriptive Statistics for Reading Measures (Raw Scores)

Variables	*N*	*M*	*SD*	*Min*	*Max*
Word Reading					
Word Identification	103	97.20	4.70	83	105
Word Attack	100	37.18	3.92	27	44
TOWRE Words	103	94.17	8.94	64	104
TOWRE NonWords	100	52.59	7.48	28	63
GORT Accuracy	102	62.33	8.91	35	70
Reading Comprehension					
GORT Comprehension	102	50.92	11.68	15	69
N-D Comprehension	98	62.14	9.50	28	76

Note. All variable measures reflect the number of items responded correctly.

Table 7

Descriptive Statistics for Reading Measures (Standard Scores)

Variables	*N*	*M*	*SD*	*Min*	*Max*
Word Reading					
Word Identification	103	102.01	8.44	82	126
Word Attack	100	103.53	10.91	83	131
TOWRE Words	103	98.69	12.04	66	114
TOWRE NonWords	102	98.11	10.72	70	120
GORT Accuracy	102	13.03	2.41	6	16
Reading Comprehension					
GORT Comprehension	102	8.46	2.38	2	12
N-D Comprehension	98	226.28	14.70	187	250

Note. All variable measures reflect the number of items responded correctly.

As discussed earlier, all raw scores from the reading measures were used in the analyses and any raw score more than 3 standard deviations above the mean was winsorized. Table 7 presents the descriptive data for standard scores for all reading measures. Standardized scale scores present the opportunity to examine whether the performance of participants in the current study show a similar or different distribution of scores to the normative sample. The word reading tests use a standard scale where the mean is 100 and the standard deviation is 15, while GORT Accuracy and reading comprehension measures follow a different standardized scale and are noted below. Using a one-sample t-test (Field, 2009), a closer look at the standard scores illustrated that adult readers in the extant dataset showed similar scores to the norming sample for TOWRE Words, $t(102) = -1.11$, $p > .05$ n.s., and TOWRE NonWords, $t(98) = -1.75$, $p > .05$ n.s. For the remaining word reading tasks, participants performed significantly better on Word ID, $t(102) = 2.42$, $p < .05$; Word Attack, $t(99) = 3.24$, $p < .01$; and GORT Accuracy, $t(101) = 12.69$, $p < .01$. For GORT Accuracy, standard scores for the normative sample had a mean of 10 and standard deviation of 3. For reading comprehension, participants performed significantly lower on GORT Comprehension, $t(101) = -6.54$, $p < .01$, where standard scores have a mean of 10 and standard deviation of 3. Participants for the current study also performed significantly better on the N-D Comprehension, $t(97) = 17.70$, $p < .01$. Their scores were 1 standard deviation above the norming sample mean where standard scores on N-D Comprehension have a mean of 200 and standard deviation of 25. Participants performed significantly better than the norming sample on most word reading tasks and silent reading, and had significantly lower scores on the oral reading comprehension task.

Word reading. Five measures of word reading ability were used to create a word reading composite score, which included word recognition, reading fluency, and decoding ability of real and nonwords at the individual word-level and at the connected-text level. Table 8 presents the intercorrelations among word reading measures. All measures were significantly correlated, with the exception of Word ID and TOWRE Words. GORT Accuracy was included as a measure of word reading ability as it involves skills important in connected-text reading including decoding and applying appropriate phonological representations to unfamiliar or difficult words. GORT Accuracy was significantly correlated with all word reading measures ranging from .28 to .69, $p < .01$.

Table 8

Intercorrelations between Word Reading Measures

Variables	1	2	3	4	5
1. Word ID	–	.52**	.16	.55**	.69**
2. Word Attack		–	.20*	.58**	.54**
3. TOWRE W			–	.52**	.28**
4. TOWRE NW				–	.68**
5. GORT Accuracy					–

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

Construct Composites: Z-Score Transformations. The correlation analyses informed the individual measures included in deriving composite scores for prosodic ability, executive function, and word reading. The strength of the relationship between variables fell in the low to moderately-high range indicating that high scores on one measure would be associated with high scores in the positive direction on other measures representing skills within the broader construct. Each variable was first standardized to z-scores to ensure that tasks were on the same scale, and have a mean of 0 and a standard deviation of 1, and each composite score was used for further analyses.

Reading Comprehension. Two measures of comprehension ability were included in the original study, an oral (GORT Comprehension) and silent reading (N-D Comprehension) measure. Table 9 indicates that the two reading comprehension measures were correlated significantly in the moderate range $r = .24$, $p < .05$. Additionally, the correlational analyses revealed that GORT-Comp was not significantly correlated with the prosodic ability and executive function composite scores, however, N-D Comp was significantly correlated with prosodic ability $r = .34$, $p < .01$ and executive function $r = -.33$, $p < .01$ (see Table 6). For all subsequent analyses, N-D Comprehension was used as the dependent measure for reading comprehension.

Table 9

Intercorrelations between Word Reading, Prosodic Ability, Executive Functioning, and Oral and Silent Reading Comprehension measures (N=98)

Variables	1	2	3	4	5
1. Word Reading Composite	–	.51**	-.31**	.05	.39**
2. Prosodic Ability Composite		–	-.37**	.04	.34**
3. Executive Function Composite			–	-.04	-.33**
4. GORT-Comp (Oral Reading)				–	.24*
5. N-D Comp (Silent Reading)					–

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

Models Tested

The present exploratory study assessed a total of eight regression models. Predictors entered in each model were informed by correlational analyses conducted to assess the strength of the relationships between all measures and to create composite factor indexes for independent constructs. Each research question is stated below followed by each model of word reading and reading comprehension explored, followed by the results of the analyses for the current study.

The first two regression models examined whether prosodic ability and executive functioning factors each contributed independently to word reading ability:

RQ1. **Flexibility of Thinking:** What were the independent contributions of prosodic ability and executive functioning, when controlling for the other, to each word reading ability, and reading comprehension?

Word Reading Regression Models

a. **Model 1:** Did prosodic ability make independent contribution to word reading ability when accounting for executive functioning?

b. **Model 2:** Did executive functioning make independent contribution to word reading ability when accounting for prosodic ability?

The results of the analysis demonstrated that, together, prosodic ability and executive function explained 27% of the total variance in the model of word reading ability (see Table 10). In Model 1, prosodic ability uniquely accounted for an additional 19% of the variance, above and beyond executive functioning in the first step, which accounted for 8% of the variance. In Model 2, executive functioning did not significantly explain additional variance in word reading above and beyond prosodic ability, which accounted for 25% of the variance in the model (see Table 10). To answer the first research question, prosodic ability was a unique predictor of word reading achievement in adults, and the executive functioning factor did not explain additional variance in the model once prosodic ability was accounted for in the first step suggesting that abilities of executive functioning are measured in the prosodic ability composite measures.

Table 10

Summary of Hierarchical Linear Multiple Regression Accounting for Variance in Word Reading ability from Prosodic Ability and Executive Functioning.

Step and predictor	*B*	*SE B*	β	R^2	ΔR^2
Model 1					
Step 1:				.08**	
Executive Function Composite	-.12	.09	-.12		
Step 2:				.27**	.19**
Prosodic Ability Composite	.43	.09	.46**		
Model 2					
Step 1:				.25**	
Prosodic Ability Composite	.43	.09	.46**		
Step 2:				.27	.02
Executive Function Composite	-.12	.09	-.12		

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

The next two regression models explored whether prosodic ability and executive functioning factors each contributed independently to reading comprehension.

Reading Comprehension Regression Models

c. **Model 3:** Did prosodic ability make independent contribution to reading comprehension when accounting for executive functioning?

d. **Model 4:** Did executive functioning make independent contribution to reading comprehension when accounting for prosodic ability?

The results for Model 3 and Model 4 showed that prosodic ability and executive functioning each contributed unique variance to silent reading comprehension above and beyond the other factor when entered in the second step explaining 16% of the model (see Table 11). In Model 3, prosodic ability significantly predicted 5% of reading comprehension above and beyond executive functioning, which accounted for 11% of the model in the first step. In Model 4, executive functioning contributed 4% above and beyond prosodic ability, which explained 12% of the variance in the model for reading comprehension. To answer the second part to the first research question, both prosodic ability and executive functioning independently contributed unique variance in adult reading comprehension when controlling for the other.

Table 11

Summary of Hierarchical Linear Multiple Regression Accounting for Variance in Reading Comprehension from Prosodic Ability and Executive Functioning.

Step and predictor	*B*	*SE B*	β	R^2	ΔR^2
Model 3					
Step 1:				.11**	
Executive Function Composite	-.30	.13	-.23*		
Step 2:				.16*	.05*
Prosodic Ability Composite	.31	.12	.26*		
Model 4					
Step 1:				.12**	
Prosodic Ability Composite	2.96	1.17	.26*		
Step 2:				.16*	.04*
Executive Function Composite	-2.84	1.24	-.23*		

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

To explore the role that prosodic ability and executive functioning have to word reading ability and silent reading comprehension, I examined the relationship between the independent measures of each construct and the control variables to examine whether contributions from prosodic ability and executive functioning are maintained when entered into a model to explain adult reading achievement.

Correlational Analyses of Reading and Predictor variables (Construct Composites)

Intercorrelations of the two reading outcomes of interest (word reading, reading comprehension) and composite scores of predictor variables are presented in Table 12.

Table 12

Intercorrelations between Reading and Predictor Variables: Control Measures (Vocabulary, Fluid Intelligence, RAN, Phonological STM), Prosody, and Executive Functioning Factor Variables (N=97)

Variables	1	2	3	4	5	6	7	8
1. Word Reading Factor	–	.38**	.38**	.05	-.55**	.45**	.50**	-.31**
2. N-D Comprehension		–	.44**	.22*	-.19	.27**	.32**	-.33**
3. Vocabulary			–	.30**	-.09	.27**	.32**	-.11
4. Fluid Intelligence				–	-.01	.11	.24**	-.16
5. RAN (Digits) [a]					–	-.07	-.45**	.46**
6. Phonological STM						–	.23*	-.04
7. Prosodic Ability							–	-.37**
8. Executive Function [a]								–

Note. Positive correlations indicate that higher performance on a measure is associated with higher performance on the other measure. Negative correlations indicate that higher performance on a measure is associated with lower performance on the other. [a] Measures reflect the time taken to complete the task, with lower scores indicating better performance.
* $p < .05$; ** $p < .01$

Results of the correlational analyses revealed that the word reading factor and N-D comprehension were moderately correlated $r = .38$, $p < .01$ to each other. The word reading factor significantly correlated independently with vocabulary, RAN (Digits), PSTM, prosodic ability, and executive functions. In comparison, N-D Comprehension (silent reading) independently correlated with vocabulary, fluid intelligence, PSTM, prosodic ability, and executive functions composite scores falling between the low to moderate range (see Table 12). Therefore, word reading ability did not correlate significantly with fluid intelligence and N-D comprehension did not correlate significantly with RAN, and both were correlated to all other control predictors. Prosodic ability and executive functions were significantly negatively correlated $r = -.37$, $p < .01$. The negative correlation indicates that higher scores on one measure were associated with lower scores on the other, and because executive functioning scores reflect a timed response, a lower response time represents higher performance on the task as it requires the individual to complete the task as accurately and as quickly as possible. The second research question aimed to investigate a model of adult reading achievement ability accounting for flexibility at the linguistic and cognitive-level by examining prosodic ability and executive functioning abilities as individual predictors of reading ability, a direction that has yet to be explored in both areas of research related to reading development and achievement.

Model 5 and 6 explored whether prosodic ability and executive functioning factors each contributed independently to word reading ability above and beyond the control variables.

RQ2. **Flexibility of Thinking as Predictor of Reading Achievement:** Did prosodic ability and executive functioning components make independent contributions to word reading and reading comprehension above and beyond vocabulary, fluid (non-verbal) intelligence, RAN (Digits), and phonological STM?

Word Reading Regression Models with Control Variables

a. **Model 5:** Did prosodic ability make independent contribution to word reading ability when control variables were entered in Step 1: Vocabulary, RAN (Digits), and PSTM and Step 2: Executive functioning?

In Model 5, prosodic ability significantly accounted for unique variance above and beyond the control variables measuring vocabulary, RAN, STM, and executive functioning (see Table 13). The control measures explained 50% of adult word reading ability, while prosodic ability contributed an additional 3% for a total of 53% of the variance explained.

Table 13

Summary of Regression Analysis of Prosodic Ability predicting Word Reading Ability above Control Variables

Step and predictor	*B*	*SE B*	β	R^2	ΔR^2
Model 5					
Step 1:				.50**	
Vocabulary (PPVT)	.02	.01	.20*		
RAN (Digits)	-.08	.02	-.42**		
Phonological STM	.09	.02	.31**		
Step 2:				.50**	.00
Executive Function Composite	.01	.08	.01		
Step 3:				.53*	.03*
Prosodic Ability Composite	.18	.08	.19*		

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

b. **Model 6:** Did executive functioning make independent contribution to word reading ability when control variables were entered Step 1: Vocabulary, RAN (Digits), and PSTM and Step 2: Prosodic ability?

A similar finding was found for Model 6, where executive functioning did not contribute unique variance above and beyond control variables, and prosodic ability in the second step. Control variables explained 50% of the model in the first step, and prosodic ability explained 3% of the variance at the second step for a total of 53% of the model of word reading explained (see Table 14).

Table 14

Summary of Regression Analysis of Executive Functioning predicting Word Reading Ability above Control Variables

Step and predictor	B	$SE\ B$	β	R^2	ΔR^2
Model 6					
Step 1:				.50**	
Vocabulary (PPVT)	.02	.01	.20*		
RAN (Digits)	-.08	.02	-.42**		
Phonological STM	.09	.02	.31**		
Step 2:				.53*	.03*
Prosodic Ability Composite	.18	.08	.19*		
Step 3:				.53*	.00
Executive Function Composite	.01	.08	.01		

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

The results of regression Model 6 and 7 were not surprising as only prosodic ability, and not executive functioning accounted for unique variance to word reading ability when it was first investigated in Model 1 and 2 (refer to Table 10). To answer my second research question, prosodic ability uniquely explained 3% of the variance in word reading ability in adult readers above and beyond vocabulary, naming speed, and short-term memory.

The last pair of regression analyses, Model 7 and 8, investigated whether prosodic ability and executive functioning each contributed independently to reading comprehension above and beyond control variables.

Reading Comprehension Regression Models with Control Variables

c. **Model 7:** Did prosodic ability make independent contribution to reading comprehension ability when control variables were entered in Step 1: Vocabulary, Fluid (Non-Verbal) Intelligence, and PSTM and Step 2: Executive functioning?

In Model 7, prosodic ability did not make a unique contribution to silent reading comprehension above and beyond control measures entered in the first step, and executive function factor entered in the second step. The finding indicated that the control variables and executive functioning explained 29% of the total variance for the model of reading comprehension (see Table 15). Vocabulary carried the weight of the control variables contributing 22% of the variance, and executive functioning explained an additional 7% in the model. No unique variance was added by prosodic ability in the last step.

Table 15

Summary of Regression Analysis for Prosodic Ability predicting Reading Comprehension above Control Variables and Executive Functioning

Step and predictor	*B*	*SE B*	β	R^2	ΔR^2
Model 7					
Step 1:				.22**	
Vocabulary (PPVT)	.04	.01	.32**		
Fluid Intelligence (WASI)	.06	.04	.05		
Phonological STM	.01	.03	.14		
Step 2:				.29**	.07**
Executive Function Composite	-.32	.12	-.25*		
Step 3:				.30	.01
Prosodic Ability Composite	.11	.13	.09		

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

d. **Model 8:** Did executive functioning make an independent contribution to reading comprehension ability when control variables were entered in Step 1: Vocabulary, Fluid (Non-Verbal) Intelligence, and PSTM and Step 2: Prosodic ability?

In Model 8, executive functioning was examined as a unique predictor of reading comprehension above and beyond the control variables. The results revealed that the executive functioning factor contributed 5% of the variance above and beyond control measures entered in the first step and prosodic ability entered in the second step (see Table 16). Similar to the findings reported for Model 7, vocabulary contributed significantly among the control measures that also included naming speed and short-term memory to explain 22% of the variance. The total model of reading comprehension explained by the control measures and executive functioning was 29%. Moreover, prosodic ability did not contribute additional variance at the second step, whereas executive functioning independently added 5% in the third step, and uniquely predicted reading comprehension ability for the present adult population.

Table 16

Summary of Regression Analysis of Executive Functioning predicting Reading Comprehension above Control Variables and Prosodic Ability

Step and predictor	*B*	*SE B*	β	R^2	ΔR^2
Model 8					
Step 1:				.22**	
Vocabulary (PPVT)	.04	.01	.32**		
Fluid Intelligence (WASI)	.01	.03	.05		
Phonological STM	.06	.04	.14		
Step 2:				.24	.02
Prosodic Ability Composite	.11	.13	.09		
Step 3:				.29*	.05*
Executive Function Composite	-.32	.12	-.25*		

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

Summary of Results

The purpose of the current study was to explore the relationship between processes representing flexibility of thinking in reading achievement within an adult population. First, I examined the independent contributions of prosodic ability (a linguistic process) and executive functioning (a cognitive process) to each word reading ability, and reading comprehension. Second, I examined whether their independent contributions to reading achievement upheld when control variables were entered in models of word reading and reading comprehension. A total of 8 hierarchical linear multiple regression models were tested for the current study. For word reading ability, Models 1 and 2 illustrated that only prosodic ability (19%) and not executive functioning accounted for unique variance in word reading ability, when controlling for the other (see Table 10). This was also reflected in the results for regression Models 5 and 6 which found that prosodic ability continued to add 3% unique variance to the model when accounting for control variables in the full model of word reading ability (see Table 13 and 14). Moreover, control variables vocabulary, naming speed, and short-term memory explained 50% of the variance in word reading ability for a total of 53% variance explained with the inclusion of prosodic ability into the model. The results for word reading achievement illustrated the importance of prosodic ability and linguistic flexibility in word reading.

For reading comprehension, Models 3 and 4 demonstrated that prosodic ability and executive functioning independently explained reading comprehension when controlling for the other (refer to Table 11). When prosodic ability was entered last, it accounted for an additional 5% explained in the reading comprehension model after executive functioning with 11% explained in the first step, for a total of 16% contributing to adult reading comprehension ability. When executive functioning was entered last in the model of silent reading comprehension, executive functioning significantly added 4% above prosodic ability with 12% in the first step. Therefore, both prosodic ability and executive functioning each uniquely contributed to reading comprehension when examined without any control predictors. In Models 7 and 8, I investigated whether each prosodic ability and executive functioning continued to contribute significantly to silent reading comprehension ability when control variables were entered into the model of reading comprehension. The outcome of the analyses found that prosodic ability did not contribute unique variance above and beyond the control measure of vocabulary (22%) and executive functioning (7%). Comparatively, executive functioning (5%), and not prosodic ability continued to uniquely contribute above and beyond control measures for reading comprehension (see Table 15 and 16). Interestingly for reading comprehension, prosodic ability did not reach levels of significance when control predictors were entered into the reading model, contrary to what would be expected following the earlier analyses in Model 3 and 4 which found that both prosodic ability and executive functioning each contributed to reading comprehension above and beyond the other factor (refer to Table 11). Moreover, executive functioning includes both flexible linguistic and cognitive processes in reading comprehension ability. The present study found evidence to support the role of prosodic ability in word reading achievement and executive functioning in reading comprehension achievement models focused on an adult population.

CHAPTER FIVE

Discussion

The present study evaluated the contribution of prosody and EF to word reading and reading comprehension. The connection between phonological processing and reading ability has been strongly supported in the literature (Stahl & Murray, 1994; Torgesen et al., 1999). Phonological processing is foundational to early reading abilities and mastery is achieved once an individual demonstrates the awareness and flexibility to manipulate components of oral language. Tasks of phonological processing have EF demands embedded within them. In general, it appears that researchers have not considered the role of EF, and as a result, have not included EF as a control variable in models of reading in published work. The current study aimed to unpack this association to examine whether prosodic ability and EF are differentially implicated in two aspects of adult reading.

In older readers, traditional tasks evaluating segmental processing (i.e., phoneme segmentation and blending) are no longer sensitive to the individual differences in reading because the skills required for completing these tasks that initially required more attention and cognitive effort have now reached asymptote through practice and experience. Traditional phonological tasks become less predictive of later reading ability (Torgesen et al., 1997), however, it should not be concluded that phonological processing is not involved in reading activities in older readers. This finding indicates that traditional measures of phonological processing are not reliably able to capture individual differences in reading performance past a certain age range or cut-off point.

Phonological processing at the suprasegmental level: Prosody. A phonological process that is relatively new to the research literature and one that better distinguishes phonological processing in older readers is prosodic awareness (Wood et al., 2009). Prosodic awareness develops together with segmental phonological abilities to support literacy acquisition. The current study examined the phonological process of prosodic ability in a model of adult word reading and reading comprehension ability. To account for the executive functioning demands involved in phonological tasks of reading, EF was assessed using measures of inhibitory control and switching attention as both a control variable and predictor in each model of reading.

Findings

Word reading is frequently used as a control variable or part of a composite reading outcome score in typical readers, unless examining specific reading deficit profiles (i.e., students classified as adequate word readers but poor comprehenders; see Sesma et al., 2009). For the present study, word reading ability was analyzed as a separate reading outcome from reading comprehension with recognition that phonological processes continue to be an important predictor of reading in older readers. That is, adults continue to encounter new vocabulary through reading and thus rely on basic processes of reading such as decoding when sounding out unfamiliar or difficult words. The correlational analyses revealed that prosody and EF were in fact differently related to word reading and reading comprehension. Prosody was more strongly correlated to word reading $r = .51$, $p < .01$ than EF $r = -.31$, $p < .01$ was to word reading. Using Steiger's (1980) Z-test for correlated correlations within a single sample containing an overlapping variable, the correlation between word reading and prosodic ability, and word reading and EF was found to be significantly different, Z = 1.975, $p < .05$. Both prosody and EF were similarly correlated to silent reading comprehension at $r = .34$, $p < .01$ for prosody, and $r = -.33$, $p < .01$ for EF (Table 9), Z = 0.094, $p > .05$ n.s. The stronger correlation of prosody to word reading may be explained by the use of two word-level tasks and one phrase-level task in the composite score of prosody; a construct weighted by the word-level prosodic ability scores. Additional experimental measures of phrase-level prosody may be explored in the future to create separate composites for word-level and phrase-level prosody to examine its contribution to reading. EF was significantly related to both reading outcomes at $r = -.31$, $p < .01$ for the word reading composite, at $r = -.33$, $p < .01$ for the silent reading comprehension measure, as well as prosodic ability at $r = -.37$, $p < .01$, suggesting that EF demands are component skills involved in tasks of phonological processing and complex reading measures.

To evaluate each of the proposed theoretical models of word reading and silent reading comprehension, a series of hierarchical linear multiple regressions examined prosody and EF as independent predictors while controlling for the other construct. It was expected that both prosody and EF would independently contribute to each word reading and reading comprehension. The first regression analyses showed that prosody, and not EF contributed significantly to word reading ability, whereas both prosody and executive ability each contributed to reading comprehension (see Figure 3). These findings, before the consideration of the control variables, suggest that EF demands are also measured in phonological processes and that prosody and EF contribute differently to adult reading achievement.

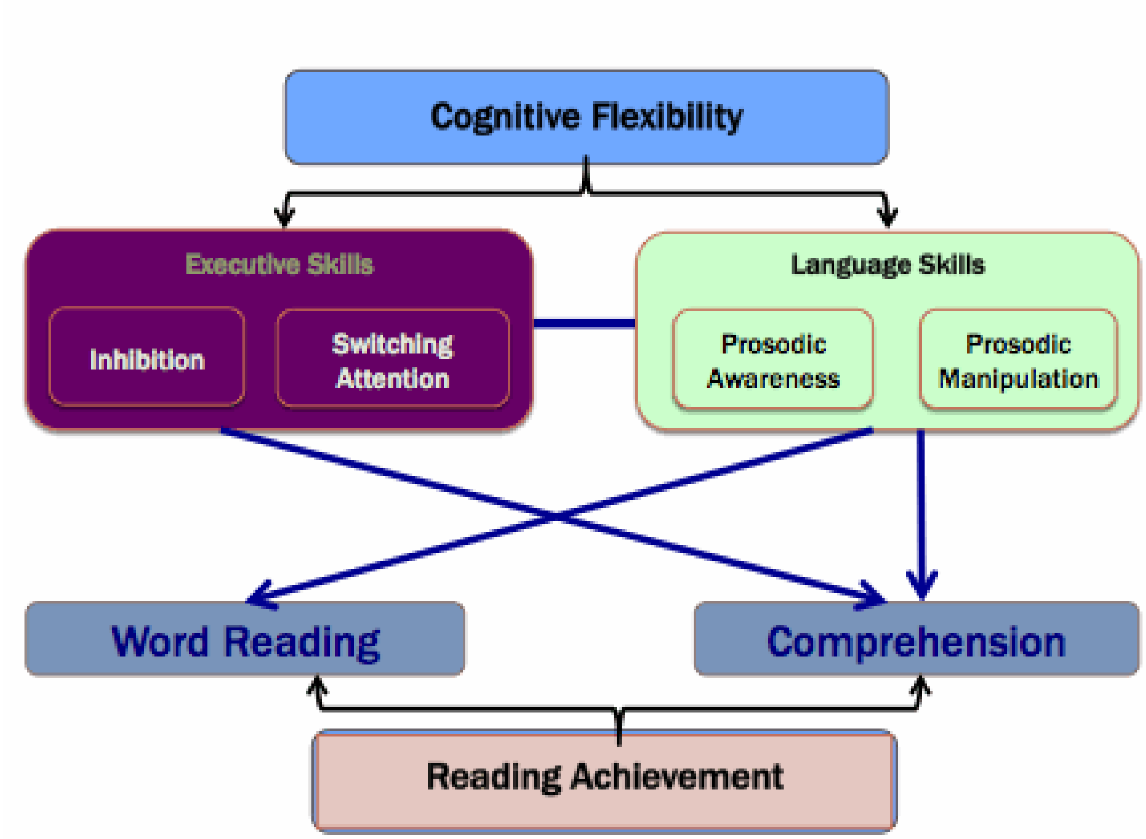

Figure 3. Updated research model investigating individual contributions of prosodic ability and executive skills in word reading, and reading comprehension in adults.

The analyses that followed, examined prosody and EF as unique predictors of reading ability above and beyond control measures (vocabulary, nonverbal intelligence, naming speed, and short term memory) to test a theoretical model of adult reading achievement. Interestingly, the second analyses found that prosody uniquely predicted adult word reading ability and not reading comprehension, despite the initial analyses indicating the role of prosodic ability in reading comprehension. Prosody's contribution to word reading above EF supports prosodic awareness as a phonological skill that can be used to explain individual differences in word reading. Whereas, EF's contribution to reading comprehension supports the role of executive processing involved in complex reading tasks (see Figure 4).

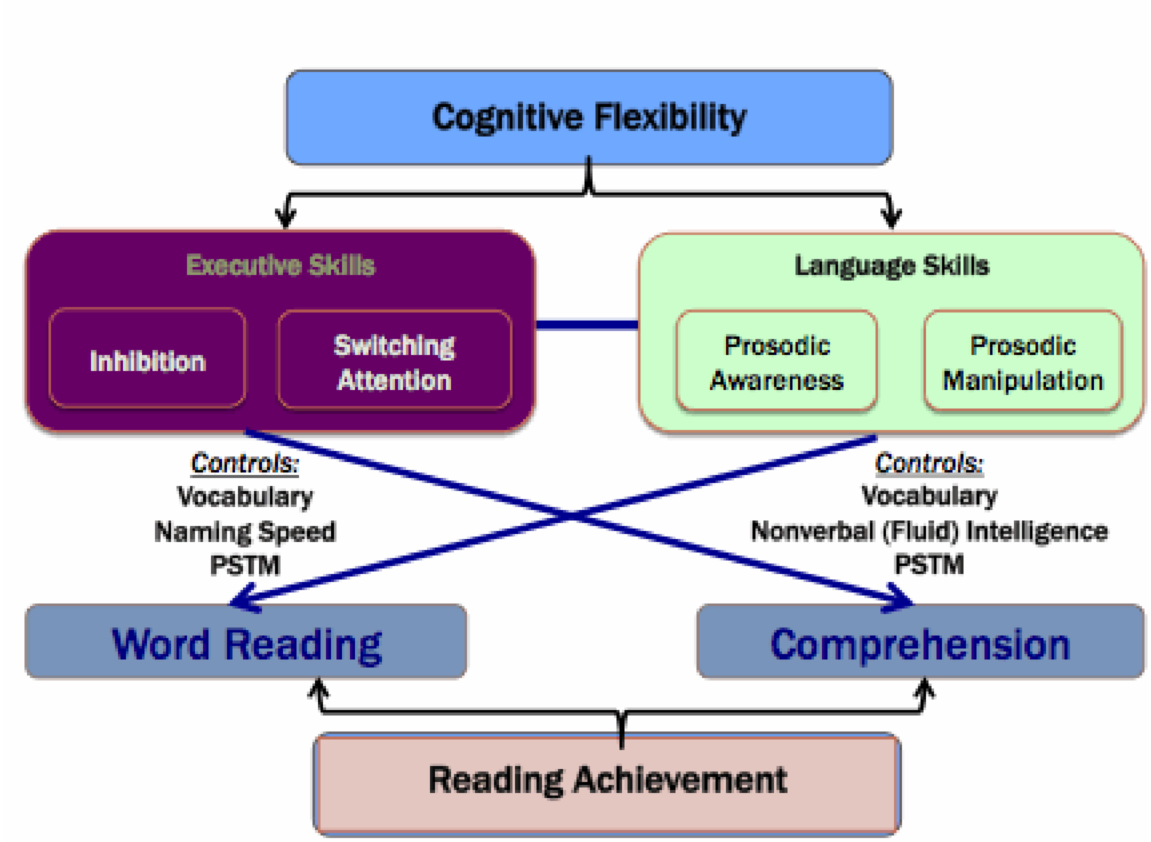

Figure 4. Updated research model investigating individual contributions of prosodic ability and executive skills in word reading, and reading comprehension in adults controlling for age, vocabulary, fluid intelligence, speed of lexical access, and PSTM.

Interpretation of Results

This exploratory study expected that both prosody and EF would make significant individual contributions to each model of reading ability. The results showed that prosody is a phonological process important for word reading, while EF is a significant contributor to silent reading comprehension in adult readers. This suggests that phonological processing, measured through prosody, continues to be an important predictor of adult word reading ability even after controlling for EF demands. When prosody and EF were examined as individual predictors of reading comprehension, EF was found to be a stronger predictor in adult readers.

The current findings mirror previous work that found prosodic awareness to be a significant correlate of adult word decoding and reading comprehension (Palm-Leis, 2013; Wade-Woolley et al., 2012). Prosody is a more challenging measure of phonological processing, and the nature of the task has significant demands on EF. Controlling for the EF elements in phonological processes provides a more robust account for the role of prosody as a phonological process in adult reading achievement.

In text comprehension, sentences are marked with punctuation such as commas, periods, and other grammatical markers. Prosody facilitates with syntactic phrasing when grouping words together to support inference making. Prosody was predictive of reading comprehension prior to the inclusion of control variables (Figure 4), however, its contribution no longer added to the silent reading comprehension model beyond EF and control variables. It is plausible that for this particular silent reading task, EF skills were more central to the performance on this silent reading comprehension task because it involved knowledge-based inference making. Two forms of inference making have been characterized in the literature related to tasks of comprehension: knowledge-based, which relies on integrating new information with our background knowledge, or text-based, which is dependent on making meaning based on the information presented in the text (Kintsch & Rawson, 2005). Since knowledge-based inferences are dependent on how quickly we are able to activate and integrate prior knowledge to the text, it may explain the contribution of EF to the silent reading comprehension measure. Whereas, text-based inferences may be more related to prosodic ability because readers chunk words syntactically and use punctuation presented in the text to help resolve potential ambiguity for its correct meaning.

Similar to other research examining the relationship between phonological awareness and reading, this study controlled for vocabulary, fluid intelligence, naming speed, and PSTM (Torgesen et al., 1997). Text comprehension is a complex task that may be influenced by differences in an individual's vocabulary or ability to store phonological representations in memory. To examine individual contributions of prosodic ability and EF within a model of reading achievement, it was important to first control for individual differences before examining the relative contribution of the two predictors in two aspects of adult reading.

For reading comprehension, the association between prosody and reading comprehension was no longer significant once control variables were entered into the model, while the contribution of EF was retained. This finding suggests that EF skills are strongly associated in silent reading comprehension. The results of the adult reading prediction models also support previous findings connecting EF and academic achievement (Best et al., 2011) and higher-level cognitive processing skills involved in reading comprehension (Duke & Carlisle, 2011). It can be interpreted that skills relevant to the task of silent reading comprehension, compared to word reading, engaged more higher-level processing due to the nature of the task. For example, given the time limit to answer increasingly difficult passages, readers had to make decisions and be strategic in choosing the best method of completing the task. Many readers may have employed a "look and search" strategy that would engage both inhibitory control and switching attention components of EF. Inhibitory control would be involved in ignoring irrelevant or distracting information and switching attention is required to selectively attend to information relevant to the question being answered, and switching mental sets after each question. Reading researchers testing individual differences models of reading achievement need to acknowledge the EF component skills embedded in tasks used as predictors of reading (i.e., phonological processing), and further explore how EF demands may be dependent on the reading outcomes measured.

Differences in Reading Comprehension Tasks

The initial analyses revealed that prosody and EF did not correlate with the oral reading comprehension measure and only correlated with the silent reading comprehension measure. It is important to consider the reasons for why cognitive predictors were represented differently between two measures that assess reading comprehension ability. This oral and silent reading comprehension performance was correlated in the moderately low range $r = .24$, $p < .05$, and suggests that the cognitive processes tested in these two types of reading tasks require different but related skills.

The differences may be a function of the task design, or due to perceived purpose of the reading task, which in turn influence the approach taken to complete it. The oral reading task required participants to read aloud at a normal pace with the knowledge that they would be expected to answer questions related to the passage without being able to refer back to it. The generation of the mental representation necessary to complete the task while reading aloud imposes a cognitive load significantly greater than reading silently. Interestingly, the oral reading task was only correlated to vocabulary $r = .33$, $p < .01$ and not to PSTM or any of the other predictors (Appendix A). This finding suggests that the difficulty of the passages in the reading comprehension measures increased largely as a function of the difficulty (low frequency) vocabulary words. Furthermore, knowing the meaning of vocabulary words presented in text had the greatest impact in building the temporary situation model in memory, which led to better scores on the oral reading comprehension test in this sample. The silent reading task was also moderately correlated to vocabulary $r = .44$, $p < .01$; however, the text was available to the reader while answering questions. This resulted in less cognitive load compared to the oral reading measure that had greater demands on memory. Also, to explain the contribution of EF to adult reading comprehension ability; the silent reading task may have recruited EF processes when searching through the text for answers to comprehension questions. This connection is important in our understanding of adult readers who engage in more silent reading behaviours in their daily lives.

Reading comprehension reflects a complex construct involving a number of skills and here is an example where cognitive processes are differentially involved between two reading tasks of reading comprehension ability (Johnston, Barnes, & Desrochers, 2008). At least for adults in this present sample, the type of reading comprehension task and nature of the task design influences the cognitive processes recruited in reading performance prosody.

Implications

The current study recognizes the element of EF involved in phonological processes and the role of EF in adult reading (Davidson et al., 2009). This was a first step taken to explore prosodic ability and executive functioning as combined predictors of adult reading achievement: an approach that has not been considered in theoretical models of reading development until now. The present study found EF to be a unique predictor in reading comprehension; future studies may want to examine whether executive functioning uniquely contributes to reading processes (e.g., decoding, fluency, word reading, and reading comprehension) across the developmental span.

Although the results may have implications for those with reading difficulties this particular study was conducted with typical readers. It has been proposed that comprehension-related deficits at both the reading and listening level represent a general cognitive or language deficit affecting learning experiences (Nation, 2005). If EF is consistently associated with phonological processing and reading to the same extent in readers of different ages and reading levels, then executive functions should not only be included as a control variable when explaining individual reading performance but also a point of consideration in remedial practice as well.

Limitations

The current study was an exploratory study of cognitive predictors contributing to word reading and reading comprehension ability. It is plausible that specific EF skills involved in the reading activity are a function of the reading measure being used. The interpretation of the association between EF and reading comprehension should be considered in light of this.

Generalizability of the findings is challenging because adults in the study were mainly comprised of adults recruited through the Faculty of Education at a postsecondary institution and most participants held a university degree. A larger and more heterogeneous sample would allow current findings to be extended to adult readers outside our demographic sample to validate a model of reading achievement. In addition, there may be variables or constructs not considered in the model mediating the relationship between the predictors examined here and the reading outcome measures.

The extant dataset had a pre-defined list of predictor variables that varied in the number of measures used to create each composite score. I found evidence to support the role of inhibitory control and switching attention in silent reading comprehension and not in oral reading abilities. EF skills of inhibitory control and switching attention are only two functions that have been examined in the current study; other functions including planning, updating and monitoring may be considered to evaluate whether the separate functions of EF differentially predicts the range of reading abilities across multiple points during reading acquisition. For example, updating and monitoring is an EF skill that describes the process of coding and monitoring incoming information based on its relevance to a particular task (Miyake et al., 2000). This is relevant in text comprehension when readers make decisions about relevant and irrelevant information to update the meaning representations in their memory when reading a passage.

Understanding the cognitive processes employed in different reading activities is a foundational building block towards considering the practical implications in teaching and remedial instruction for improving reading achievement. The role of prosody in text comprehension is important for syntactic phrasing and understanding text using grammatical markers. Due to different skills that are represented in oral and silent reading comprehension measures, future work exploring phonological processing in models of reading achievement may benefit from examining how prosody is implicated across specific comprehension processes (e.g., inference making, comprehension monitoring, and sensitivity to story structure) to supplement current understandings of general reading comprehension (Perfetti, Landi, & Oakhill, 2005). I also feel encouraged to explore additional methods and experimental tasks to measure prosodic ability, and extend current findings of prosody as a unique predictor in reading.

Future Directions

St Clair-Thompson and Gathercole (2006) asserted that there is "a fundamental difference in the organization of executive functions between children and adults" (p. 754) and that future work should include the examination and comparison of executive skills between both children and adults. Identifying the potential sources for individual differences in typically achieving adult reading ability helps us identify the benchmarks in reading that early readers are building towards. Distinguishing the cognitive processes and predictors contributing to word reading and reading comprehension will allow us to draw age-group comparisons regarding student development and progress. A cross-sectional and longitudinal design study is warranted to examine the developmental trajectory of prosody and EF related to reading achievement. This is needed in order to make age-group comparisons about the ways in which each process supports reading acquisition across different reading levels.

The unique contribution of prosody to adult word reading ability even after EF skills were controlled supports prosody as a phonological predictor that should be measured in any study that examines the relationship between phonological processing and reading achievement. The differences in the association among EF, phonological processes, and reading abilities suggest that EF operates differentially across the developmental lifespan and should be analyzed as both a control variable and predictor of reading ability. Lastly, a larger sample size and additional measures testing each construct would improve the generalizability and conclusions drawn from the findings about the relationship between prosody, EF, and reading achievement.

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Appendix A

Intercorrelations between all variables: Demographics, Control measures, Reading outcomes, Prosody, and Executive Functions

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Gender	–																			
2. Age	-.23*	–																		
3. Vocabulary	-.10	.42**	–																	
4. Fluid Intell.	-.05	-.01	.26*	–																
5. RAN (Digits)	.07	-.003	-.09	-.01	–															
6. PSTM	.02	.06	.28**	.09	-.07	–														
7. Word ID	-.07	.26**	.53**	.17	-.30**	.37**	–													
8. Word Attack	.12	-.06	.31**	.07	-.27**	.35**	.52**	–												
9. TOWRE W	-.05	-.03	.02	-.03	-.62**	.22*	.16	.20*	–											
10. TOWRE NW	.16	.07	.26**	.03	-.57**	.40**	.55**	.58**	.52**	–										
11. GORT-Acc	-.001	.14	.33**	.14	-.28**	.33**	.69**	.54**	.28**	.68**	–									
12. GORT-Comp	.16	.10	.33**	.18	.06	-.07	.12	-.04	-.07	.03	.10	–								
13. N-D Comp	.03	.08	.44**	.22*	-.19	.27**	.30**	.16	.26*	.36**	.41**	.24*	–							
14. Stress ID	.06	-.02	.20*	.18	-.37**	.22*	.35**	.33**	.18	.38**	.34**	.04	.38**	–						
15. Phrase ID	-.09	.27*	.13	.09	-.29**	.02	.28*	.25*	.04	.28*	.32**	.03	.22	.25*	–					
16. Stress Move	.10	.12	.37**	.28**	-.38**	.26**	.47**	.44**	.13	.41**	.38**	-.02	.21*	.75**	.31**	–				
17. Inhibition	-.16	.22*	-.02	-.08	.40**	-.10	-.15	-.20	-.26**	-.33**	-.25*	-.06	-.24*	-.41**	-.12	-.34**	–			
18. Inhib./ Switch	.13	.05	-.09	-.08	.39**	.01	-.08	-.01	-.37**	-.25*	-.19	-.06	-.22*	-.24*	-.25*	-.22*	.52**	–		
19. N-L Switch	-.06	-.09	-.15	-.08	.26**	-.02	-.02	.14	-.29**	-.12	-.08	-.01	-.29**	-.16	-.07	-.09	.30**	.32**	–	
20. Inhib.–Switch	.27**	-.11	-.09	-.03	.16	.09	.02	.14	-.24*	-.05	-.04	-.02	-.08	.03	-.19	-.007	-.14	.77**	.15	–

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

Appendix B

Ethics Approval

Queen's

May 13, 2013

Ms. Jessica Chan, Master's Student
Faculty of Education
Duncan McArthur Hall
Queen's University
511 Union Street
Kingston, ON, K7M 5R7

GREB Ref #: GEDUC-669-13; Romeo # 6009447
Title: "GEDUC-669-13 Exploring the role of Executive Processing and Prosodic Awareness in Reading Fluency and Reading Comprehension: A study of cognitive flexibility in Adult Readers"

Dear Ms. Chan:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled **"GEDUC-669-13 Exploring the role of Executive Processing and Prosodic Awareness in Reading Fluency and Reading Comprehension: A study of cognitive flexibility in Adult Readers"** for ethical compliance with the Tri-Council Guidelines (TCPS) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (article D.1.6) and Senate Terms of Reference (article G), your project has been cleared for one year. At the end of each year, the GREB will ask if your project has been completed and if not, what changes have occurred or will occur in the next year.

You are reminded of your obligation to advise the GREB, with a copy to your unit REB, of any adverse event(s) that occur during this one year period (access this form at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Adverse Event Report). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To make an amendment, access the application at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Amendment to Approved Study Form. These changes will automatically be sent to the Ethics Coordinator, Gail Irving, at the Office of Research Services or irvingg@queensu.ca for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

John G. Freeman

John Freeman, Ph.D.
Professor and Acting Chair
General Research Ethics Board

cc: Dr. Lesly Wade-Woolley, Faculty Supervisor
Dr. Don Klinger, Chair, Unit REB
Erin Wicklam, c/o Graduate Studies and Bureau of Research

Appendix C

Letter of Information

Dear Participant,

With this letter of information, I invite you to participate in a research project entitled "Untangling prosody, reading fluency, and reading comprehension." The research project is funded by the Social Sciences and Humanities Research Council of Canada and has been granted clearance according to the recommended principles of Canadian ethics guidelines and Queen's policies.

This project studies the relationship between reading ability and an aspect of spoken language that is very important in English: prosody, or the patterns of emphasis among and within words. For example, the difference between *record* used as a noun (e.g., "He kept a *record* of his experiences.") and a verb (e.g., "He was asked to *record* his experiences.") is one of stress placement. We are looking specifically at prosody's role in reading fluency and at the relationship of reading with expression to one's understanding of what s/he is reading. The research is important because findings will provide relevant information for:

- Clarifying the relationship between spoken language skills and reading development;
- Identifying contributory factors in reading difficulties; and
- Providing ways to identify and assist those who have difficulty learning to read.

You will be asked to participate in a number of language- and literacy-related activities, including activities that tap oral language skills, reading accuracy and fluency. The tasks will require you to respond by speaking or pointing, sometimes reading and sometimes listening to prerecorded words and sentences. In some cases, your responses will be digitally recorded to allow scoring at a later time. In these cases, your responses will be identified on the recording by numbers only, and once the responses have been scored and coded, the digital files will be deleted.

You will meet individually with a trained research assistant (RA) twice, each session on a different day, in the winter of 2013. Each session will be no longer than 60 minutes in length, including breaks, and an RA will contact you to schedule the sessions at a convenient time. Sessions will be located at a mutually convenient location, such as a study room in the library or an empty classroom or practice room. The total time commitment requested is 120 minutes.

Protecting the privacy of the people who participate in our project is important to us. Here is how we will protect your privacy:

- No participant names will be used in the data or published work.
- The paper and computer data will be locked indefinitely in an office at Queen's University. (Data will be retained indefinitely to enable secondary analysis related to prosody and reading.)

- Only the researchers and their trained students and assistants will have access to the data.
- RAs will not leave data unattended during testing.
- The data will only be used for research purposes and only group data, not individual data, will be reported.
- None of the data will appear in or influence your academic records.
- The data will not be used to evaluate you in any way.

Your participation is voluntary – you are free to withdraw from the study at any time with no effect on your academic standing. To withdraw from the study, you may do so in one of two ways: tell the RA in the session with you (whether this occurs before the sessions begin, mid-session, or immediately after a session) or contact the coordinating RA with whom you set up the appointment by email if you wish to withdraw between sessions. If you decide to withdraw, your data will be removed. There are no known risks, discomforts or inconveniences associated with participation in the research study. You are not obliged to answer any questions that you find objectionable or that make you feel uncomfortable. To thank you for your participation in our study, we will give you $15.00 at the end of each session, for a total of $30.00.

The findings of the research will be published in academic and educational research journals and presented at professional conferences. In accordance with the Faculty of Education's policy, data from this study will be retained for a minimum of five years after publication or presentation of the results. After five years, data will be kept indefinitely. If the data are made available to other researchers for a new or different type of analysis, your identity will never be disclosed. A summary of the final report will be made available to you, upon request (*see Consent Form*).

If you consent to participate in the research study, please review and sign the attached consent form, indicating that you understand the procedures involved. Keep this letter of information and the second copy of the consent form for your information.

If you have any questions about this project, please contact me, Dr. Lesly Wade-Woolley, at 613-533-6000, ext. 77230, or by email at lesly.wade-woolley@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board, Dr. Joan Stevenson, at 613-533-6081 or by email at chair.GREB@queensu.ca.

Sincerely,

Lesly Wade-Woolley, Ph.D.
Professor, Faculty of Education
Queen's University

Appendix D

Consent Form

Please <u>sign one</u> copy of this Consent Form. Please <u>keep</u> the second copy of the Consent Form and the Letter of Information for your records.

- I have read and retained the Letter of Information and a copy of this Consent Form. I have had any questions answered to my satisfaction.

- I understand that I am being asked to participate in the research project entitled *Untangling prosody, reading fluency, and reading comprehension* conducted by Dr. Lesly Wade-Woolley of Queen's University.

- I understand that my participation in the winter of 2013 will involve 2 sessions of 60 minutes each, each session on a different day, working individually with a research assistant.

- I understand that the purpose of the study is to study the role of prosody as a factor associated with individual differences in reading development, fluent reading, and reading comprehension.

- I understand that there are no known risks, discomforts or inconveniences associated with participation in the research study.

- I understand that my participation in this study is voluntary. Furthermore, I understand that I can withdraw from the study at any time and that withdrawal will not affect my academic standing. If I withdraw, I understand that my data will be removed from the study.

- I understand that I will receive $15.00 after each session, for a total of $30.00, as a thank you for my participation.

- I understand that the combined data from this study will be published in academic and professional journals and presented at academic conferences. If the data are made available to other researchers for secondary analysis, my identity will never be disclosed.

- I have been assured that the data are confidential and that any digital audio files of my responses will be deleted after scoring of responses.

I understand that I can contact Dr. Lesly Wade-Woolley at 613-533-6000, ext. 77230, or by email at lesly.wade-woolley@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board, Dr. Joan Stevenson, at 613-533-6081 or by email at chair.GREB@queensu.ca.

Name (*Please print.*):

____

Signature: ____

Date: ____________________________

θ YES! I wish to receive a copy of the summary of findings!
(*Please provide your email or mailing address below.*)